Knee & Shoulder Arthroscopy And Arthroplasty
ISKSAA

JOURNAL OF ARTHROSCOPY AND JOINT SURGERY

JAJS

Official Journal of the International Society for Knowledge for Surgeons on Arthroscopy and Arthroplasty (ISKSAA)

Indexed in Scopus & Embase

Volume 11 | Issue 4 | October-December 2024

ISSN: 2542-6001

Wolters Kluwer

https://journals.lww.com/jajs

Medknow

ISKSAA International Society for Knowledge for Surgeons on Arthroscopy and Arthroplasty

ISKSAA (**I**nternational **S**ociety for **K**nowledge for **S**urgeons on **A**rthroscopy and **A**rthroplasty) is a society of orthopaedic surgeons from around the world to share and disseminate knowledge, support research and improve patient care in Arthroscopy and Arthroplasty. We are proud to announce that ISKSAA membership has crossed the **2350** mark (India & Overseas) with members from **over 42 countries** making it the fastest growing Orthopaedic Association in the country & region in just 13 years of its inception . With over **550000 hits from over 174 countries** on the website **www.isksaa.com** & more and more interested people joining as members of ISKSAA, we do hope that ISKSAA will stand out as a major body to provide opportunities to our younger colleagues in training, education and fellowships.

Our Goals.........

- To provide health care education opportunities for increasing cognitive and psycho-motor skills in Arthroscopy and Arthroplasty
- To provide CME programs for the ISKSAA members as well as other qualified professionals.
- To provide Clinical Fellowships in Arthroscopy and Arthroplasty
- To provide opportunities to organise and collaborate research projects
- To provide a versatile website for dissemination of knowledge

ISKSAA Life Membership

The membership is open to Orthopaedic Surgeons, Postgraduate Orthopaedic students and Allied medical personal interested in Arthroscopy & Arthroplasty.

Benefits of ISKSAA Life membership include....

- **Free Subscription** of ISKSAA's official , SCOPUS INDEXED , EMBASE INDEXED peer reviewed , online scientific journal **Journal of Arthroscopy and Joint Surgery (JAJS**).
- Eligibility to apply for **ISKSAA's Prestigious Fellowship Programme**. We have finalised affiliations with ESSKA , ISAKOS , BOA , BASK , BOSTAA , BESS , Edge Hill University at Wrightington and FLINDERS MEDICAL CENTRE , IMRI AUSTRALIA to provide more **ISKSAA Fellowships** in India , UK , USA , Australia and Europe . We have offered over **600 Clinical Fellowships as of date including 54 in ISKSAA 2014 , 40 in ISKSAA 2015 , 63 in ISKSAA 2016 , 55 in ISKSAA 2017 , 20 in ISKSAA 2018 , 100 in ISKSAA 2019 , over 125 in ISKSAA 2022 & 110 in april 2024 and over 60 ISKSAA Wrightington MCh Fellowships from 2014 to 2024 .**
- **The last round of ISKSAA fellowship interviews for 110 Fellowships were held at CENTER FOR SPORTS INJURY , the new ISKSAA secretariat on 15th April 2024 ONLY for existing ISKSAA members at that time .**
- **The next round of ISKSAA fellowship interviews along with the ISKSAA Wrightington MCh fellowships will be held at CENTER FOR SPORTS INJURY during ISKSAA 2024 on 8th Nov 2024 .**
- Only as a life member , you can enjoy the benefit of **reduced Congress charges** in future ISKSAA Conferences .
- We had offered **60 1 week ISKSAA certified Fellowships** from 11th – 15th June & 25-29th June 2018 for ISKSAA members registered for ISKSAA LEEDS 2018 on a first come first basis **.**
- **Free Subscription** of ISKSAA's official , peer reviewed , SCOPUS & EMBASE Indexed , online scientific journal **Journal of Arthroscopy and Joint Surgery (JAJS**) which is also available on Science Direct and is professionally managed by the international publishing house Wolters Kluwer.
- **Member's only section** on the website which has access to the conference proceedings and live surgeries of ISKSAA 2012 , 2013 , 2014 & 2016 along with a host of other educational material .
- Important opportunity for interaction with world leaders in Arthroscopy & Arthroplasty .
- Opportunity to participate in ISKSAA courses and workshops

To enjoy all the benefits & privileges of an ISKSAA member, you are invited to apply for the Life membership of ISKSAA by going to the membership registration section of the website and entering all your details electronically. All details regarding membership application and payment options are available on the website (www.isksaa.com)

Journal of Arthroscopy and Joint Surgery

General Information

The Journal

Journal of Arthroscopy and Joint Surgery, JAJS is an official, peer reviewed, online scientific journal. The first edition of which rolled out in January 2014. The journal's full text is available online at https://journals.lww.com/jajs and issues are published quarterly in March, June, September, December. The Journal is committed to bring forth scientific manuscripts in the form of original research articles, current concept reviews, meta-analyses, case reports with a clear message and letters to the editor.

Abstracting and Indexing Information

The journal is registered with the following abstracting partners:

Baidu Scholar, CNKI, China National Knowledge Infrastructure, EBSCO Publishing's Electronic Databases, Ex Libris – Primo Central, Google Scholar, Hinari, Infotrieve, National Science Library, ProQuest, TDNet, Wanfang Data.

The journal is indexed with, or included in, the following:
EMBASE, SCOPUS.

Information for Authors

There are no page charges for IPCARES submissions. please check https://journals.lww.com/jajs/Pages/iInformationforauthors.aspx for details.

All manuscripts must be submitted online at https://review.jow.medknow.com/jajs.

Subscription Information

A subscription to the Journal of Arthroscopy and Joint Surgery comprises 4 issues. Prices include postage. Annual Subscription Rate for non-members-

- Institutional: INR 14,400.00 for India
  USD 200.00 for outside India
- Personal: INR 12,000.00 for India
  USD 200 for outside India

For mode of payment and other details, please visit www.medknow.com/subscribe.asp

Claims for missing issues will be serviced at no charge if received within 60 days of the cover date for domestic subscribers, and 3 months for subscribers outside India. Duplicate copies cannot be sent to replace issues not delivered because of failure to notify publisher of change of address.

The journal is published and distributed by Wolters Kluwer India Private Limited. Copies are sent to subscribers directly from the publisher’s address. It is illegal to acquire copies from any other source. If a copy is received for personal use as a member of the association/society, one cannot resale or give-away the copy for commercial or library use.

Nonmembers: All change of address information to be sent to WKHLRPMedknow_subscriptions@wolterskluwer.com

Advertising policies

The journal accepts display and classified advertising. Frequency discounts and special positions are available. Inquiries about advertising should be sent to Wolters Kluwer India Private Limited, WKHLRPMedknow_advertise@wolterskluwer.com.

The journal reserves the right to reject any advertisement considered unsuitable according to the set policies of the journal.

The appearance of advertising or product information in the various sections in the journal does not constitute an endorsement or approval by the journal and/or its publisher of the quality or value of the said product or of claims made for it by its manufacturer.

Copyright

Permissions

For information on how to request permissions to reproduce articles/information from this journal, please visit www.medknow.com.

Disclaimer

The information and opinions presented in the Journal reflect the views of the authors and not of the Journal or its Editorial Board or the Publisher. Publication does not constitute endorsement by the journal. Neither the Journal of Arthroscopy and Joint Surgery nor its publishers nor anyone else involved in creating, producing or delivering the Journal of Arthroscopy and Joint Surgery or the materials contained therein, assumes any liability or responsibility for the accuracy, completeness, or usefulness of any information provided in the Journal of Arthroscopy and Joint Surgery, nor shall they be liable for any direct, indirect, incidental, special, consequential or punitive damages arising out of the use of the Journal of Arthroscopy and Joint Surgery. The Journal of Arthroscopy and Joint Surgery nor its publishers, nor any other party involved in the preparation of material contained in the Journal of Arthroscopy and Joint Surgery represents or warrants that the information contained herein is in every respect accurate or complete, and they are not responsible for any errors or omissions or for the results obtained from the use of such material. Readers are encouraged to confirm the information contained herein with other sources.

Editorial office:
Dr. Pushpinder Singh Bajaj
Managing Editor,
Journal of Arthroscopy and Joint Surgery,
Center for Sports Injury (CSI),
B-5/4, Safdarjung Enclave, New Delhi - 110029, India
TEL : 01141223333 (20 lines)
Email: isksaaeducation@gmail.com

Published by
Wolters Kluwer India Private Limited,
A-202, 2nd Floor, The Qube, C.T.S. No.1498A/2 Village Marol,
Andheri, East, Mumbai - 400 059, India.
Phone: 91-22-66491818
Website: www.medknow.com

Printed at
Nikeda Art Printers Pvt. Ltd.,
Building No. C/3 - 14,15,16,
Shree Balaji Complex, Vehele Road,
Village Bhatale, Taluka Bhiwandi,
District Thane - 421302, India.

Journal of Arthroscopy and Joint Surgery

Volume 11 | Issue 4 | October-December 2024

Contents

Review Articles

Original Articles

Case Report


Reject
Accept

All-inside Technique versus Conventional Full-tunnel Reconstruction for Anterior Cruciate Ligament Tears of the Knee: A Systematic Review and Meta-analysis

Sumit Banerjee, Akshat Gupta[1], Sanchit Roy, Chirag Jain, Abhay Elhence

Department of Orthopaedics, All India Institue of Medical Sciences, Jodhpur, Rajasthan, [1]Department of Orthopaedics, All India Institute of Medical Sciences, Rajkot, Gujarat, India

Abstract

Introduction: There is a paucity of evidence in literature regarding the efficacy of all-inside anterior cruciate ligament reconstruction (AIACLR) vis-à-vis the traditionally used full-tunnel (FT) technique. The primary aim of this review, thus, was to shed light on this discrepancy and determine which of the two methods had more optimum results. **Methods:** PubMed and Cochrane Library databases were systematically searched by two independent reviewers. Selection criteria were laid down as per the patient, intervention, control, and outcome (PICO) format. All included studies were checked for quality and methodological strength using well-defined risk-of-bias assessment tools. Techniques were compared with respect to their graft and tunnel dimensions, functional outcome scores, and complication rates. Data analysis was carried out using the RevMan 5.3® software. **Results:** A total of 12 articles (six randomized control trials or randomized clinical trials and six prospective/retrospective cohort studies) with 880 knees were included in this study. In most instances of AIACLR, a short and thick quadrupled semitendinosus graft was used for reconstruction. Suspensory fixation devices alone or in combination with interference screws were used for graft fixation. The two techniques were comparable in terms of their functional outcomes, with a slightly lower graft failure rate with AIACLR. **Conclusion:** The AI technique provides a safe and reliable alternative to conventional ACLR in terms of comparable functional results, reduced postoperative pain, and lower graft failure rates. However, more comparative trials with long-term follow-ups are needed before a definitive statement can be put forward.

Keywords: All-inside technique, anterior cruciate ligament, arthroscopic reconstruction, conventional anterior cruciate ligament reconstruction, full-tunnel technique

Introduction

Anterior cruciate ligament (ACL) ruptures constitute one of the most commonly seen musculoskeletal sports-related injuries encountered by orthopedic surgeons in their clinical practice. Based on the data available, more than 175,000 patients suffer from ACL injuries every year in the United States (US), out of which approximately 100,000 undergo surgical intervention.[1] In the Indian population too, these injuries are fairly common, accounting for about 86% of all sports-related trauma.[2] The last few decades have seen much advancement in the techniques of ACL reconstruction (ACLR), starting with an improved knowledge of the biology and biomechanics of graft incorporation, new choices for graft material, better graft fixation devices, and more accelerated rehabilitation protocols.

Access this article online	
Quick Response Code:	**Website:** https://journals.lww.com/jajs
	DOI: 10.4103/jajs.jajs_10_24

The surgical approach to ACLR can broadly be classified into two types – a more traditionally oriented full-tunnel (FT) technique and the all-inside (AI) technique. The latter was first described in the mid-90s by Morgan[3] and then again by Cerulli *et al*.[4] and involves creating "sockets" or "half-tunnels" from the articular surface of the tibia "inside" the knee joint using retrograde drills as against the conventional technique where

Address for correspondence: Dr. Akshat Gupta, Department of Orthopaedics, All India Institute of Medical Sciences, Rajkot - 360 110, Gujarat, India. E-mail: drguptaakshat@gmail.com

Submitted: 18-Jan-2024 **Revised:** 13-Mar-2024
Accepted: 21-Mar-2024 **Published:** 11-Oct-2024

How to cite this article: Banerjee S, Gupta A, Roy S, Jain C, Elhence A. All-inside technique versus conventional full-tunnel reconstruction for anterior cruciate ligament tears of the knee: A systematic review and meta-analysis. J Arthrosc Jt Surg 2024;11:171-82.

"FTs" are created from "outside" with the help of an aiming guide. Some of the postulated benefits of AI anterior cruciate ligament reconstruction (AIACLR) include a more anatomical tibial tunnel, better host bone-graft integration, preservation of bone stock, improved postoperative flexion strength, reduced incidence of tibial fractures, and less bone tunnel widening due to minimization of dead space.[5,6]

A recent meta-analysis by Fu *et al*.[6] demonstrated comparable outcomes between the two techniques. Similar findings were also reported by Connaughton *et al*.[7] However, since then, a number of studies have been added to the literature. Therefore, this study was conceptualized with the following objectives: (i) to systematically review the available literature regarding the AI technique of ACLR and (ii) make an objective assessment as to whether AIACLR does offer any benefit in terms of better functional outcome and reduced complications when compared with the FT method.

Materials and Methods

No ethical clearance was needed as this study was a systematic review of available literature.

Protocol registration

The study protocol was registered with the PROSPERO database (ID number: CRD42023483461) of systematic reviews and meta-analyses.

Inclusion and exclusion criteria

We used the Patient, Intervention, Control, Outcome (PICO) format to define the inclusion/exclusion criteria of our study. All comparative trials and research articles which included patients: (i) in the skeletally mature age group who had sustained ACL tears of the knee; (ii) underwent anatomical ACLR with either of the two techniques, i.e., AI or conventional FT; (iii) had outcome assessment using objective or subjective functional evaluation scores; and (iv) had a minimum follow-up of 6 months, were included in this review. Single-arm/noncomparative studies, studies on cadavers and animals, biomechanical studies, review articles, case reports, and studies describing any other technique other than the aforementioned were excluded.

Search strategy

Two reviewers (AG and SB) searched the following databases – PubMed/MEDLINE and Cochrane Library – using a search strategy which was conceptualized *a priori*. In addition, references to the primary search results were also screened and relevant articles were included. The complete search strategy is described in Appendix 1.

Study selection

A systematic review of all published literature was carried out in accordance with the Preferred Reporting Items of Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[8] PubMed and Cochrane Library databases were searched using terms with multiple synonyms or alternate words (to make the search more sensitive) for all English literature articles published since inception that have made a comparative analysis of the two techniques of ACL reconstruction as described above. Keywords used to further refine the search were "Anterior cruciate ligament," "ACL," "reconstruction," "AI technique," "arthroscopy," "arthroscopic surgery," "arthroscopically," and "functional outcome." Database-specific abbreviations, limiters, and Boolean operators were used to combine specific search keywords and yield results. Screening was carried out by two independent reviewers (AG and CJ), to minimize bias.

In the first step, only the titles and abstracts were screened. Following this, full texts of relevant articles were obtained to determine eligibility. Irrelevant, duplicate citations as well as studies not meeting our inclusion criteria were left out. Discrepancies, if any, were resolved with mutual agreement and in case of an impasse, the senior reviewer's (SB) decision was final.

Risk-of-bias assessment

Two independent reviewers (CJ and SR) assessed the included studies for methodological strength and quality. The tools used were the Cochrane risk-of-bias (ROB) assessment scale for randomized clinical trials (RCTs) and the methodological index for nonrandomized studies (MINORS) questionnaire [Appendix 2].[9,10]

The Cochrane ROB tool analyses a clinical trial for bias across a range of domains such as randomization, allocation concealment, blinding, attrition, and selective reporting and then classifies the amount as low, unclear, or high based on the information presented in the study.[9] To quantify the amount of bias, the following scoring system was devised: a score of "2" was given if the ROB was low, "1" if it was unclear, and "0" if there was a high ROB in the study. These values were then added to compute the final score, with a-1-deduction done from the latter in case of the presence of any other source of bias. Studies were then accordingly categorized as good (score: 10–12), fair (score: 7–9), and poor (score < 6).

The MINORS scale was used for prospective/retrospective nonrandomized studies and uses a 12-point questionnaire to grade included articles into "good," "fair," and "poor."[10] All studies which scored >19 were considered "good," whereas those scoring between 14 and 18 and <14 points were categorized as "fair" and "poor," respectively.

In addition, publication bias assessment of included studies was done using specific Funnel plots.

Outcome measures

The two techniques (AI versus FT) were compared primarily with respect to their overall functional outcomes at the time of final follow-up. The scoring systems used included – (i) Lysholm score, (ii) International Knee Documentation Committee (IKDC) subjective score, (iii) Tegner Activity Scale (TAS), (iv) Differential Knee Laxity, (v) Visual Analogue Scale (VAS), and (vi) Knee Society Score Pain (KSS-P) and the KSS function.[11] A note was also made of the frequency and nature of associated surgical complications such as infections, graft failure rate, implant failure and breakage, and postoperative knee stiffness.

Data compilation and analysis

Selected articles were first imported into a reference manager software (Zotero version 6.0.30). Demographic details of each study were summarized on a Microsoft Excel spreadsheet. These included author and year of publication; type of study; sample size in each of the comparison arms; extent of attrition; age and sex ratio; mode of injury; body mass index (BMI); duration of average follow-up; average time period from injury to treatment; graft characteristics and mode of fixation in each of the two techniques; duration of surgery; and functional outcome scores in both arms of the study. Quantitative data were expressed as mean ± standard deviation.

Further analysis was carried out using the software RevMan version 5.3 designed by the Cochrane collaboration.[12] Summaries of the intervention effects of each study were provided by pooling the results on a random effects model and calculating the odd's ratio (for dichotomous outcomes) and mean difference (for continuous outcomes). Comparisons made included – (i) graft length; (ii) graft diameter; (iii) femoral and tibial tunnel diameters; (iv) surgical time; (v) complication rates; and (vi) functional outcomes – Lysholm score, IKDC (s) score, TAS, VAS, differential knee laxity, and KSS. Heterogeneity was calculated using the I^2 test. Significance was set at $P < 0.05$ with 95% confidence interval (CI). Forest plots were used to graphically depict a comparison between the two techniques for each outcome of interest.

Results

Literature search

Sixty-one studies were identified from PubMed and eight from the Cochrane Library databases. Eleven more studies were added after scanning the references of the primary search results. A total of 80 records were, thus, identified in the initial phase of screening.

From the above, 17 articles were identified as potentially meeting the study criteria and were carried forward to the second step of the selection process. Further screening involved retrieving full-length texts of these articles, which were then closely scrutinized. Two studies had the same data set, even though they had presented their results in different journals.[13,14] Hence, while both were included in our final search results, their data were tabulated under a single study heading to avoid confusion during analysis.

A total of 12 studies were finally included in the review.[13-24]

The PRISMA flowchart depicting the same with reasons for study exclusion is given in Figure 1.

Risk-of-bias assessment

Out of the six RCTs[15-19,21] evaluated using the Cochrane Collaboration ROB tool, two studies – Kulshreshtha *et al*.[17] and Lin *et al*.[19] – scored "Good," whereas the remaining four were categorized as "Fair." This difference can chiefly be attributed to the efficacy of personnel as well as assessor blinding in these two studies vis-à-vis the rest.

Remaining articles[13,14,20,22-24] were all prospective/retrospective cohort studies and hence, checked using the MINORS questionnaire. The latter graded two studies as "good" and the rest as "fair," with the difference mainly being in the quality of blinding and contemporary nature of the comparison arms.

None of the studies in either group was graded as "Poor."

The detailed ROB assessment is presented in Appendix 3. Funnel plots depicting publication bias are described in Appendix 4.

Patient demographics

A total of 880 knees (454 AI and 426 FT) were included in this study. However, 43 cases were excluded from the analysis due to incomplete follow-up, re-fracture, intraoperative injuries, etc., These included 20 in the AI and 23 in the FT groups, respectively. Ultimately, 837 knees were available for review. These included 514 males and 235 females (10 studies evaluated) with a mean age of 29.4 ± 4.3 years. The average BMI calculated was 24.6 ± 0.7.

The mean time to surgery varied from 2.2 months[23] to 25.7 months[16] (mean value: 11.1 ± 7.9 months). Surgical duration was significantly higher in patients undergoing AIACL reconstruction (75 ± 12.7 min) as compared to those operated using the conventional technique (65.1 ± 5 min) (MD 6.31 [95% CI: 1.13–11.5]) [Figure 2]. Most commonly associated injuries were meniscal tears (medial > lateral) (146/191 or 76.4%) followed by chondral defects (45/191 or 23.6%).

The average duration of follow-up was 21.1 ± 9.3 months.

These findings have been summarized in the Appendix 5.

Graft parameters and type of fixation device

Barring Lubowitz *et al*.,[15] all studies had made the use of the quadrupled semitendinosus (STQ) autograft for AIACL reconstruction and double/quadruple stranded gracilis semitendinosus (GST) graft for the conventional FT surgical technique. While the average graft length was significantly shorter in the AI method (64.25 ± 2.5 mm vs. 90.8 ± 13.9 mm) (MD: 26.54 [95% CI: −49.18, −3.91]), the quantitative analysis did not reveal any significant difference between the two techniques vis-à-vis graft width and diameter (MD 0.47 [95% CI: 0.11–0.83]) [Figure 3a and b].

Most studies employed a suspensory fixation (SF) device for both tibial and femoral ends in the AI technique, whereas interference screws (IFS) and SF implants were used for the tibial and femoral ends in FT ACL reconstruction. Benea *et al*.[16] and Mayr *et al*.,[18] however, had used IFS as fixation modalities at both ends of the graft in their FT technique. Lubowitz *et al*.[15] utilized IFS for graft fixation in both AI and FT reconstruction.

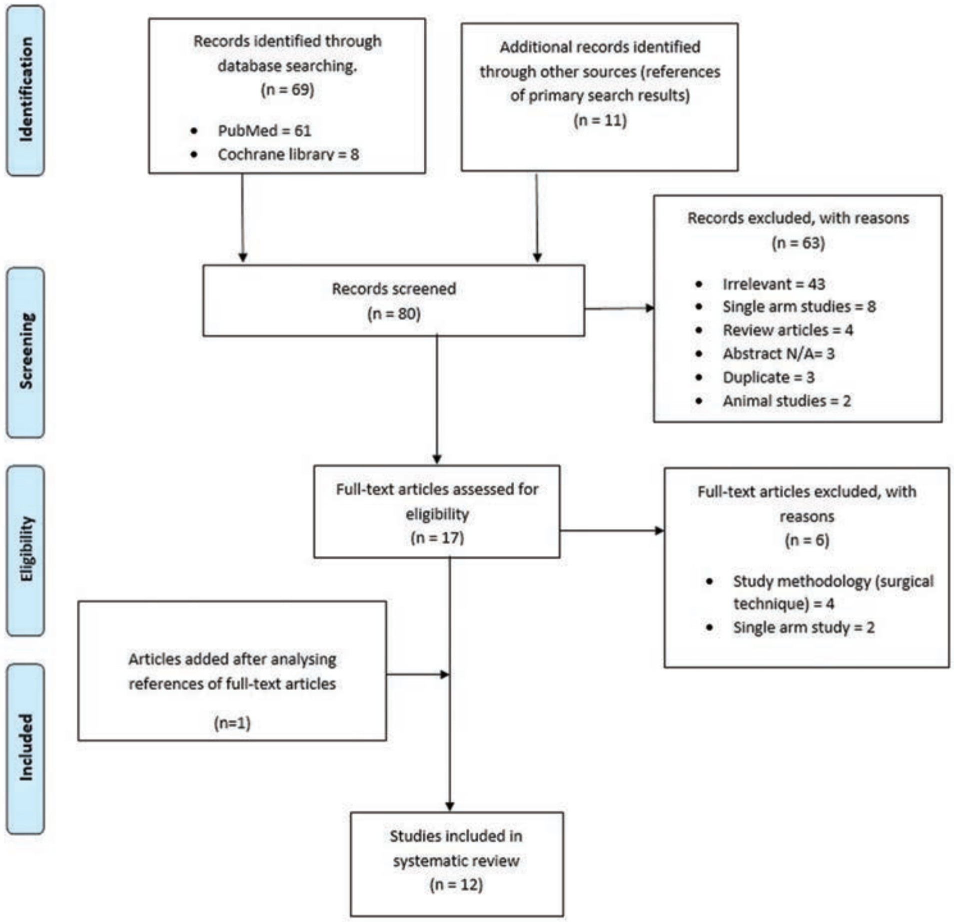


Figure 1: Flowchart depicting screening of search results and study selection

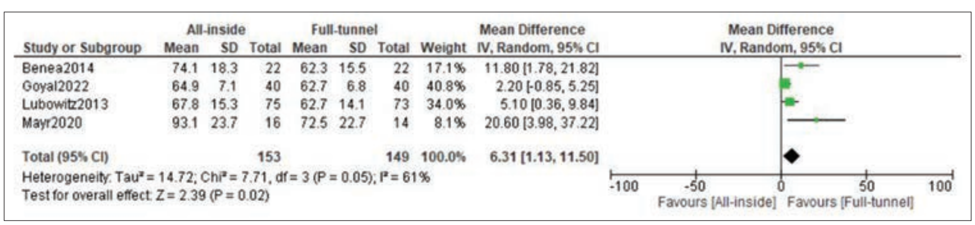


Figure 2: Forest diagram showing a comparison in surgical time between the all-inside and full-tunnel groups

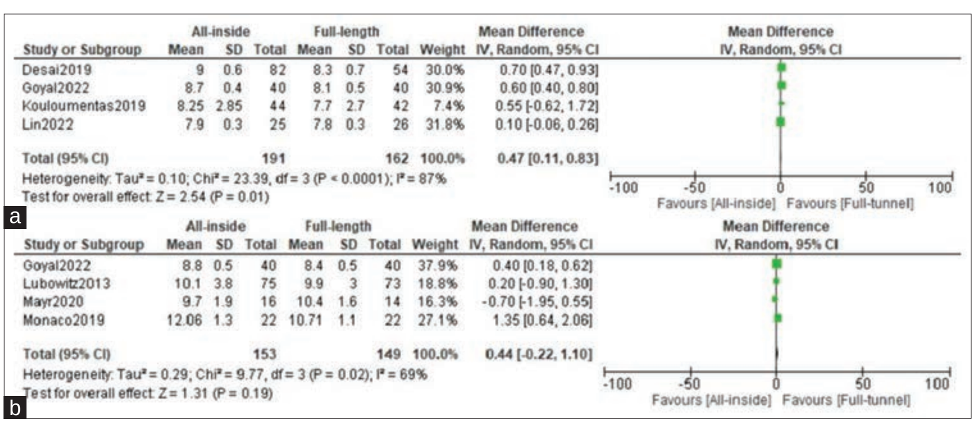


Figure 3: (a and b) Forest charts depicting average graft length and diameter in each group

The two techniques did not differ with respect to their femoral tunnel dimensions (MD 0.44 [95% CI: −0.22–1.10]) [Figure 4a]. However, tibial tunnel width was significantly smaller in patients who underwent AIACL reconstruction (9.6 ± 0.7 mm) as compared to those operated using the FT technique (10.7 ± 1.4 mm) (MD: 0.98 [95% CI: −2.12-0.16]) [Figure 4b].

These observations have been summed up in Table 1.

Functional outcomes

Lysholm score

Eight studies measured the Lysholm score.[14,18-24] Only one noted a statistically significant difference between the two techniques ($P = 0.001$).[24]

The average score in either arm was 93.6 ± 4.1 and 93.1 ± 3.4 (AI and FT), and this difference was not significant (MD: 0.08 [95% CI: −1.95-1.79]) [Figure 5a].

Subjective International Knee Documentation Committee score

IKDC (s) was used as a parameter for functional outcome comparison by nine authors.[14-16,18,19,21-24] None of them, barring Shantanu *et al*.,[24] observed any significant difference between the two techniques. The same has been depicted in Figure 5b (MD 1.14 [95% CI: 0.2–2.08]).

Tegner activity scale

The Tegner activity score data were extracted from the five studies reporting it.[14,17-19,23] A significantly higher score in the

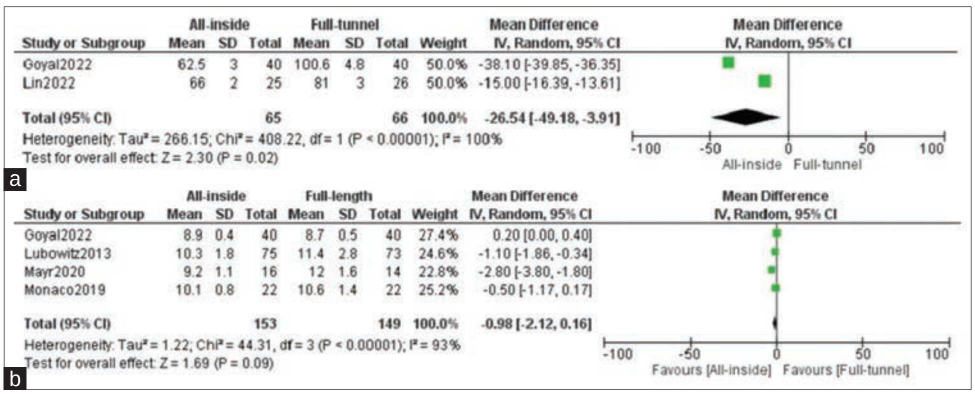


Figure 4: (a and b) Comparison of the femoral and tibial tunnel dimensions between the all-inside and full-tunnel groups

Table 1: A summary of the graft dimensions and other intraoperative parameters of the two techniques

Serial number	Author (year)	Graft type		Graft length (mm)		Graft diameter (mm)		Fixation device		Tunnel diameter (femur) (mm)		Tunnel diameter (tibia) (mm)	
		AI	FT	AI	FT	AI	FT	AI	FT	AI	FT	AI	FT
1	Lubowitz *et al*. (2013)[15]	AG	AG	NR	NR	NR	NR	IFS	IFS	10.1±3.8	9.9±3	10.3±1.8	11.4±2.8
2	Benea *et al*. (2014)[16]	STQ	GST	NR	NR	NR	NR	SF	IFS	NR	NR	NR	NR
3	Shantanu *et al*. (2016)[24]	AG	AG	NR	NR	NR	NR	SF	SF (F) + IFS (T)	NR	NR	NR	NR
4	Monaco *et al*. (2019)[13,14]	STQ	GST	NR	NR	NR	NR	SF	SF (F) + IFS (T)	12.1±1.3	10.7±1.1	10.1±0.8	10.6±1.4
5	Desai *et al*. (2019)[23]	STQ	GST	NR	NR	9±0.6	8.3±0.7	SF	SF (F) + IFS (T)	NR	NR	NR	NR
6	Kouloumentas *et al*. (2019)[21]	STQ	GST	NR	NR	8.25±2.85	7.7±2.7	SF	SF (F) + IFS (T)	NR	NR	NR	NR
7	Mayr *et al*. (2020)[18]	STQ	GST	NR	NR	NR	NR	SF	IFS	9.7±1.9	10.4±1.6	9.2±1.1	12±1.6
8	Kyriakopoulos *et al*. (2021)[20]	STQ	GST	NR	NR	NR	NR	SF	SF (F) + IFS (T)	NR	NR	NR	NR
9	Kulshrestha *et al*. (2021)[17]	STQ/ GST	STQ/ GST	NR	NR	NR	NR	SF	SF (F) + IFS (T)	NR	NR	NR	NR
10	Goyal *et al*. (2022)[22]	STQ	GST	62.5±3	100.6±4.8	8.7±0.4	8.1±0.5	SF	SF (F) + IFS (T)	8.8±0.5	8.4±0.5	8.9±0.4	8.7±0.5
11	Lin *et al*. (2022)[19]	STQ	GST	66±2	81±3	7.9±0.3	7.8±0.3	SF	SF (F) + IFS (T)	NR	NR	NR	NR

AI: All-inside, FT: Full tunnel, AG: Allograft, STQ: Semitendinosus quadrupled, GST: Gracilis/semitendinosus, SF: Suspensory fixation, IFS: Interference screw, NR: Not reported

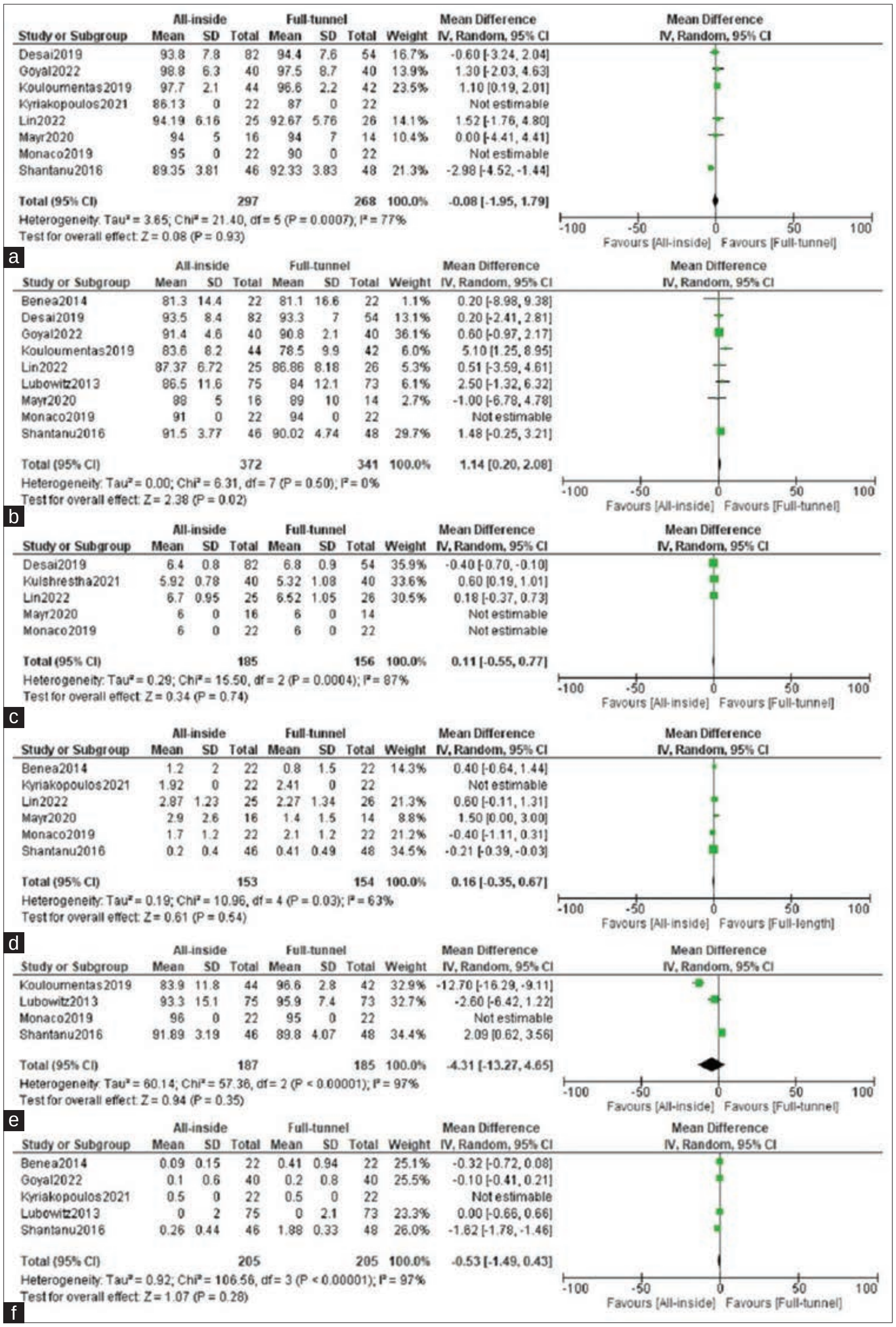


Figure 5: Forest plots depicting comparison between the all-inside and full-tunnel techniques in the following domains: (a) Lysholm score, (b) subjective International Knee Documentation Committee scores. (c) Tegner Activity Scale. (d) Differential Knee Laxity. (e) Knee Society Score. (f) Visual Analogue Scale

FT group (6.8 vs. 6.4, $P = 0.048$) was noted by Desai *et al*.[23] However, Kulshreshtha *et al*.[17] depicted a greater degree of improvement in the TAS values with the AI technique (2.3 ± 0.97) as compared to the conventional method (1.5 ± 1.3).

Overall, the two techniques showed no statistical difference between their mean values (6.2 ± 0.3 in AI and 6.1 ± 0.6 in FT) (MD: 0.11 [95% CI: −0.55–0.77]) [Figure 5c].

Differential knee laxity

Six studies investigated the anteroposterior stability of the operative knee.[14,16,18-20,24] Out of these, five used an instrumented knee laxity measuring devices such as the KT-1000 arthrometer,[14,18,20] Rollimeter®,[16] and the GNRB arthrometer.[19] Shantanu *et al*.,[24] on the other hand, used clinical evaluation by the Lachman test for quantifying knee laxity. The average postoperative knee laxity in each group was 1.8 ± 1 mm (AI) and 1.6 ± 0.8 mm (FT), respectively.

At 12-month follow-up, Lin *et al*.[19] observed a greater degree of knee laxity in the patients who had undergone AIACL reconstruction. This was in sharp contrast to the findings by Shantanu *et al*.,[24] where the average knee laxity at 6-month postsurgery was 0.2 ± 0.4 mm (AI) vis-à-vis 0.41 ± 0.49 (FT).

Quantitative analysis did not reveal any significant difference between the two techniques (MD: 0.16 [95% CI: −0.35–0.67]) [Figure 5d].

Knee society score

Only two studies – Lubowitz *et al*.[15] and Monaco *et al*.[14] – had measured the KSS (function) postoperatively. Average final scores in both groups were comparable (98.8 ± 1.7 vs. 99.4 ± 0.8).

KSS (pain) was measured by four authors as outcome assessment parameters and the values improved postoperatively in all studies.[14,15,21,24] Lubowitz *et al*.[15] found a significant KSS pain score difference in favor of AI at 1.5 weeks ($P < 0.05$), but in subsequent follow-ups, the two techniques were found to have comparable results. Similar findings were also noted by Kouloumentas *et al*.,[21] Shantanu *et al*.[24] found a significant difference between the two groups at 6 months ($P = 0.001$) (AI > FT).

Statistical analysis showed a trend in favor of the AI technique (MD-4.31 [95% CI: −13.27–4.65]) [Figure 5e], even though the results were not statistically significant.

Visual Analog Scale

Five studies compared the AI and traditional techniques of ACLR with respect to their VAS scores at the time of final follow-up.[15,16,20,22,24] Except Shantanu *et al*.,[24] none of the authors found any significant difference between the two.

These values have been depicted in Figure 5f.

A brief summary of the functional outcome comparison between the two techniques has been presented in Table 2.

Complications

In the AI group, there were a total of five postoperative infections, 12 cases of graft failure, and two incidents each of implant failure and knee stiffness. One patient had a superficial wound breakdown necessitating an operative closure and another was afflicted with postoperative hemarthrosis, which was washed arthroscopically without implant removal. Furthermore, three patients required additional revision surgeries for meniscal injuries.

Among the patients who were operated using the traditional method of ACLR, two had superficial wound infections with the remaining having the following complication rates – 13 patients of graft failure, one case of postoperative knee stiffness, and two incidents of implant breakage. There was one additional case of hemarthroses and two patients who underwent revision meniscal surgery.

Quantitative analysis revealed comparable results, with a trend slightly in favor of AIACLR [Figure 6a]. However, the incidence of graft failure was higher with the conventional technique, even though the difference was not statistically significant (OR 0.57 [95% CI: 0.24–1.36]) [Figure 6b].

These findings are collectively summarized in Table 3.

Discussion

The history of ACLR dates back to 1895 when the first successful procedure was carried out by Robson on a 41-year-old miner.[25] Since then, significant strides have been made in not only the surgical techniques but also the choice of available instrumentation, types of graft material, and modalities of fixation. The greatest innovation took place in 1980 with the advent of arthroscopy.[26] Another significant development at about the same time was the introduction of metallic, and later, bioabsorbable IFS.[27] A number of subsequent experimental studies led to further refinement and the introduction of a new technique of ACLR – the AI technique.[3,4] The latter relied on creating "sockets" or "half-tunnels" on both the tibia and femur from within the knee joint and proposed using a new class of implants known as the SF devices for graft stabilization. The results of this method were first presented to the world in 2001 during the First Icelandic Conference on Arthroscopy and Sports Medicine at Reykjavik.[28] Proponents of the AIACLR believe that the technique is associated with lesser postoperative pain and equivalent long-term functional results when compared to the FT technique.[5,15-17,22] The same was upheld by Fu *et al*. in their systematic review of nine studies published in 2020.[6] However, there has been a substantial addition to the literature in the past 3 years with some studies reporting significant findings.[17,19,20,22] This convinced us to explore the topic once again and make an attempt at clarifying the discrepancy regarding the efficacy of either technique.

Regarding the choice of graft for reconstruction, all authors with the exception of Lubowitz *et al*.[15] had used the STQ tendon in AIACLR. This was because using a larger diameter drill to create bone sockets preempts the need for a longer graft, thereby allowing the latter to be folded as much as four times.[17,21] On the other hand, conventional reconstruction requires an additional gracilis tendon to achieve the required thickness (which is still less than that achieved with a STQ graft as the gracilis tendon is thinner).[17,21] While bone patellar tendon bone (BPTB) grafts have shown to have an improved bony incorporation and are considered by many as the gold standard,[20] no difference has been observed in the overall functional outcome and graft failure rate between the BPTB and hamstring grafts in patients undergoing primary ACLR.[29] Our review demonstrated that the graft tendon used for AIACLR was shorter and wider than that in the FT technique. This finding assumes significance as graft thickness and diameter is one parameter closely linked to the successful outcome of an ACL surgery. Few authors have observed a higher failure rate

Table 2: A tabular comparison of the two techniques vis-à-vis their overall functional outcomes

Serial number	Author (year)	Lysholm score		IKDC (s) score		TAS		Differential knee laxity (mm)		KSS (pain)		VAS¶	
		AI	FT	AI	FT	AI	FT	AI	FT	AI	FT	AI	FT
1	Lubowitz *et al*. (2013)[15]	NR	NR	86.5±11.6	84±12.1	NR	NR	NR	NR	93.3±15.1	95.9±7.4	0±2	0±2.1
2	Benea *et al*. (2014)[16]	NR	NR	81.3±14.4	81.1±16.6	NR	NR	1.2±2	0.8±1.5	NR	NR	0.1±0.15	0.4±0.9
3	Shantanu *et al*. (2016)[24]	89.35±3.8	92.3±3.8	91.5±3.8	90±4.7	NR	NR	0.2±0.4	0.4±0.5	91.9±3.2	89.8±4.1	0.3±0.4	1.9±0.3
4	Monaco *et al*. (2019)[13,14]	95	90	91	94	6	6	1.7±1.2	2.1±1.2	96	95	NR	NR
5	Desai *et al*. (2019)[23]	93.8±7.8	94.4±7.6	93.5±8.4	93.3±7	6.4±0.8	6.8±0.9	NR	NR	NR	NR	NR	NR
6	Kouloumentas *et al*. (2019)[21]	97.7±2.1	96.6±2.2	83.6±8.2	78.5±9.9	NR	NR	NR	NR	83.9±11.8	96.6±2.8	NR	NR
7	Mayr *et al*. (2020)[18]	94±5	94±7	88±5	89±10	6	6	2.9±2.6	1.4±1.5	NR	NR	NR	NR
8	Kyriakopoulos *et al*. (2021)[20]	86.1	87	NR	NR	NR	NR	1.9	2.4	NR	NR	0.5	0.5
9	Kulshrestha *et al*. (2021)[17]	NR	NR	NR	NR	5.9±0.8	5.3±1.1	NR	NR	NR	NR	NR	NR
10	Goyal *et al*. (2022)[22]	98.8±6.3	97.5±8.7	91.4±4.6	90.8±2.1	NR	NR	NR	NR	NR	NR	0.1±0.6	0.2±0.8
11	Lin *et al*. (2022)[19]	94.2±6.2	92.7±5.8	87.4±6.7	86.9±8.1	6.7±1	6.5±1.1	2.9±1.2	2.3±1.3	NR	NR	NR	NR

¶Studies with negative values of VAS have been denoted as zero. AI: All-inside, FT: Full tunnel, IKDC (s): International Knee Documentation Committee (subjective), TAS: Tegner Activity Scale, KSS (pain): Knee society score pain, VAS: Visual Analogue Scale, NR: Not reported

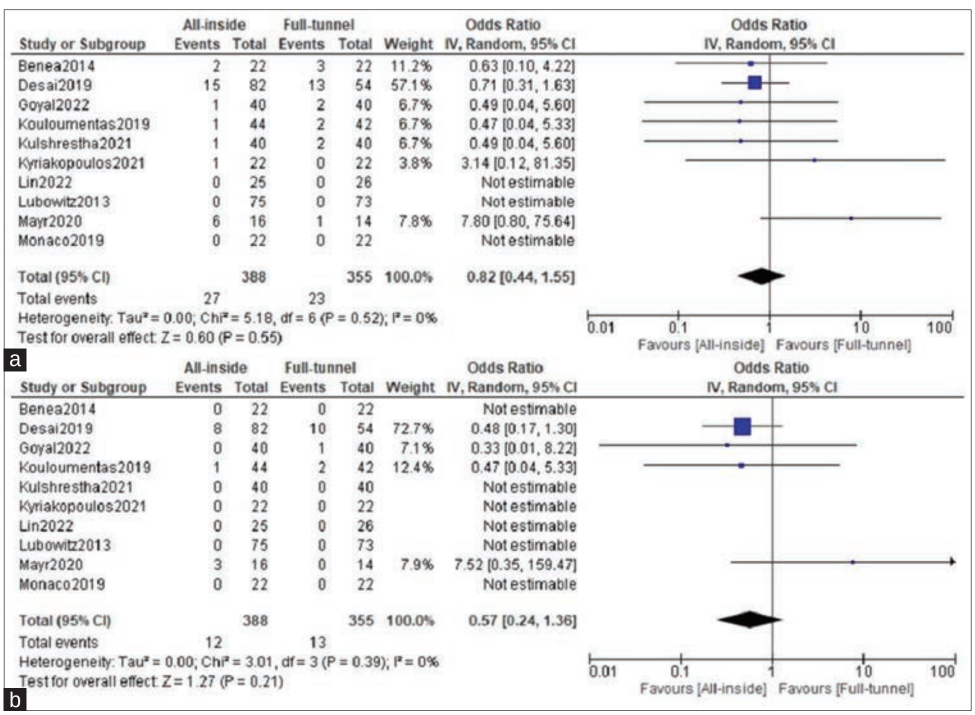


Figure 6: Forest plots showing a comparison of the all-inside technique vis-à-vis the full-tunnel technique with respect to – (a) Overall complication rates, (b) Extent of Graft failure

and worsened patient-reported outcomes if the average graft width is < 8 mm.[30-32] However, no such finding was noted by Desai *et al*.[23] In their study, failure rates were comparable between the two techniques of ACLR even though a larger graft was used in the AI method. These observations were further supported by Wernecke *et al*.[33] who showed that increased

Table 3: Complications following anterior cruciate ligament reconstruction (all-inside vs. full tunnel)

Serial number	Author (year)	Infection		Graft failure		Knee stiffness		Implant breakage/failure		Others	
		AI	FT	AI	FT	AI	FT	AI	FT	AI	FT
1	Lubowitz *et al*. (2013)[15]	0	0	0	0	0	0	0	0	0	0
2	Benea *et al*. (2014)[16]	1	0	0	0	0	0	0	0	1**	3**
3	Shantanu *et al*. (2016)[24]	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
4	Monaco *et al*. (2019)[13,14]	0	0	0	0	0	0	0	0	0	0
5	Desai *et al*. (2019)[23]	1	0	8	10	2	1	0	0	4##	2##
6	Kouloumentas *et al*. (2019)[21]	0	0	1	2	0	0	0	0	0	0
7	Mayr *et al*. (2020)[18]	1	0	3	0	0	0	2	1	0	0
8	Kyriakopoulos *et al*. (2021)[20]	0	0	0	0	0	0	0	0	1¶¶	0
9	Kulshrestha *et al*. (2021)[17]	1	2	0	0	0	0	0	0	0	0
10	Goyal *et al*. (2022)[22]	1	0	0	1	0	0	0	1	0	0
11	Lin *et al*. (2022)[19]	0	0	0	0	0	0	0	0	0	0

**One cyclops lesion in the AI group and one case of hemarthrosis and two cyclops lesions in the FT group, ##Three revision meniscal surgeries and one patient of superficial wound dehiscence (AI); two revision meniscal surgeries (FT), ¶¶One incident of hemarthrosis in patients undergoing AIACL reconstruction. AI: All-inside, FT: Full tunnel, NR: Not reported, AIACL: AI anterior cruciate ligament

hamstring graft diameter did not significantly diminish improvement in functional outcome scores. Despite this, it is now agreed that STQ grafts must possess a minimum length of 28 mm and a diameter of 8 mm.[30,34] Using a four-stranded semitendinosus (ST) has a few advantages. First, preservation of the gracilis ensures an autograft source for future ligament repairs/reconstructions. Second, gracilis acts as a secondary knee stabilizer, and its retention significantly improves postoperative hamstring strength.[24] This was documented by Kouloumentas *et al*.[21] who reported significantly better flexor isokinetic measurements at 180°/s in patients treated with a STQ autograft than those in whom GST was used. This also suggests that the AI technique may be more suited to patients involved in dynamic contact sports that require rapid knee flexion such as soccer.[21] Finally, the STQ tendon can easily be harvested from the posterior aspect of the knee using a small stab incision. This makes it more cosmetically acceptable than the traditional anteromedial portal technique.[5,6,24]

In addition to the choice and dimensions of autograft material used, width of the tibial and femoral tunnels is another determinant of the outcome of an ACLR surgery. A host of biological and biomechanical factors are at play here. However, even then, the exact mechanism of tunnel widening has not been fully understood.[14,18] Maximum enlargement in the size of the tunnels created occurs within the first 6 weeks following surgery.[14] As the extent of widening is inversely related to the degree of bone ingrowth, a greater degree of enlargement is seen with hamstring tendon grafts than with BPTB. For the same reason, maximum widening is reported at the tunnel aperture (the "synovial bathing effect").[14,35]

One more factor which has a significant bearing on the average size of the tunnels is the choice of fixation device. We observed that, for conventional ACLR, most authors had used an IFS for graft stabilization in the tibial side with cortical SF implants applied on the femoral side. In contrast, SF devices were used for graft fixation on both the tibia and the femur during the AI technique. Both categories of implants have their respective pros and cons. IFS is known to provide a limited contact area for host bone-graft integration. They are also associated with a host of complications such as breakage, graft tear, foreign-body/allergic reactions, cyst, and abscess formation.[18,22,36] In comparison, SF systems provide a greater contact area and promote "four-zone direct graft healing."[37,38] However, they are known to cause increased micromotion within the tunnel along both the longitudinal ("bungee-cord effect") and transverse axis ("windshield wiper effect").[14,17-19] Despite these, both Mayr *et al*.[18] and Monaco *et al*.[14] noted less femoral and tibial tunnel enlargements in the AI technique than with FTACLR. The argument put forward was that an adjustable loop fixation employing STQ tendon allows complete filling up of the tunnel socket by the graft which in turn reduces the empty space available for synovial fluid migration.[14] Similar observations were made by Lin *et al*.[19] who suggested that the reason why tunnel widening was higher after FTACLR was because IFS used in the procedure caused continuous erosion of the tunnel wall, leading to leakage of synovial fluid. Overall, our review demonstrated that the average tibial tunnel widening was lower in patients undergoing AIACLR, with the exception of one study.[22] These inconsistencies in measurements across different studies can probably be attributed to the differences in reference points used for calculating the tunnel width.[6]

A number of clinically validated outcome measures were used by the studies included in our review to compare the two ACLR techniques. Kulshrestha *et al*.[17] had used a new version of the KSS as they felt that the original scoring system had a number of ambiguities which were addressed by the new score. They also opined that the modified KSS score provided a more subjective and holistic measure of postoperative knee functioning.[39] Almost all authors were unanimous in their opinion that both techniques – AI and FT – produce comparable functional results.[14-16,18,20-23] This was similar to the findings of Fu *et al*.[6] as well as our own review. One parameter which was seen to be significantly better in the AI technique was the VAS score. The understanding here is that sockets or half tunnels are drilled as per graft length as against the anteromedial portal technique where the entire length of the tunnel needs to be drilled in the tibia.[24] Moreover, AIACLR avoids significant knee cartilage damage as the sockets are created from the lateral side using a FlipCutter. This is in contrast to the FT method where femoral tunnel drilling is done from the anteromedial portal which may cause injury to the knee articular cartilage.[24] Two additional reasons are postulated for the lower levels of pain score in the immediate postoperative period following AIACLR. First, an anatomically more accurate tibial tunnel positioning which precludes pain secondary to mechanical impingement of the implant in an incorrectly placed tunnel.[40] Second, preserving the gracilis reduces pain at the hamstring tendon harvesting site.[16]

Intra-articular healing of the graft following ACLR involves an initial phase of cellular necrosis (<3 months) followed by graft revascularization and graft remodeling.[41,42] In an RCT, Lin *et al*.[19] demonstrated significantly lower graft maturity with AIACLR at 6 month postsurgery than after conventional ACLR. However, values were comparable at 1-year follow-up. Likewise, Mayr *et al*.[18] observed a higher degree of overall graft elongation during cyclical loading in the AI technique, which then translates into greater knee laxity with more than 3 mm side-to-side difference (or ACLR failure). These observations have been attributed to the use of adjustable loop SF devices which not only can cause increased tunnel widening due to the “bungee” and “windshield wiper” effects but also can lead to slippage of the tendon strands at the securing sutures.[18,19] These effects are most profound at the mid-region of the graft which is subjected to primary distraction forces.[19] However, studies by Monaco *et al*.[14] and Kouloumentas *et al*.[21] revealed comparable knee laxity between AIACLR and FTACLR. Another observation by Desai *et al*.[23] showed a higher graft failure rate (10/54 or 18.5%) with the traditional FT technique as against the AI method (8/82 or 9.8%). The authors found failure rates as described in the literature (4.9%–12.7%) and concluded that neither of the two techniques had any clear-cut superiority with regard to the incidence of overall graft failure. Although Connaughton *et al*.[7] did report a higher rate of failure after AIACLR, the studies in their review had used allografts for reconstruction. The latter are biomechanically weaker than autografts and more prone to failure, especially in a young and active population group.[43] Our study revealed a slightly higher rate of reconstruction failure with FTACLR, even though the difference was not significant.

We carried out this meta-analysis despite a similar study 4 years ago.[6] This was because there were significant differences in certain aspects of the study methodology between our review and that of Fu *et al*.[6] First, a number of new studies had been added to the literature only recently and hence were evaluated by us.[17,19,20,22] Second, we had not included any article which served to compare the type of arthroscopic fixation device only. While this precluded us from using a number of the studies which found their way into Fu *et al*.’s[6] review,[37,44] it allowed us to objectively compare the two techniques by minimizing any confounding caused due to implant design. For instance, Lubowitz *et al*.[15] had employed IFS for both AIACLR and FTACLR. Likewise, most surgeons use a combination of SF devices (for the femur) and IFS (tibia) during conventional ACLR. Finally, two studies – Volpi *et al*.[45] and Baldassarri *et al*.[46] – were not included in our analysis. The former had used a transtibial technique for drilling the femoral tunnel which, in our opinion, does not represent a truly anatomical technique of FTACLR.[45] Baldassarri *et al*.,[46] on the other hand, had used a distinct graft harvesting technique (with maintained tibial attachment) which we believed could probably skew the results in favor of conventional ACLR. Hence, this study was excluded too.

Overall, despite the steep learning curve and relatively longer operative time, the AI technique was found to be a less invasive surgical option with equivalence in functional outcomes and complication rates. It has the added advantage of reduced knee pain postoperatively, slightly lower failure rates and provision of a higher graft versatility to the operating surgeon. This method can also be used in skeletally immature patients due to the short length of tunnels required.[15,20] We believe the AI technique has the potential to change the scope of clinical practice with more and more surgeons opting for the same in light of the above benefits.

Our study had a few limitations. Variations in study design, patient characteristics, sample size, graft choice and fixation systems used, reporting of outcome, and postoperative rehabilitation protocol resulted in a high degree of heterogeneity when the studies were analyzed. To mitigate this, all data entries were thoroughly checked and a random effects model was used during meta-analysis. However, since all studies were trying to measure a common endpoint, it was decided by mutual consent of all authors to include them in our review. Second, some parameters such as landmarks for tunnel position have not been elaborated in detail in a few studies. As a result, measurements of tunnel dimensions could not be standardized. Furthermore, as in most cases, duration of follow-up was 2 years, long-term complication rates such as implant failure or graft loosening could not be assessed. Finally, AIACLR is a relatively new technique, and not all surgeons are well versed with it. This could raise concerns of latent performance bias.

Despite these drawbacks, necessary steps were taken to ensure the methodological robustness of this review. We utilized the PICO format to frame our study objectives and systematically searched two databases for relevant literature. To minimize bias, two independent reviewers screened the search results and also performed ROB quality assessment. To the best of our knowledge, this is the largest review so far which compares the AI and traditional FT techniques of ACLR.

Conclusion

The AI technique of ACLR has the potential to serve as a reliable alternate to the conventional anteromedial portal technique. It is associated with equivalent clinical outcomes with reduced incidences of postoperative pain and reconstruction failure. However, more comparative trials with long-term follow-ups are needed to truly validate its usefulness over the FT technique.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Di Benedetto P, Di Benedetto E, Fiocchi A, Beltrame A, Causero A. Causes of failure of anterior cruciate ligament reconstruction and revision surgical strategies. Knee Surg Relat Res 2016;28:319-24.
2. John R, Dhillon MS, Syam K, Prabhakar S, Behera P, Singh H. Epidemiological profile of sports-related knee injuries in Northern India: An observational study at a tertiary care centre. J Clin Orthop Trauma 2016;7:207-11.
3. Morgan CD. The all-inside ACL reconstruction. In: Morgan CD, editor. Operative Technique Manual. Naples, FL: Arthrex; 1995.
4. Cerulli G, Zamarra G, Vercillo F, Pelosi F. ACL reconstruction with "the original all-inside technique." Knee Surg Sports Traumatol Arthrosc 2011;19:829-31.
5. de Sa D, Shanmugaraj A, Weidman M, Peterson DC, Simunovic N, Musahl V, *et al.* All-inside anterior cruciate ligament reconstruction – A systematic review of techniques, outcomes, and complications. J Knee Surg 2018;31:895-904.
6. Fu CW, Chen WC, Lu YC. Is all-inside with suspensory cortical button fixation a superior technique for anterior cruciate ligament reconstruction surgery? A systematic review and meta-analysis. BMC Musculoskelet Disord 2020;21:445.
7. Connaughton AJ, Geeslin AG, Uggen CW. All-inside ACL reconstruction: How does it compare to standard ACL reconstruction techniques? J Orthop 2017;14:241-6.
8. Shamseer L, Moher D, Clarke M, Ghersi D, Liberati A, Petticrew M, *et al.* Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: Elaboration and explanation. BMJ 2015;350:g7647.
9. Higgins JP, Altman DG, Gøtzsche PC, Jüni P, Moher D, Oxman AD, *et al.* The Cochrane collaboration's tool for assessing risk of bias in randomised trials. BMJ 2011;343:d5928.
10. Slim K, Nini E, Forestier D, Kwiatkowski F, Panis Y, Chipponi J. Methodological index for non-randomized studies (minors): Development and validation of a new instrument. ANZ J Surg 2003;73:712-6.
11. Collins NJ, Misra D, Felson DT, Crossley KM, Roos EM. Measures of knee function: International Knee Documentation Committee (IKDC) subjective knee evaluation form, Knee Injury and Osteoarthritis Outcome Score (KOOS), Knee Injury and Osteoarthritis Outcome Score Physical Function Short Form (KOOS-PS), Knee Outcome Survey Activities of Daily Living Scale (KOS-ADL), lysholm knee scoring scale, Oxford Knee Score (OKS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), Activity Rating Scale (ARS), and Tegner Activity Score (TAS). Arthritis Care Res (Hoboken) 2011;63 Suppl 11:S208-28.
12. The Nordic Cochrane Centre. Review Manager (RevMan). Copenhagen: The Cochrane Collaboration; 2014.
13. Monaco E, Redler A, Fabbri M, Proietti L, Gaj E, Daggett M, *et al.* Isokinetic flexion strength recovery after ACL reconstruction: A comparison between all inside graft-link technique and full tibial tunnel technique. Phys Sportsmed 2019;47:132-5.
14. Monaco E, Fabbri M, Redler A, Gaj E, De Carli A, Argento G, *et al.* Anterior cruciate ligament reconstruction is associated with greater tibial tunnel widening when using a bioabsorbable screw compared to an all-inside technique with suspensory fixation. Knee Surg Sports Traumatol Arthrosc 2019;27:2577-84.
15. Lubowitz JH, Schwartzberg R, Smith P. Randomized controlled trial comparing all-inside anterior cruciate ligament reconstruction technique with anterior cruciate ligament reconstruction with a full tibial tunnel. Arthroscopy 2013;29:1195-200.
16. Benea H, D'Astorg H, Klouche S, Bauer T, Tomoaia G, Hardy P. Pain evaluation after all-inside anterior cruciate ligament reconstruction and short term functional results of a prospective randomized study. Knee 2014;21:102-6.
17. Kulshrestha V, Sood M, Kumar S, Kawale A. Original study: Early patient-reported functional outcome of all-inside ACL reconstruction as compared to anteromedial portal technique. Eur J Orthop Surg Traumatol 2021;31:1477-83.
18. Mayr R, Smekal V, Koidl C, Coppola C, Eichinger M, Rudisch A, *et al.* ACL reconstruction with adjustable-length loop cortical button fixation results in less tibial tunnel widening compared with interference screw fixation. Knee Surg Sports Traumatol Arthrosc 2020;28:1036-44.
19. Lin R, Zhong Q, Wu X, Cui L, Huang R, Deng Q, *et al.* Randomized controlled trial of all-inside and standard single-bundle anterior cruciate ligament reconstruction with functional, MRI-based graft maturity and patient-reported outcome measures. BMC Musculoskelet Disord 2022;23:289.
20. Kyriakopoulos G, Manthas S, Vlachou M, Oikonomou L, Papadakis SA, Kateros K. Anterior cruciate ligament reconstruction with the all-inside technique: Equivalent outcomes and failure rate at three-year follow-up compared to a doubled semitendinosus-gracilis graft. Cureus 2021;13:e20508.
21. Kouloumentas P, Kavroudakis E, Charalampidis E, Kavroudakis D, Triantafyllopoulos GK. Superior knee flexor strength at 2 years with all-inside short-graft anterior cruciate ligament reconstruction versus a conventional hamstring technique. Knee Surg Sports Traumatol Arthrosc 2019;27:3592-8.
22. Goyal T, Das L, Paul S, Choudhury AK, Sethy SS. Outcomes of retro-drilled all-inside tibial tunnel versus complete tibial tunnel techniques in anterior cruciate ligament reconstruction-a comparative study. Eur J Orthop Surg Traumatol 2022;32:523-32.
23. Desai VS, Anderson GR, Wu IT, Levy BA, Dahm DL, Camp CL, *et al.* Anterior cruciate ligament reconstruction with hamstring autograft: A matched cohort comparison of the all-inside and complete tibial tunnel techniques. Orthop J Sports Med 2019;7:2325967118820297.
24. Shantanu K, Kushwaha SS, Kumar D, Kumar V, Singh S, Sharma V. A comparative study of the results of the anatomic medial portal and all-inside arthroscopic ACL reconstruction. J Clin Diagn Res 2016;10:C01-3.
25. Robson AW. VI. Ruptured crucial ligaments and their repair by operation. Ann Surg 1903;37:716-8.
26. Potalivo G, Placella G, Sebastiani E. History of the "all-inside" technique and its clinical application. J Orthop 2011;3:81-6.
27. Kurosaka M, Yoshiya S, Andrish JT. A biomechanical comparison of different surgical techniques of graft fixation in anterior cruciate ligament reconstruction. Am J Sports Med 1987;15:225-9.
28. Cerulli G. ACL Reconstruction Only Inside Technique in Proceedings 1st Icelandic Conference on Arthroscopy and Sports Medicine Reykjavik, Iceland; 2001.
29. Sajovic M, Stropnik D, Skaza K. Long-term comparison of semitendinosus and gracilis tendon versus patellar tendon autografts for anterior cruciate ligament reconstruction: A 17-year follow-up of a randomized controlled trial. Am J Sports Med 2018;46:1800-8.
30. Mariscalco MW, Flanigan DC, Mitchell J, Pedroza AD, Jones MH, Andrish JT, *et al.* The influence of hamstring autograft size on patient-reported outcomes and risk of revision after anterior cruciate ligament reconstruction: A multicenter orthopaedic outcomes network (MOON) cohort study. Arthroscopy 2013;29:1948-53.
31. Conte EJ, Hyatt AE, Gatt CJ Jr., Dhawan A. Hamstring autograft size can be predicted and is a potential risk factor for anterior cruciate ligament reconstruction failure. Arthroscopy 2014;30:882-90.
32. Spragg L, Chen J, Mirzayan R, Love R, Maletis G. The effect of autologous hamstring graft diameter on the likelihood for revision of anterior cruciate ligament reconstruction. Am J Sports Med

2016;44:1475-81.
33. Wernecke GC, Constantinidis A, Harris IA, Seeto BG, Chen DB, MacDessi SJ. The diameter of single bundle, hamstring autograft does not significantly influence revision rate or clinical outcomes after anterior cruciate ligament reconstruction. Knee 2017;24:1033-8.
34. Kern M, Love D, Cotter EJ, Postma W. Quadruple-bundle semitendinosus-gracilis graft technique for all-inside anterior cruciate ligament reconstruction. Arthrosc Tech 2016;5:e1317-20.
35. Rodeo SA, Arnoczky SP, Torzilli PA, Hidaka C, Warren RF. Tendon-healing in a bone tunnel. A biomechanical and histological study in the dog. J Bone Joint Surg Am 1993;75:1795-803.
36. Böstman O, Hirvensalo E, Mäkinen J, Rokkanen P. Foreign-body reactions to fracture fixation implants of biodegradable synthetic polymers. J Bone Joint Surg Br 1990;72:592-6.
37. Lubowitz JH, Schwartzberg R, Smith P. Cortical suspensory button versus aperture interference screw fixation for knee anterior cruciate ligament soft-tissue allograft: A prospective, randomized controlled trial. Arthroscopy 2015;31:1733-9.
38. Smith PA, Stannard JP, Pfeiffer FM, Kuroki K, Bozynski CC, Cook JL. Suspensory versus interference screw fixation for arthroscopic anterior cruciate ligament reconstruction in a translational large-animal model. Arthroscopy 2016;32:1086-97.
39. Scuderi GR, Bourne RB, Noble PC, Benjamin JB, Lonner JH, Scott WN. The new knee society knee scoring system. Clin Orthop Relat Res 2012;470:3-19.
40. Howell SM, Clark JA. Tibial tunnel placement in anterior cruciate ligament reconstructions and graft impingement. Clin Orthop Relat Res 1992. p. 187-95.
41. Li Q, Zhang Y, Zhan L, Han Q, Wu M, Zhang N. Correlation analysis of magnetic resonance imaging-based graft maturity and outcomes after anterior cruciate ligament reconstruction using international knee documentation committee score. Am J Phys Med Rehabil 2019;98:387-91.
42. Janssen RP, Scheffler SU. Intra-articular remodelling of hamstring tendon grafts after anterior cruciate ligament reconstruction. Knee Surg Sports Traumatol Arthrosc 2014;22:2102-8.
43. Pallis M, Svoboda SJ, Cameron KL, Owens BD. Survival comparison of allograft and autograft anterior cruciate ligament reconstruction at the United States military academy. Am J Sports Med 2012;40:1242-6.
44. Colombet P, Graveleau N, Jambou S. Incorporation of hamstring grafts within the tibial tunnel after anterior cruciate ligament reconstruction: Magnetic resonance imaging of suspensory fixation versus interference screws. Am J Sports Med 2016;44:2838-45.
45. Volpi P, Bait C, Cervellin M, Denti M, Prospero E, Morenghi E, *et al.* No difference at two years between all inside transtibial technique and traditional transtibial technique in anterior cruciate ligament reconstruction. Muscles Ligaments Tendons J 2014;4:95-9.
46. Baldassarri M, Perazzo L, Ghinelli D, Ricciarelli M, Pilla F, Buda R. Return to sport after ACL surgery: A comparison between two different reconstructive techniques. J Knee Surg 2019;32:513-8.J

Orthopedic Applications of Single-photon Emission Computed Tomography/Computed Tomography in Identifying Pain Generators in the Pre- and Post-operative Patient

George O. Theobald, Robert Foley, Sean Scattergood, Stewart Redman, Richard Graham, David Little, Randeep Kulshrestha[1]

Department of Radiology, Royal United Hospitals Bath NHS Foundation Trust, Bath, [1]Department of Radiology, University Hospitals Bristol and Weston NHS Foundation Trust, Bristol, UK

Abstract

Postoperative and benign bone pathologies can sometimes be difficult to elicit on purely anatomical-based imaging. Single-photon emission computed tomography-computed tomography (SPECT-CT) is an established modality with emerging applications in the musculoskeletal field that combines cross-sectional structural imaging with the metabolic data. It is thought to offer certain clinical advantages to conventional imaging modalities as it can be sensitive to conditions before they appear as a structural abnormality. The aim of this pictorial review is to demonstrate the musculoskeletal applications of SPECT/CT in the pre- and post-operative orthopedic patient. The evidence for the musculoskeletal application of SPECT/CT is reviewed in various pre- and post-operative patients focusing on the advantages and disadvantages of this imaging modality alongside conventional imaging. Alongside this we present a series of musculoskeletal SPECT/CT cases in postoperative spinal and extremity joints identifying such pathologies as loosening, pseudoarthroses and prosthetic joint infection. We also include cases on the nonoperative joint identifying pain generators for targeted therapy. This review has shown that SPECT/CT can be a useful adjunct alongside other conventional imaging modalities in identifying musculoskeletal pain generators in the postoperative patient. It is especially useful in situations where anatomical imaging modalities alone provide insufficient diagnostic information or lack of symptomatic improvement. SPECT/CT is therefore likely to remain an complimentary investigative tool for unidentified musculoskeletal pain or for postoperative patients with metalwork *in situ*.

Keywords: Musculoskeletal, orthopedic (s), pain generators, single-photon emission computed tomography/computed tomography

Introduction

Recent advances in magnetic resonance imaging (MRI), computed tomography (CT), and ultrasound have led to considerable improvements in musculoskeletal imaging but are subject to limitations such as metal susceptibility artefact or the inability to accurately examine deeper structures. Functional imaging such as planar scintigraphy is useful as it may identify pathology before it becomes evident on conventional scans but can lack specificity or anatomical precision. Single-photon emission CT combined with CT (SPECT/CT) is now recognized as being able to offer the best of both worlds by combining anatomical with functional information.[1] SPECT/CT has been commercially available since 1999 and is now widely used in the UK, with the latest technology offering shorter acquisition times and higher resolution imaging. Excellent guidelines on the practice of SPECT/CT in bone scintigraphy have been published by the British Nuclear Medicine Society[2] and European Association of Nuclear Medicine.[3]

It traditionally combines a dual-detector gamma camera integrated with an X-ray tube mounted on the same gantry,[4] with more modern systems capable of low dose and multi-slice CT.[5] The data sets from the SPECT and CT can then be fused to aid interpretation. The integrated use of CT imaging allows

Access this article online	
Quick Response Code:	**Website:** https://journals.lww.com/jajs
	DOI: 10.4103/jajs.jajs_88_23

Address for correspondence: Dr. George O. Theobald, Royal United Hospitals Bath NHS Foundation Trust, Combe Park, Bath, Avon BA1 3NG, UK.
E-mail: george.theobald@uhbw.nhs.uk

Submitted: 18-Nov-2023 **Revised:** 29-Nov-2023
Accepted: 04-Dec-2023 **Published:** 11-Oct-2024

How to cite this article: Theobald GO, Foley R, Scattergood S, Redman S, Graham R, Little D, *et al*. Orthopedic applications of single-photon emission computed tomography/computed tomography in identifying pain generators in the pre- and post-operative patient. J Arthrosc Jt Surg 2024;11:183-91.

for precise co-registered anatomical localization as well as providing an attenuation correction map for the subsequent SPECT acquisition. However, one drawback of SPECT/CT is the ionizing radiation dose involved compared to MRI or ultrasound. The effective dose for CT can range from 0.01 to 7.4 mSv whilst for SPECT it ranges from 1.1 to 12.2 mSv, combining these two together is a significant effective radiation dose.[6]

We aim to outline the indications for SPECT/CT in patients with musculoskeletal symptoms and illustrate the variety of diagnoses that can be made using this technique. Our images have been acquired using either a traditional 2-headed gamma camera (GE Discovery 670) or a more novel 12-headed gamma camera (Veriton 360° CZT digital SPECT/CT), which can both be utilized to provide SPECT images, CT images, and fused images [Figure 1].

Orthopedic Applications of Single-photon Emission Computed Tomography/Computed Tomography

Sites of altered bone turnover indicate areas of abnormal osteoblastic activity which may be pathological. Using pyrophosphate analogues such as bisphosphonate radiopharmaceutical tracers for example hydroxymethylene diphosphonate (HDP) or methylene diphosphonate (MDP), one can identify these before conventional anatomical imaging.[7] Bone scintigraphy using 99mTc bisphosphonate agents has the benefit of being able to evaluate the integrity of the entire human skeleton in a single study. The use of SPECT/CT then provides further 3-dimensional reformatting, anatomical localization, and lesion morphology.[7]

Scintigraphy is well established in metastatic bone disease.[8] We, however, will focus on the nononcological orthopedic applications, with an increasing evidence base for use in the postoperative and nonoperative setting to identify pain generators.

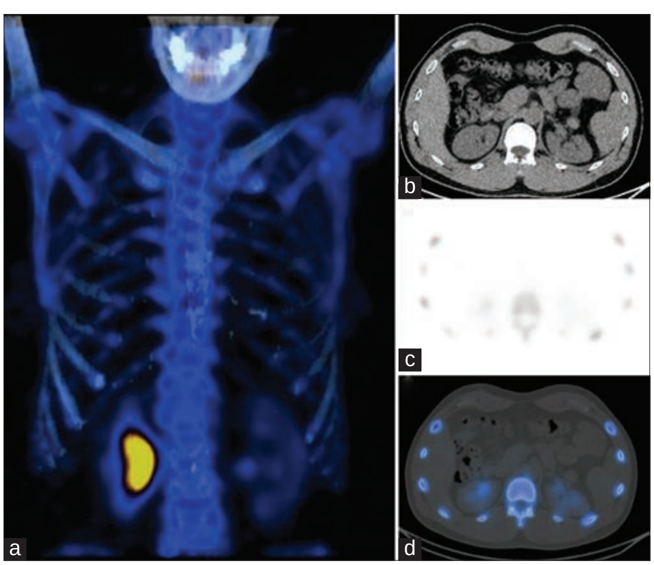


Figure 1: Normal example of (a): fused 3D SPECT-CT image with component (b): axial CT, (c): axial SPECT and (d): fused axial SPECT/CT

Joint Prosthesis Imaging

Loosening

Lower limb arthroplasty is a common and successful procedure in western countries. However, chronic postoperative pain can affect up to 44% of patients with total hip replacements and 27% of patients with total knee replacements (TKRs).[9] One potential cause of pain is aseptic loosening of the prosthesis. Aseptic loosening is described as a failure of the prosthesis to integrate into the bone with apparent migration and no associated infection.[10]

The diagnosis of loosening can be made using an array of imaging modalities including plain film, CT, and MRI alongside laboratory tests such as blood C-reactive protein levels and aspiration of the joint to exclude infection. SPECT/CT provides functional information alongside traditional modalities: a focal increase in tracer uptake at a site of radio-lucency is a common manifestation of loosening [Figure 2].[11]

SPECT/CT arthrography has also proven to have excellent diagnostic accuracy for detecting aseptic loosening in patients with persistent pain following primary hip and knee arthroplasty.[9] This is performed through the introduction of 99mTc-sulphur colloid into the joint space in question prior to image acquisition. This has been seconded by Murer *et al*., who found excellent sensitivity (95%) and specificity (100%) for the detection of tibial and femoral compartment prosthetic joint loosening.[12] There is also thought to be less influence from metallic artefact than radiography and MRI.[13]

One drawback of radiotracer-based imaging is that joint arthroplasty can remain metabolically active for many months or years after surgery and can have variable uptake patterns according to the bone or joint involved as well as the prosthetic used.[11] Bone adjacent to new hip prostheses can remain metabolically active for 12 months with an increased incidence in cementless implants. Periprosthetic uptake with knee prostheses can even last several years.[14] Further studies have shown high physiological uptake in the spinal vertebrae can last for 2 months postcervical spine surgery[15] and 3 months postlumbar spine fusion.[16] This can mislead interpretations leading to false positives, and so needs to be taken in with the clinical context.

Prosthetic joint infection

Prosthetic joint infection is a frequent cause of mortality and morbidity with an incidence ranging between 0.5% and 6.5%[17] which can be investigated with SPECT/CT.

Differentiating between infection and other bone pathology is challenging; MRI is commonly used due to its superior ability to characterize lesions and provide excellent anatomy[7] but can be affected by artifact from the metal around the region of interest. Scintigraphy can be useful in identifying osteomyelitis and help distinguish it from other pathologies. Planar bisphosphonate bone scans can

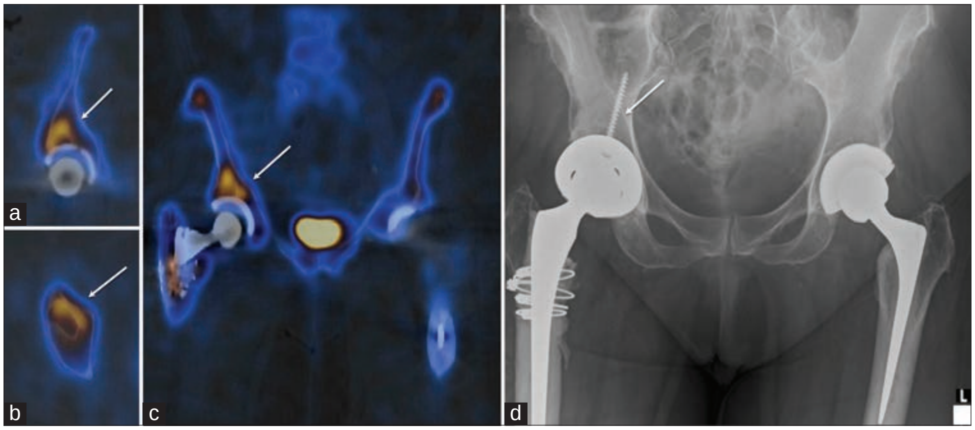


Figure 2: (a): Sagittal fused SPECT/CT, with (b): axial and (c): coronal images showing intense uptake associated with the superior acetabular cup prosthesis and a lucent region of adjacent bone loss, typical for loosening. (d): The patient then underwent revision surgery and acetabular screw placement (arrow)

identify the focal areas of increased bone turnover suggesting hyperemia and inflammation, where the absence of this focal hyperemia can exclude infection. The addition of SPECT/CT to planar imaging when combined with the bone scan can add specific anatomical and morphological attributes [Figure 3].[18]

Infection on a bone scan shows dynamic triple phase uptake using Tc99m labeled with a diphosphonate as the radiotracer, with reported sensitivity and specificity above 90%.[19] Nagoya *et al*.'s case series of 43 patients due for revision hip surgery demonstrated a high sensitivity and specificity in the diagnosis of periprosthetic infection of 88% and 90%, respectively.[20] Infection on imaging was confirmed with intra-operative samples.

A large meta-analysis of patients with TKR demonstrated bone scintigraphy to be highly sensitive but lacking in specificity, although some included studies did not use triple phase uptake as their diagnostic criteria; perhaps partially accounting for their observed low specificity.[21] It is important to note that Tc99m-MDP bone scintigraphy can be suggestive of infection in both postoperative and nonoperative settings, but it cannot be diagnostic.[22]

Aside from conventional bisphosphonate bone scans, utility has been found in using white blood cell (WBC) labeled scans using either 99mTc HMPAO or 111In oxine. In combination with SPECT/CT, this technique has great value in distinguishing osteomyelitis from soft-tissue infection which is valuable in patients who have not had surgery.[23]

Spinal Imaging

Nonoperative lumbar spine

Chronic lower back pain is common, can severely affect quality of life, and accounts for a significant amount of socio-economic costs to society.[7] Cause is multi-factorial but degenerative changes at the disc or facet joints are regularly implicated. Spinal imaging for chronic back pain is complex, as many abnormalities seen on traditional imaging techniques may not contribute to symptoms.[7]

Pain generator localization

Pain generator localization using traditional imaging modalities relies on structural changes but in most cases, anatomy is already distorted through degenerative change which is often identified in asymptomatic individuals and is a nonspecific finding.[24] Whilst CT and MRI can accurately identify structural change, it often fails to accurately localize the source of pain.[7]

Bone scintigraphy with SPECT/CT has been shown to accurately pinpoint pain generators and can effectively identify and localize active facet joint disease, which was not evident on CT or plain radiography[8] [Figure 4]. This was corroborated by Gnanasegaran *et al*. who observed that SPECT/CT has increased sensitivity for facet joint pain generators compared to CT alone (80% vs. 20%).[25]

Osteoporotic vertebral collapse can cause chronic pain, in part due to facet joint arthropathy through altered spinal alignment putting abnormal strain across the joint. This may be accurately detected using SPECT/CT and further guide specific treatment.[8,26]

SPECT/CT is sensitive but poorly specific; however, since SPECT/CT can precisely locate metabolically active disease such as facet joint arthropathy it therefore may provide utility in diagnosis, while also guiding appropriate treatment strategies in patients with diagnostic uncertainty.

Postoperative spine

Spinal surgery is indicated for a range of conditions including vertebral instability, degenerative disc disease, and disc herniation.[7] Unfortunately, recurrent pain after intervention is well documented, affecting 15%–30% of patients.[27] There are many potential causes of postoperative pain; some examples include metalwork failure, pseudoarthrosis, and infection. Mainly, conventional CT imaging is used and can be useful in evaluating structural issues such as prosthetic alignment,

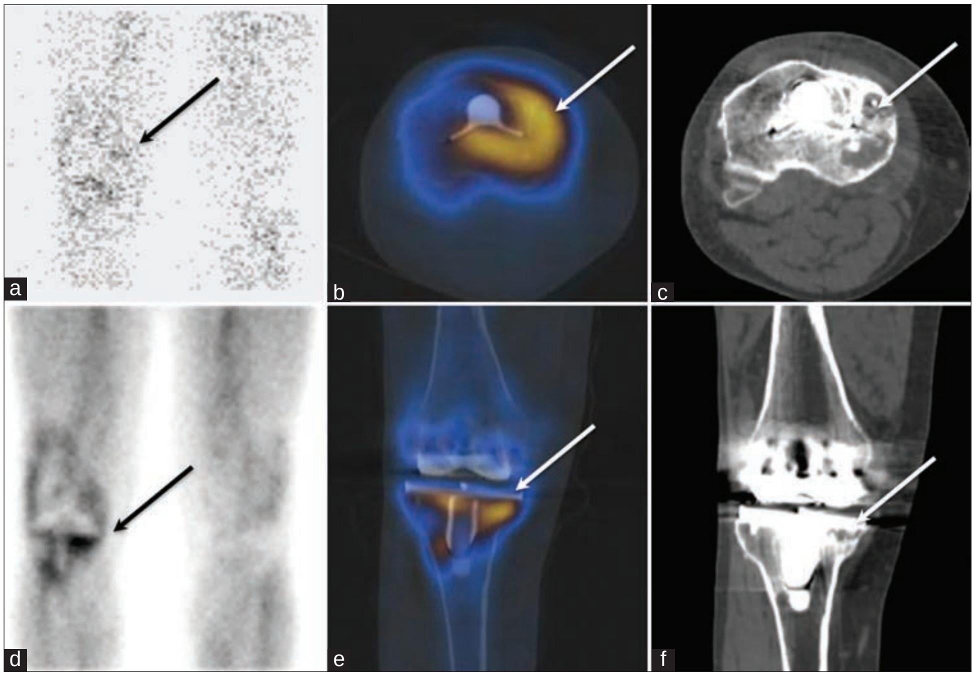


Figure 3: The right knee demonstrates increased uptake on the (a): blood flow imaging with corresponding (b): fused axial SPECT/CT showing increased uptake at the tibial shelf. Complementary (c): axial CT slice shows increased lucency at this site with cortical destruction. Increased uptake also seen on the (d): Blood pool imaging and (e): Fused coronal SPECT/CT with zoomed in (f): coronal CT slice showing increased lucency. The patient underwent revision surgery, which confirmed prosthetic infection.

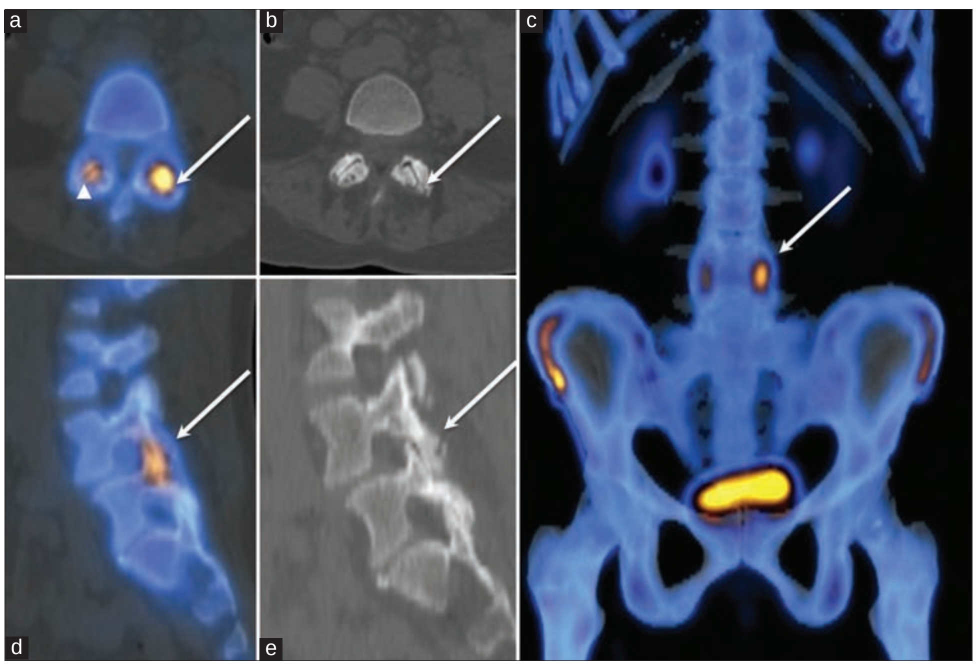


Figure 4: (a): Axial fused SPECT/CT, corresponding (b): axial CT slice through L4/L5 with associated (c): 3D SPECT-CT image. (d): Parasagittal SPECT/C fused slice through the right L4/5 facet joint with corresponding (e): parasagittal CT. This showsintense uptake in left L4/5 facet joint (arrows) and moderate uptake in the right L4/5 facet joint (arrowhead)

established nonunion, metalwork failure, and metalwork loosening but SPECT/CT has distinct advantages.[7]

Pseudoarthrosis

Arthrodesis is defined as the purposeful surgical fusion of two or more joints, typically to reduce severe joint pain. Failure of fusion presents with continued pain and can be defined as no osseous bridging at 1-year post surgery resulting in a pseudarthrosis or fibrous nonunion.[25] Plain radiography and CT are traditionally used in these circumstances with MRI being used where certain metallic implant materials allow.[25]

However, the use of CT is limited when trying to evaluate early pseudarthroses or evolving malunion as it relies on changes in structural architecture, and MRI is limited by metallic artefact used in the prosthetics.[28,29]

Radionuclide bone scans detect the sites of failed fusion due to the increased metabolic activity and osteoblastic turnover. SPECT/CT has already proven to be superior to planar imaging in identification of delayed healing and nonunion after acute fractures [Figure 5].[30] SPECT/CT is also known to increase specificity for detection of nonunion of interbody devices compared with CT alone as sites of increased activity can be further interrogated on the anatomically based CT.[31]

SPECT/CT has shown increased specificity in comparison to CT alone in the detection of nonunion in spinal fixation (93% vs. 68%).[31] This is because persistent increased activity on 99mTc bisphosphonate bone scans a year after surgery can be a sign of evolving pseudoarthrosis.[7] It has also been recommended for investigating other causes of postoperative complications including prosthetic misalignment, loosening, or subsidence.[32]

Loosening

Loosening and misalignment of spinal fusion hardware is surprisingly common and is reported in up to 18%–31% of cases.[25] This can be detected on CT as a rim of lucency; however, there is also occasionally evidence of increased bone turnover at these sites which can be detected on bone scans and SPECT.[33] Hudyana *et al*. found that SPECT/CT was highly sensitive (100%) and specific (90%) for identifying lumbar screw loosening in a study of 59 patients.[33]

Degenerative changes

Postoperatively, there is a risk of adjacent bone segment instability presenting as facet joint arthropathy, and vertebral body endplate degeneration resulting in pain. This is associated with increased metabolic changes and detected on bisphosphonate bone scintigraphy and SPECT with correlation of the structural changes seen on CT. This can identify pain generators differentiating facet joint arthropathy from pedicle screw loosening and hence guide therapy,[25] [Figure 6]. Rager *et al*. showed that SPECT/CT had increased sensitivity for nonunion and facet joint pain compared to CT alone.[31]

Extremities

The foot/ankle and wrist can be difficult to assess on planar imaging or SPECT alone due to the size and complexity of the joints coupled with the poor resolution associated with these imaging modalities. Ultrasound, CT and MRI are therefore commonly used due to their ability to express the required resolution. However, they are not able to assess functional changes in bone turnover or metabolism that may indicate pathology. The use of SPECT/CT thus can be helpful in combining the strengths of functional and cross-sectional morphological imaging.

Nonoperative ankle

There are a number of potential applications suggested for SPECT/CT in the foot and ankle.[8,34,35] These include osteoarthritis (OA), stress fractures, osteochondral defects, tendonitis, tarsal coalition, and plantar fasciitis. OA is a common problem within the foot and ankle, particularly in active patients. Accurate localization and assessment of the pain and area of pathology are vital for planning management.[35] High correlation between sites of pain in OA and increased 99mTc-bisphosphonate uptake is seen due to increased bone turnover.[36] SPECT/CT is now increasingly used to localize and assess osteoarthritic changes, combining anatomical clarity with functional imaging [Figure 7].[34]

As described earlier, SPECT/CT with 99mTc labeled phosphate analog is highly sensitive to bone infections but has a much lower specificity which decreases its diagnostic utility.

Figure 5: (a): axial SPECT/CT fusion slice at L4/L5 and at (b): L5/S1 with (c): 3D Bone SPECT and (d): Sagittal SPECT/CT demonstrating intense uptake associated with the metalwork and across the intervertebral disc space, in keeping with a failed fusion and pseudoarthrosis formation (arrows)

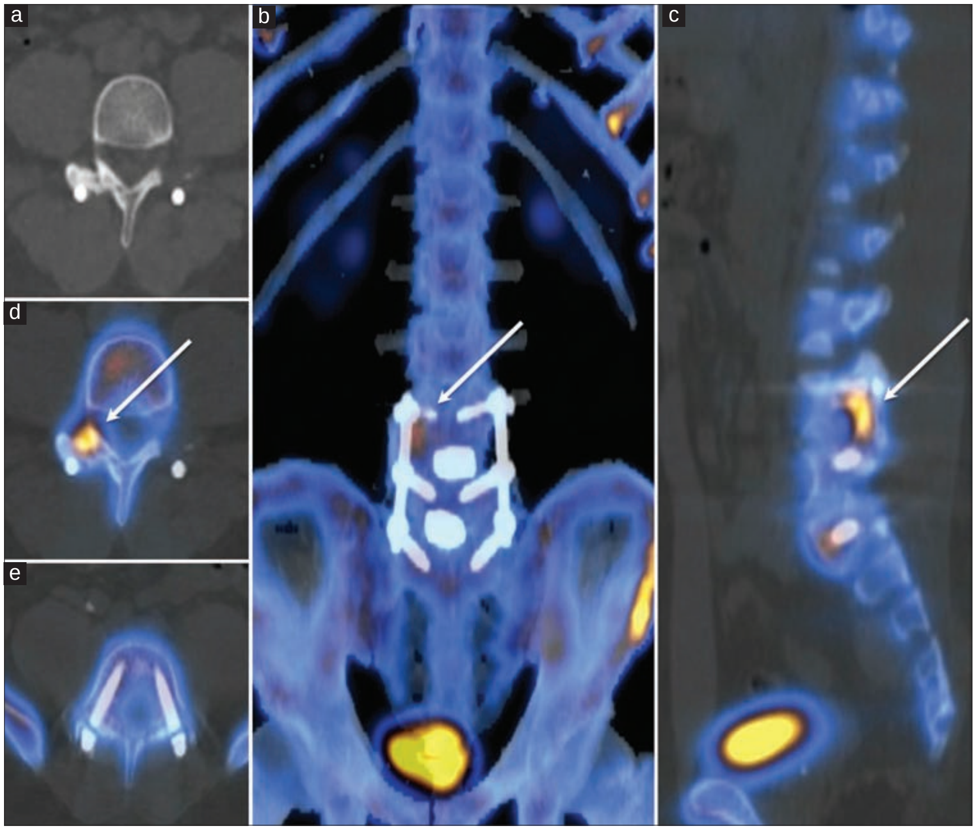


Figure 6: (a): Axial CT at L4/5 with (b): 3D Bone SPECT/CT , (c): parasagittal and (d): selected axial fusion slices at L4/5 and (e): L5/S1. This shows increased uptake associated with the L4/5 right facet joint and no uptake at L5/S1

However, radiolabeled WBCs in SPECT/CT are able to identify the sites of leukocyte accumulation: Combining these two modalities can enhance diagnostic accuracy.[35] Nathan *et al*. found that dual isotope SPECT/CT (99mTc-hydroxymethan disphosphonate, HDP and 111In-WBCs) was an accurate modality that improved detection, localization, and discrimination of soft-tissue inflammation from osteomyelitis in the diabetic foot.[37]

MRI has been shown to be more sensitive than CT and scintigraphy in the detection of stress fractures (88%), but this has not been compared directly with SPECT/CT. 99mTc bone scintigraphy alone allows earlier visualization of stress fractures, prior to radiographic changes.[38] SPECT/CT may be used to identifying these injuries when clinical uncertainty arises.

Furthermore, there is evidence that guidance of foot and ankle injections using SPECT/CT has excellent response rates (90%–96%) when compared to just using CT alone (57%).[34] Overall, SPECT/CT can provide additional information and act as a clinical adjunct to help in patients with diagnostic uncertainty. It has been demonstrated to lead to the changes in management, improvement of therapeutic injection sites, and modification in surgical approach.[7,34,39]

Postoperative ankle

The postoperative ankle can add complexity to interpretation with conventional imaging with increased structural changes and the introduction of metalwork resulting in further problems locating a true pain generator. A correlation between bone pain and degree of tracer uptake (99mTc labelled bisphosphonate analogues) is already well described.[40] It may aid in the diagnosis of nonunion, mal-union, loosening, degenerative change, or infection as the cause of the pain.[39]

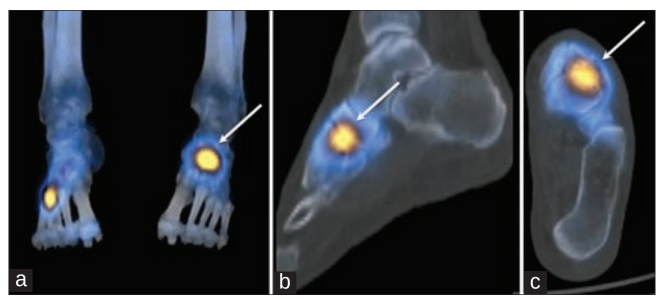


Figure 7: (a): 3D Bone SPECT, (b): fused sagittal and (c): fused axial slices show increased uptake in the naviculocuneiform joints

Due to the increased density and magnetic interference from most orthopedic implants and metalwork, a significant amount of metallic artifact is associated with conventional imaging. Kampen *et al*. have concluded that SPECT/CT is the gold standard if metallic artefact will affect the quality of CT or MRI.[40] In patients with metalwork *in situ* SPECT/CT can also highlight areas of pain separate to the operative site, helping to exclude other causes of pain [Figure 8].

In patients with postarthrodesis pain, with remaining clinical signs and the radionuclide scan detecting increased activity, failed fusion is likely [Figure 9].[41] SPECT/CT shows high specificity in the investigation of nonunion and absent fusion as found by Strobel *et al*.[42] Nathan *et al*. found that in patients with persistent foot pain after ankle arthrodesis, SPECT/CT demonstrated accurate localization and characterization of abnormal uptake in 98% of cases, improved diagnostic confidence in 83% of patients and influence on subsequent patient management in 75% of cases.[37]

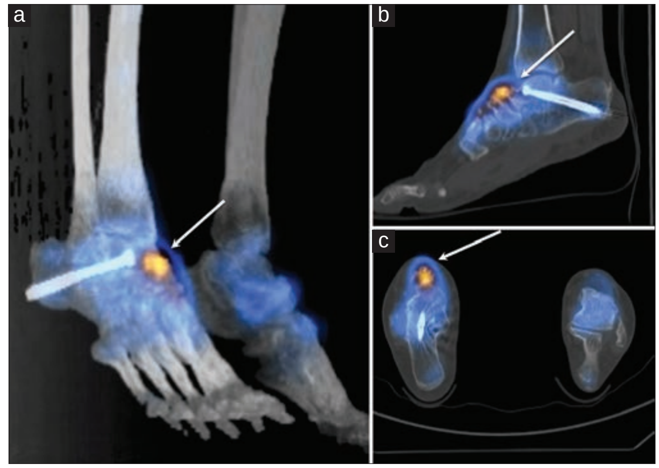


Figure 8: (a): 3D SPECT-CT images, (b): fused sagittal plane and (c): fused axial showing no uptake associated with previous subtalar fusion and intense uptake in the talonavicular joint, identifying an alternative pain source in this patientt

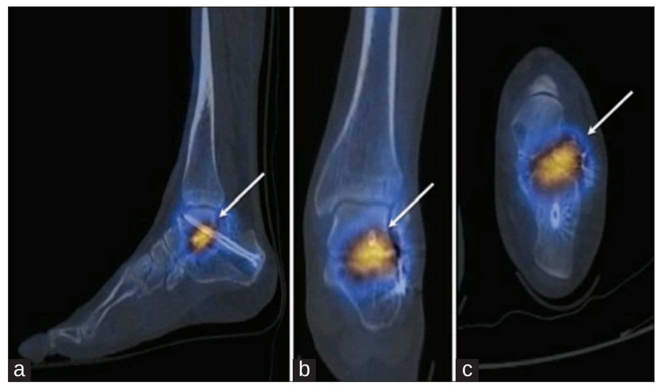


Figure 9: Fused SPECT-CT images in the (a): sagittal, (b): coronal and (c): axial planes showing intense uptake in the subtalar joint and no CT evidence of fusion

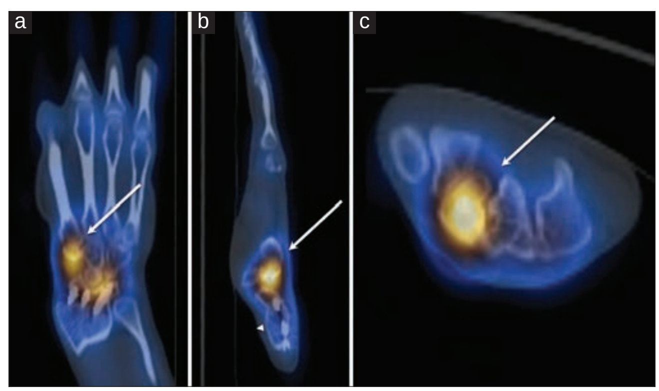


Figure 10: Fused SPECT-CT images in the (a): coronal, (b): sagittal and (c): axial planes showing intense uptake in trapezoid at the scaphotrapeziotrapezoidal (STT) joint (arrows) and mild uptake in the lunocapitate joint. There is no increased uptake associated with the metalwork from previous surgery (arrowheads)

Nonoperative wrist

Data on the use of SPECT/CT in the hand and wrist is limited but has been shown to highlight OA in the wrist, particularly at the trapeziometacarpal joint [Figure 10].[43] SPECT/CTs main strength is detecting disease that other modalities have not shown, as well as localizing the areas of increased bone metabolism associated with disease. Occult fractures, for example, can be readily identified on SPECT/CT with improved diagnosis compared to CT alone.[44] The combination of functional and anatomical imaging in SPECT/CT has shown confident identification of Kienbock's disease and ulnocarpal impaction.[45] Simultaneous acquisition of both hands is also possible which may be beneficial in the investigation of systemic and inflammatory disorders.[45]

Whilst MRI may be the investigation of choice, SPECT/CT allows for more problem-solving in patients with artifact from surgical hardware, diagnostic dilemma, or a negative CT or MRI with persistent clinical suspicion of bone rather than soft tissue pathology.

Postoperative wrist

Wrist surgery ranges from fracture fixation, arthrodesis, and joint replacement in arthritis to resections for malignancy. Postoperative complications such as persistent pain, secondary OA, nonunion, malunion, or infection can cause patients to return to clinic in search of treatment. Strobel *et al*. found that SPECT/CT can be accurately used to assess nonunion, absent fusion, and OA in correlation with CT with a high specificity.[42]

Wrist arthrodesis for OA or rheumatoid arthritis is infrequently performed and can result in formation of a pseudoarthrosis after nonunion, with a documented rate of 29% at the scaphoid-trapezium-trapezoid joint. SPECT/CT has been shown to be useful in assessing this nonunion by detecting increased uptake on the functional imaging combined with the CT element,[46] or indeed may show an alternative pain generator [Figure 10].

Conclusion

SPECT/CT is a valuable asset in the investigative arsenal required in orthopedic imaging. However, an understanding of the advantages and limitations of SPECT/CT as well as the variety of tracers on offer, the best interpretation of the imaging findings and the best direction for further management in each individual patient is paramount to its use.

The evidence for bone scintigraphy and SPECT is currently limited to observational data mainly in the form of case series but is rapidly evolving. Our review has found that SPECT/CT is a useful imaging adjunct in the appropriate clinical setting, especially when there is an inconclusive diagnosis from other imaging techniques.

Evidence for the use of SPECT/CT is still developing with many studies focusing on comparisons with planar scintigraphy or SPECT alone. Further studies directly comparing SPECT/CT with MRI across a range of presentations are warranted to strengthen the evidence base. Evidence to date shows that SPECT/CT leads to improved diagnostic accuracy, can change management strategies, and is a useful tool in cases of diagnostic uncertainty.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. O'Connor MK, Kemp BJ. Single-photon emission computed tomography/computed tomography: Basic instrumentation and innovations. Semin Nucl Med 2006;36:258-66.
2. Fowler C. BNMS Bone Scintigraphy Guideline. Dr J Charlotte Fowler. Available from: https://cdn.ymaws.com/www.bnms.org.uk/resource/resmgr/guidelines/bnms_bone_scintigraphy.cf_14.pdf. [Last accessed on 2022 Jul 18].
3. Van den Wyngaert T, Strobel K, Kampen WU, Kuwert T, van der Bruggen W, Mohan HK, *et al.* The EANM practice guidelines for bone scintigraphy. Eur J Nucl Med Mol Imaging 2016;43:1723-38.
4. Townsend DW, Cherry SR. Combining anatomy and function: The path to true image fusion. Eur Radiol 2001;11:1968-74.
5. Gnanasegaran G, Barwick T, Adamson K, Mohan H, Sharp D, Fogelman I. Multislice SPECT/CT in benign and malignant bone disease: When the ordinary turns into the extraordinary. Semin Nucl Med 2009;39:431-42.
6. Rausch I, Füchsel FG, Kuderer C, Hentschel M, Beyer T. Radiation exposure levels of routine SPECT/CT imaging protocols. Eur J Radiol 2016;85:1627-36.
7. Koppula BR, Morton KA, Al-Dulaimi R, Fine GC, Damme NM, Brown RK. SPECT/CT in the evaluation of suspected skeletal pathology. Tomography 2021;7:581-605.
8. Saha S, Burke C, Desai A, Vijayanathan S, Gnanasegaran G. SPECT-CT: applications in musculoskeletal radiology. Br J Radiol. 2013;86:20120519. [doi: 10.1259/bjr.20120519].
9. Bao B, Liu CS, Masson EC, Abele JT. Diagnostic accuracy of SPECT/CT arthrography in patients with suspected aseptic joint prostheses loosening. Eur J Hybrid Imaging 2021;5:4.
10. Sundfeldt M, Carlsson LV, Johansson CB, Thomsen P, Gretzer C. Aseptic loosening, not only a question of wear: A review of different theories. Acta Orthop 2006;77:177-97.
11. Tam HH, Bhaludin B, Rahman F, Weller A, Ejindu V, Parthipun A. SPECT-CT in total hip arthroplasty. Clin Radiol 2014;69:82-95.
12. Murer AM, Hirschmann MT, Amsler F, Rasch H, Huegli RW. Bone SPECT/CT has excellent sensitivity and specificity for diagnosis of loosening and patellofemoral problems after total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc 2020;28:1029-35.
13. van der Bruggen W, Hirschmann MT, Strobel K, Kampen WU, Kuwert T, Gnanasegaran G, *et al.* SPECT/CT in the postoperative painful knee. Semin Nucl Med 2018;48:439-53.
14. Palestro CJ. Nuclear medicine and the failed joint replacement: Past, present, and future. World J Radiol 2014;6:446-58.
15. Gates GF. SPECT bone scanning of the spine. Semin Nucl Med 1998;28:78-94.
16. Iseda T, Nakano S, Suzuki Y, Miyahara D, Uchinokura S, Moriyama T, *et al.* Radiographic and scintigraphic courses of union in cervical interbody fusion: Hydroxyapatite grafts versus iliac bone autografts. J Nucl Med 2000;41:1642-5.
17. Chan VO, Morrison WB, Kavanagh EC. Postoperative infection in the foot and ankle. Semin Musculoskelet Radiol 2012;16:241-53.
18. Horger M, Eschmann SM, Pfannenberg C, Storek D, Dammann F, Vonthein R, *et al.* The value of SPET/CT in chronic osteomyelitis. Eur J Nucl Med Mol Imaging 2003;30:1665-73.
19. Schauwecker DS. The scintigraphic diagnosis of osteomyelitis. AJR Am J Roentgenol 1992;158:9-18.
20. Nagoya S, Kaya M, Sasaki M, Tateda K, Yamashita T. Diagnosis of peri-prosthetic infection at the hip using triple-phase bone scintigraphy. J Bone Joint Surg Br 2008;90:140-4.
21. Verberne SJ, Sonnega RJ, Temmerman OP, Raijmakers PG. What is the accuracy of nuclear imaging in the assessment of periprosthetic knee infection? A meta-analysis. Clin Orthop Relat Res 2017;475:1395-410.
22. Gold RH, Hawkins RA, Katz RD. Bacterial osteomyelitis: Findings on plain radiography, CT, MR, and scintigraphy. AJR Am J Roentgenol 1991;157:365-70.
23. Bar-Shalom R, Yefremov N, Guralnik L, Keidar Z, Engel A, Nitecki S, *et al.* SPECT/CT using 67Ga and 111In-labeled leukocyte scintigraphy for diagnosis of infection. J Nucl Med 2006;47:587-94.
24. Kato S, Demura S, Matsubara H, Inaki A, Shinmura K, Yokogawa N, *et al.* Utility of bone SPECT/CT to identify the primary cause of pain in elderly patients with degenerative lumbar spine disease. J Orthop Surg Res 2019;14:185.
25. Gnanasegaran G, Paycha F, Strobel K, van der Bruggen W, Kampen WU, Kuwert T, *et al.* Bone SPECT/CT in postoperative spine. Semin Nucl Med 2018;48:410-24.
26. Ryan PJ, Fogelman I. Osteoporotic vertebral fractures: Diagnosis with radiography and bone scintigraphy. Radiology 1994;190:669-72.
27. Herrera Herrera I, Moreno de la Presa R, González Gutiérrez R, Bárcena Ruiz E, García Benassi JM. Evaluation of the postoperative lumbar spine. Radiologia 2013;55:12-23.
28. Larsen JM, Capen DA. Pseudarthrosis of the lumbar spine. J Am Acad Orthop Surg 1997;5:153-62.
29. Rutherford EE, Tarplett LJ, Davies EM, Harley JM, King LJ. Lumbar spine fusion and stabilization: Hardware, techniques, and imaging appearances. Radiographics 2007;27:1737-49.
30. Bhure U, Agten C, Lehnick D, Perez-Lago MDS, Beeres F, Link BC, *et al*. Value of SPECT/CT in the assessment of necrotic bone fragments in patients with delayed bone healing or non-union after traumatic fractures. Br J Radiol. 2020;93(1114):20200300. doi: 10.1259/bjr.20200300.
31. Rager O, Schaller K, Payer M, Tchernin D, Ratib O, Tessitore E. SPECT/CT in differentiation of pseudarthrosis from other causes of back pain in lumbar spinal fusion: Report on 10 consecutive cases. Clin Nucl Med 2012;37:339-43.
32. Smith JS, Shaffrey CI, Ames CP, Demakakos J, Fu KM, Keshavarzi S, *et al.* Assessment of symptomatic rod fracture after posterior instrumented fusion for adult spinal deformity. Neurosurgery 2012;71:862-7.
33. Hudyana H, Maes A, Vandenberghe T, Fidlers L, Sathekge M, Nicolai D, *et al.* Accuracy of bone SPECT/CT for identifying hardware loosening in patients who underwent lumbar fusion with pedicle screws. Eur J Nucl Med Mol Imaging 2016;43:349-54.
34. Upadhyay B, Mo J, Beadsmoore C, Marshall T, Toms A, Buscombe J. Technetium-99m methylene diphosphonate single-photon emission computed tomography/computed tomography of the foot and ankle. World J Nucl Med 2017;16:88-100.
35. Yoo IR. Bone SPECT/CT of the foot and ankle: Potential clinical application for chronic foot pain. Nucl Med Mol Imaging 2020;54:1-8.
36. Holder LE. Radionuclide bone-imaging in the evaluation of bone pain. J Bone Joint Surg Am 1982;64:1391-6.
37. Nathan M, Mohan H, Vijayanathan S, Fogelman I, Gnanasegaran G. The role of 99mTc-diphosphonate bone SPECT/CT in the ankle and foot. Nucl Med Commun 2012;33:799-807.
38. Geslien GE, Thrall JH, Espinosa JL, Older RA. Early detection of stress

fractures using 99mTc-polyphosphate. Radiology 1976;121:683-7.
39. Mohan HK, Gnanasegaran G, Vijayanathan S, Fogelman I. SPECT/CT in imaging foot and ankle pathology-the demise of other coregistration techniques. Semin Nucl Med 2010;40:41-51.
40. Kampen WU, Westphal F, Van den Wyngaert T, Strobel K, Kuwert T, Van der Bruggen W, *et al.* SPECT/CT in postoperative foot and ankle pain. Semin Nucl Med 2018;48:454-68.
41. Sumer J, Schmidt D, Ritt P, Lell M, Forst R, Kuwert T, *et al.* SPECT/CT in patients with lower back pain after lumbar fusion surgery. Nucl Med Commun 2013;34:964-70.
42. Strobel K, van der Bruggen W, Hug U, Gnanasegaran G, Kampen WU, Kuwert T, *et al.* SPECT/CT in postoperative hand and wrist pain. Semin Nucl Med 2018;48:396-409.
43. Corre AL, Huynh KP, Dhaliwal RS, Bain GI. Development of a protocol for SPECT/CT in the assessment of wrist disorders. J Wrist Surg 2016;5:297-305.
44. Allainmat L, Aubault M, Noël V, Baulieu F, Laulan J, Eder V. Use of hybrid SPECT/CT for diagnosis of radiographic occult fractures of the wrist. Clin Nucl Med 2013;38:e246-51.
45. Huellner MW, Strobel K. Clinical applications of SPECT/CT in imaging the extremities. Eur J Nucl Med Mol Imaging 2014;41 Suppl 1:S50-8.
46. Minami A, Kato H, Suenaga N, Iwasaki N. Scaphotrapeziotrapezoid fusion: Long-term follow-up study. J Orthop Sci 2003;8:319-22.

Original Article

Mid-term Clinical Outcomes after Reversed Shoulder Arthroplasty are Comparable between Older Patients with Rheumatoid Arthritis and those with Osteoarthritis

Takeshi Mochizuki, Koichiro Yano[1], Katsunori Ikari[1], Ken Okazaki[1]

Department of Orthopaedic Surgery, Kamagaya General Hospital, Chiba, [1]Department of Orthopaedic Surgery, Tokyo Women's Medical University, Tokyo, Japan

Abstract

Background: To investigate the clinical outcomes of reverse shoulder arthroplasty (RSA) in patients with rheumatoid arthritis (RA), using patient-reported outcome (PRO) measures, and compare the finding to those in patients with osteoarthritis (OA). **Materials and Methods:** The study included 24 patients (11 with RA and 13 with OA) who underwent primary RSA with a minimum of 2 years of follow-up. Clinical data, including range of motion (ROM; flexion, abduction, external rotation, and internal rotation) and PRO measures (Shoulder36 questionnaire and disability/symptom scale in Quick Disability of the Arm, Shoulder, and Hand [QuickDASH-DS]), were assessed. **Results:** ROM, Shoulder36 scores (except sports ability scores), and QuickDASH-DS in the RA group, and ROM (expect internal rotation), Shoulder36 scores (except general health scores), and QuickDASH-DS scores in the OA group were significantly improved at follow-up than the preoperative state. At follow-up, there was no significant difference found in any of the variables between the RA and OA groups (flexion: 116.4° vs. 133.1°, $P = 0.102$; abduction: 100.5° vs. 120.8°, $P = 0.159$; pain score in Shoulder36: 1.8 vs. 2.1, $P = 0.397$; ROM score in Shoulder36: 2.1 vs. 2.1, $P = 0.578$; muscle strength in Shoulder36: 1.8 vs. 1.9, $P = 0.680$; QuickDASH-DS score: 48.1 vs. 32.7, $P = 0.059$). **Conclusion:** The mid-term clinical results after RSA were comparable between patients with RA and those with OA. RSA can be considered the surgical treatment of shoulder in both patients with RA and those with OA.

Keywords: Mid-term, osteoarthritis, patient-reported outcome, reversed shoulder arthroplasty, rheumatoid arthritis

Introduction

Rheumatoid arthritis (RA) is a systemic inflammatory autoimmune disease that causes joint damage. The shoulder joint mainly contributes to patient's assessment of pain, patient's global assessment of disease activity, and the Health Assessment Questionnaire Disability Index.[1,2] Damage of the shoulder joint, assessed with the medialization distance, medial displacement index, and upward migration index, progresses gradually in the long term.[3] One of the factors of joint damage is thought to be a rotator cuff tear. A massive rotator cuff tear has been shown to be associated with severe damage of the shoulder joint (grade 4 or 5 according to Larsen's grading system).[4,5]

Patients' satisfaction of total shoulder arthroplasty (TSA) was found to be lower than that of total joint arthroplasty of the hip, knee, ankle, and elbow.[6] Reverse shoulder arthroplasty (RSA) has been reported to provide superior results compared with TSA.[7,8] Most data were derived from patients with cuff tear arthropathy and osteoarthritis (OA), and the outcomes in patients with RA remain to be clarified. Recently, the treat-to-target strategy has been used to control disease activity of RA.[9] This led us to speculate that results of RSA in patients with RA were not inferior to those in patients with OA.

This study aimed to examine the clinical outcomes of RSA in patients with RA, using patient-reported outcome (PRO)

Access this article online	
Quick Response Code:	**Website:** https://journals.lww.com/jajs
	DOI: 10.4103/jajs.jajs_99_23

Address for correspondence: Dr. Takeshi Mochizuki, Department of Orthopaedic Surgery, Kamagaya General Hospital, 929-6 Hatsutomi, Kamagaya, Chiba 273-0121, Japan. E-mail: twmutamo@gmail.com

Submitted: 30-Dec-2023 **Revised:** 31-Jul-2024
Accepted: 13-Aug-2024 **Published:** 11-Oct-2024

How to cite this article: Mochizuki T, Yano K, Ikari K, Okazaki K. Mid-term clinical outcomes after reversed shoulder arthroplasty are comparable between older patients with rheumatoid arthritis and those with osteoarthritis. J Arthrosc Jt Surg 2024;11:192-7.

measures, and compare the findings to those in patients with OA.

Materials and Methods

Study design

This retrospective study enrolled 24 older patients (11 with RA and 13 with OA) who underwent primary RSA with a minimum of 2 years of follow-up. The implant used for the procedure was AEQULIS REVERSED FX (Stryker, Kalamazoo, MI, USA). The inclusion criteria were presence of RA or OA and use of RSA owing to continued pain and dysfunction. The exclusion criteria were histories of rotator cuff repair surgery, bone grafting or tendon transfer in RSA and lack of clinical data within 2 years.

Clinical data, including range of motion ([ROM]; flexion, abduction, external rotation, and internal rotation) and PRO measures (assessed using the Shoulder36 questionnaire and the disability/symptom scale in the Quick Disability of the Arm, Shoulder, and Hand questionnaire [QuickDASH-DS]), were assessed preoperatively and at follow-up. The internal rotation in ROM was ranked using the Constant score.[10] Shoulder36 contains 36 questions that are categorized into six domains (pain, ROM, muscle strength, general health, activity of daily living, and sports ability). In Shoulder36, questions are scored from 0 to 4, with higher scores indicating less disability as follows: (0) unable to do; (1) able to do with major difficulty; (2) able to do with some difficulty; (3) able to do with minor difficulty; and (4) able to do without any difficulty.[11] QuickDASH-DS is an 11-item questionnaire and is scored on a scale from 0 to 5, with higher scores corresponding to reduced function and increased severity.[12,13]

Image assessment of shoulder on surgical side was performed using magnetic resonance imaging (MRI) before surgery. The MRI images were observed for the presence of rotator cuff deficiency.

Accordingly, this study was conducted following the principles of the Declaration of Helsinki. Informed consent was obtained from all patients. This research has been approved by the Institutional Review Board of the authors' affiliated institutions.

Statistical analysis

The Wilcoxon signed-rank test was used to compare the preoperative and postoperative ROM and the findings of each domain of Shoulder36 in the RA and OA groups. Moreover, the Wilcoxon signed rank-sum test or Fisher's exact test (as appropriate) was used to compare clinical data between the RA and OA groups. All analyses were performed using R Statistical Package, version 3.3.2 (http://www.r-project.org/; R Foundation for Statistical Computing, Vienna, Austria). A $P < 0.05$ was considered to indicate statistical significance.

Results

The baseline demographic and clinical characteristics of the patents in the RA and OA groups are summarized in Table 1.

Table 1: Comparison of disease characteristics and clinical data at baseline between patients with rheumatoid arthritis and those with osteoarthritis

Mean±SD	RA group (*n*=11)	OA group (*n*=13)	*P*
Age (years)	78.1±5.3	78.2±4.0	0.921
Sex, female (%)	72.7	61.5	0.679
Follow-up period, month)	36.5±9.5	30.4±5.5	0.171
Rate of rotator cuff deficiency (%)	72.7	30.8	0.100
Duration of RA (years)	19.6±14.0		NA
bDMARD use (%)	54.5		NA
MTX use (%)	36.4		NA
Glucocorticoid use (%)	45.5		NA
DAS28-ESR	4.02±0.50		NA
CDAI	9.6±3.1		NA
HAQ-DI	1.6±0.5		NA
Flexion (°)	71.8±33.8	70.4±27.2	0.740
Abduction (°)	64.6±28.4	63.1±27.8	0.989
External rotation (°)	21.8±9.4	26.9±10.7	0.304
Internal rotation	2.4±1.1	2.8±1.2	0.456
Domain of Shoulder36			
Pain	0.9±0.5	1.5±0.6	0.028
ROM	1.1±0.6	1.4±0.6	0.323
Muscle strength	0.9±0.5	1.2±0.7	0.322
General health	1.5±0.8	2.1±0.9	0.143
Activity of daily living	1.1±0.5	1.6±0.7	0.079
Sports ability	0.7±0.6	0.7±0.9	0.747
QuickDASH-DS score	59.5±16.2	51.9±13.0	0.270

SD: Standard deviation, RA: Rheumatoid arthritis, bDMARD: Biological disease-modifying antirheumatic drug, MTX: Methotrexate, DAS: Disease activity score, ESR: Erythrocyte sedimentation rate, CDAI: Clinical disease activity index, HAQ-DI: Health Assessment Questionnaire Disability Index, QuickDASH-DS: Disability/symptom scale in Quick Disability of the Arm, Shoulder, and Hand, NA: Not applicable, ROM: Range of motion

The pain score of Shoulder36 was significantly lower in the RA group than in the OA group. There were no differences in age; sex; follow-up period; rate of rotator cuff deficiency; ROM of flexion, abduction, external rotation, and internal rotation; ROM; muscle strength; general health; activity of daily living; sports ability scores of Shoulder36; and QuickDASH-DS scores between the two groups.

In the RA group, ROM, Shoulder36 scores (except sports ability scores), and QuickDASH-DS scores were significantly better at follow-up than at baseline. In the OA group, ROM (expect internal rotation), Shoulder36 scores (except general health scores), and QuickDASH-DS scores were significantly better at follow-up than at baseline [Table 2].

The results of the comparison of the RA and OA groups are as follows: flexion, 116.4° ± 22.3° and 133.1° ± 19.4° ($P = 0.102$); abduction, 100.5° ±24.9° and 120.8° ± 29.5° ($P = 0.159$); external rotation, 36.4° ± 11.5° and 43.1° ± 12.6° ($P = 0.167$); internal rotation, 4.5 ± 1.2 and 3.8 ± 0.9 ($P = 0.124$); pain scores in Shoulder36, 1.8 ± 0.5 and 2.1 ± 0.7 ($P = 0.397$); ROM scores in Shoulder36, 2.1 ± 0.6 and 2.1 ± 0.7 ($P = 0.578$);

Table 2: Comparison of clinical data at follow-up between patients with rheumatoid arthritis and those with osteoarthritis

Mean±SD	RA group (*n*=11)	OA group (*n*=13)	*P*
Flexion (°)	116.4±22.3**	133.1±19.4**	0.102
Abduction (°)	100.5±24.9**	120.8±29.5**	0.159
External rotation (°)	36.4±11.5**	43.1±12.6**	0.167
Internal rotation	4.5±1.2**	3.8±0.9	0.124
Domain of Shoulder36			
Pain	1.8±0.5**	2.1±0.7**	0.397
ROM	2.1±0.6**	2.1±0.7**	0.578
Muscle strength	1.8±0.9**	1.9±1.0**	0.680
General health	2.4±0.6**	2.3±1.0**	0.988
Activity of daily living	2.0±0.7**	2.2±0.9	0.831
Sports ability	0.9±0.6	1.2±0.8*	0.508
QuickDASH-DS score	48.1±18.2**	32.7±12.5**	0.059

*$P<0.05$, **$P<0.001$ (vs. baseline). SD: Standard deviation, QuickDASH-DS: Disability/symptom scale in Quick Disability of the Arm, Shoulder, and Hand, RA: Rheumatoid arthritis, OA: Osteoarthritis, ROM: Range of motion

muscle strength scores in Shoulder36, 1.8 ± 0.9 and 1.9 ± 1.0 (P = 0.680); general health scores in Shoulder36, 2.4 ± 0.6 and 2.3 ± 1.0 (P = 0.988); activity of daily living scores in Shoulder36, 2.0 ± 0.7 and 2.2 ± 0.9 (P = 0.831); sports ability scores in Shoulder36, 0.9 ± 0.6 and 1.2 ± 0.8 (P = 0.508); and QuickDASH-DS score, 48.1 ± 18.2 and 32.7 ± 12.5 (P = 0.059), respectively. There were no differences in all variables at follow-up between the two groups [Table 2].

One case of intraoperative fracture of the humerus was recorded in the RA group. There was no case of infection or neurological complication in any of the groups.

Discussion

The present study reported the mid-term clinical results of RSA in patients with RA or OA, and reported the results of the comparison of the two patient groups.

In previous systematic reviews, the mean ages of RA and OA patients were 54–72 years and 71–79 years, respectively.[14-17] In the present study, the mean ages of RA and OA patients were 78.1 years and 78.2 years, respectively. The RA patients in this study were older than those in previous studies. Similarly, owing to the effects of RA treatment, an older age at total knee arthroplasty has been reported.[18]

The patients in both groups had significantly better outcomes for many variables postoperatively than preoperatively. In a previous study, among 14 patients with RA (mean age, 74 years) who underwent RSA, flexion, and abduction were significantly better 4 years postoperatively than preoperatively (flexion improved from 77° to 122°; abduction improved from 67° to 111°). However, external rotation significantly decreased postoperatively (from 26° to 7°).[19] In another study, among 15 patients with RA (mean age, 67.3 years) and rotator cuff tear who underwent RSA, flexion, and abduction were significantly better at 24.3 months postoperatively than preoperatively (flexion improved from 68.4°–123°; abduction improved from 65.9°–119.7°).[20] Moreover, in 14 patients with RA (mean age, 60.3 years), flexion and abduction increased from 85.7° ± 17.6° and 77.1° ± 19.4° to 126.4° ± 5.2° and 106.4° ± 11.7°, respectively.[21] Although the patients with RA in this study were elderly (mean age, 78.1 years), flexion and abduction improved from 71.8° ± 33.8° and 64.6° ± 28.4° to 116.4° ± 22.3° and 100.5° ± 24.9°, respectively. We believe that improvements in ROM after RSA have been obtained regardless of age in patients with RA.

Similarly, among 67 patients with OA who underwent RSA, flexion, and external rotation were significantly better at 30 months postoperatively than preoperatively (flexion improved from 99.4°–141.7°; external rotation improved from 25° to 56.9°).[22] Furthermore, among 24 patients with OA who underwent RSA, flexion, abduction, and external rotation were significantly better at 30 months postoperatively than preoperatively (flexion improved from 72° to 153.3°; abduction improved from 60.4°–140.4°; external rotation improved from 5.1°–47.1°).[23]

PRO measures are important for patient assessment of postoperative outcomes. In evaluations using a constant score, the postoperative scores in the RA and OA groups were 52–65[20,24,25] and 65–67,[26,27] respectively. Considering the American Shoulder and Elbow Surgeons score, the postoperative scores in RA and OA groups were 76–82[16,28,29] and 80–83,[30,31] respectively. Similar to the findings in previous studies,[16,19] our results showed improvements in pain, function, and muscle strength in terms of PRO measures using the Shoulder36 and QuickDASH-DS questionnaires among patients with RA and OA. The results of RSA in patients with RA are expected to be similar to those in patients with OA.

In this study, regarding the mid-term results, there were no differences in all variables between the two groups. Commonly, patients with RA have a risk of pathological changes of the rotator cuff.[32,33] Using propensity score matching methods, it was found that the hazard ratio (HR) of rotator cuff disease in patients with RA was 1.56 compared with a control group.[32] The outcomes of rotator cuff repair in patients with RA are controversial.[34,35] On the other hand, RSA has been demonstrated to reduce pain and improve function in patients with rotator cuff insufficiency.[36,37] Among RA patients with a similar degree of rotator cuff conditions according to the Goutallier grade, clinical outcomes, including ROM, pain, and function, were not significantly different between patients who underwent RSA and those who underwent cuff tear arthropathy.[38] We believe that the reason for the absence of a difference between the two study groups according to our results may be that RSA performance does not depend on the condition of the rotator cuff. However, patients with RA face specific challenges, such as the destruction of glenoid bone and porotic bones. In addition, 45% of patients with RA who underwent RSA had glenoid bone defects, limiting the location of baseplate.[39] In the long term, glenoid loosening is one of the major complications of RSA, especially among patients with RA. Glenoid loosening is associated with poor bone stock and quality in patients with RA. The use of bone grafting for glenoid bone loss has been shown to reduce the rate of glenoid loosening.[20,24,40] We believe that the improvement of disease activity in patients with RA will contribute to better surgical results.

A systematic review found that the fracture rates in patients with RA and OA who underwent RSA were 41% and 1.4%, respectively.[16] When dealing with patients with RA, it is important to be vigilant for intraoperative fractures as the RSA rates have increased annually over the past decade.[41,42] Moreover, acromial stress fractures can occur in the postoperative period. Acromial fractures were reported in 7% of 335 patients after RSA and were associated with RA.[43] In accordance with a previous report,[44] a larger lateral offset of the greater tuberosity was adopted to prevent this complication.

During orthopedic intervention in patients with RA, anesthetists need to be aware of potential risks for appropriate pre- and intraoperative management. We performed RSA in the beach chair position. As patients with RA often develop atlantoaxial subluxation, preoperative evaluation and appropriate positioning during intubation and intraoperatively are essential.[45,46] Moreover, anesthetists are required to deal with extra-articular involvement specific to patients with RA such as cardiovascular, respiratory, renal, and skin involvement. RA is a risk factor for postoperative complications in patients who use biological disease-modifying antirheumatic drugs (bDMARDs). The use of bDMARDs has been reported to be a risk factor for surgical-site infection (SSI) (HR, 1.66; 95% confidence interval [CI], 1.25–2.19).[47] Moreover, the risk of SSI has been shown to be higher in patients with RA than those with OA (odds ratio [OR], 1.54; 95% CI, 1.29–1.90[47] and OR, 2.30; 95% CI, 1.37–3.30[48]). The guidelines by the American College of Rheumatology recommend the timing of surgery after the last dose of DMARDs in patients with rheumatic disease.[49] Although no infections occurred among patients in this study, attention should be paid to the perioperative handling of DMARDs and wound conditions.

This study had some limitations. First, this study involved a small sample size and retrospective short-term outcomes. Different results may be obtained if the number of cases is increased. However, the power analysis indicated a value under 0.80 (alpha = 0.05 and effect size = 0.5) in this study. Regarding the mid-term results of RSA (mean follow-up period, 7 years), the rate of survivorship free of revision at 5 years was 96% in patients with RA.[30] Regarding the long-term results of RSA (mean follow-up period, 127.6 months), revision surgery was performed after 7 years and the rate of survivorship free of revision at 10 years was 95.2% in patients with cuff tear arthropathy and OA.[50] It is important to obtain the long-term results of RSA in patients with a variety of backgrounds. Second, the clinical backgrounds of the RA and OA groups were not perfectly matched. Therefore, further prospective studies with a large sample size are warranted in the future to evaluate the results of RSA in the long-term period in the RA and OA groups. Nevertheless, we believe that the results of the present study will help in the management of shoulder disease in patients with RA and OA in daily practice.

Conclusion

This study compared patients with RA and those with OA who underwent RSA. Among older patients, the mid-term clinical results after RSA were comparable between older patients with RA and those with OA. RSA can be considered for the surgical treatment of the shoulder in both patients with RA and those with OA.

Ethical approval

This study was conducted following the principles of the Declaration of Helsinki. Informed consent was obtained from all patients. This research has been approved by the Institutional Review Board of the authors' affiliated institutions (approval number: TGE02195-064).

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Tanaka E, Saito A, Kamitsuji S, Yamada T, Nakajima A, Taniguchi A, *et al.* Impact of shoulder, elbow, and knee joint involvement on assessment of rheumatoid arthritis using the American College of Rheumatology Core Data Set. Arthritis Rheum 2005;53:864-71.
2. Shidara K, Inoue E, Hoshi D, Tanaka E, Seto Y, Nakajima A, *et al.* The influence of individual joint impairment on functional disability in rheumatoid arthritis using a large observational database of Japanese patients. J Rheumatol 2012;39:476-80.
3. Lehtinen JT, Belt EA, Kauppi MJ, Kaarela K, Kuusela PP, Kautiainen HJ, *et al.* Bone destruction, upward migration, and medialisation of rheumatoid shoulder: A 15 year follow up study. Ann Rheum Dis 2001;60:322-6.
4. Lehtinen JT, Belt EA, Lybäck CO, Kauppi MJ, Kaarela K, Kautiainen HJ, *et al.* Subacromial space in the rheumatoid shoulder: A radiographic 15-year follow-up study of 148 shoulders. J Shoulder Elbow Surg 2000;9:183-7.
5. Larsen A, Dale K, Eek M. Radiographic evaluation of rheumatoid arthritis and related conditions by standard reference films. Acta Radiol Diagn (Stockh) 1977;18:481-91.
6. Sobue Y, Kojima M, Kojima T, Ito H, Nishida K, Matsushita I, *et al.* Patient satisfaction with total joint replacement surgery for rheumatoid arthritis: A questionnaire survey for the 2020 update of the Japan college of rheumatology clinical practice guidelines. Mod Rheumatol 2022;32:121-6.
7. Boileau P, Watkinson D, Hatzidakis AM, Hovorka I. Neer award 2005: The grammont reverse shoulder prosthesis: Results in cuff tear arthritis, fracture sequelae, and revision arthroplasty. J Shoulder Elbow Surg 2006;15:527-40.

8. Wall B, Nové-Josserand L, O'Connor DP, Edwards TB, Walch G. Reverse total shoulder arthroplasty: A review of results according to etiology. J Bone Joint Surg Am 2007;89:1476-85.
9. Yamanaka H, Tanaka E, Nakajima A, Furuya T, Ikari K, Taniguchi A, *et al*. A large observational cohort study of rheumatoid arthritis, IORRA: Providing context for today's treatment options. Mod Rheumatol 2020;30:1-6.
10. Constant CR, Gerber C, Emery RJ, Søjbjerg JO, Gohlke F, Boileau P. A review of the constant score: Modifications and guidelines for its use. J Shoulder Elbow Surg 2008;17:355-61.
11. Shimo S, Sakamoto Y, Amari T, Gemma S. Validation of the shoulder36 for the activities of daily living with shoulder disorders. J Phys Ther Sci 2017;29:635-40.
12. Beaton DE, Wright JG, Katz JN, Upper Extremity Collaborative Group. Development of the QuickDASH: Comparison of three item-reduction approaches. J Bone Joint Surg Am 2005;87:1038-46.
13. Imaeda T, Toh S, Wada T, Uchiyama S, Okinaga S, Kusunose K, *et al.* Validation of the Japanese Society for Surgery of the Hand Version of the Quick Disability of the Arm, Shoulder, and Hand (QuickDASH-JSSH) questionnaire. J Orthop Sci 2006;11:248-53.
14. Khan WS, Longo UG, Ahrens PM, Denaro V, Maffulli N. A systematic review of the reverse shoulder replacement in rotator cuff arthropathy, rotator cuff tears, and rheumatoid arthritis. Sports Med Arthrosc Rev 2011;19:366-79.
15. Cho CH, Kim DH, Song KS. Reverse shoulder arthroplasty in patients with rheumatoid arthritis: A systematic review. Clin Orthop Surg 2017;9:325-31.
16. Kennedy J, Klifto CS, Ledbetter L, Bullock GS. Reverse total shoulder arthroplasty clinical and patient-reported outcomes and complications stratified by preoperative diagnosis: A systematic review. J Shoulder Elbow Surg 2021;30:929-41.
17. Kim H, Kim CH, Kim M, Lee W, Jeon IH, Lee KW, *et al.* Is reverse total shoulder arthroplasty (rTSA) more advantageous than anatomic TSA (aTSA) for osteoarthritis with intact cuff tendon? A systematic review and meta-analysis. J Orthop Traumatol 2022;23:3.
18. Fujimura K, Haraguchi A, Sakurai R, Kamura S, Sakuraba K, Miyahara H, *et al.* Have the radiographic characteristics of total knee arthroplasty recipients in rheumatoid arthritis changed after the induction of biologic disease modifying antirheumatic drugs? Mod Rheumatol 2022;32:1047-53.
19. Nagase Y, Naito M, Momoyama G, Uchida Y, Nishikawa T, Makabe K, *et al.* Midterm clinical outcomes of reverse shoulder arthroplasty in Japanese patients with rheumatoid arthritis using patient-reported outcome measures (Shoulder36). JSES Int 2021;5:114-20.
20. John M, Pap G, Angst F, Flury MP, Lieske S, Schwyzer HK, *et al.* Short-term results after reversed shoulder arthroplasty (Delta III) in patients with rheumatoid arthritis and irreparable rotator cuff tear. Int Orthop 2010;34:71-7.
21. He Y, Xiao LB, Zhai WT, Xu YL. Reverse shoulder arthroplasty in patients with rheumatoid arthritis: Early outcomes, pitfalls, and challenges. Orthop Surg 2020;12:1380-7.
22. Kirsch JM, Puzzitiello RN, Swanson D, Le K, Hart PA, Churchill R, *et al.* Outcomes after anatomic and reverse shoulder arthroplasty for the treatment of glenohumeral osteoarthritis: A propensity score-matched analysis. J Bone Joint Surg Am 2022;104:1362-9.
23. Steen BM, Cabezas AF, Santoni BG, Hussey MM, Cusick MC, Kumar AG, *et al.* Outcome and value of reverse shoulder arthroplasty for treatment of glenohumeral osteoarthritis: A matched cohort. J Shoulder Elbow Surg 2015;24:1433-41.
24. Young AA, Smith MM, Bacle G, Moraga C, Walch G. Early results of reverse shoulder arthroplasty in patients with rheumatoid arthritis. J Bone Joint Surg Am 2011;93:1915-23.
25. Ekelund A, Nyberg R. Can reverse shoulder arthroplasty be used with few complications in rheumatoid arthritis? Clin Orthop Relat Res 2011;469:2483-8.
26. Gallusser N, Farron A. Complications of shoulder arthroplasty for osteoarthritis with posterior glenoid wear. Orthop Traumatol Surg Res 2014;100:503-8.
27. Haritinian EG, Belgaid V, Lino T, Nové-Josserand L. Reverse versus anatomical shoulder arthroplasty in patients with intact rotator cuff. Int Orthop 2020;44:2395-405.
28. Holcomb JO, Hebert DJ, Mighell MA, Dunning PE, Pupello DR, Pliner MD, *et al.* Reverse shoulder arthroplasty in patients with rheumatoid arthritis. J Shoulder Elbow Surg 2010;19:1076-84.
29. Hattrup SJ, Sanchez-Sotelo J, Sperling JW, Cofield RH. Reverse shoulder replacement for patients with inflammatory arthritis. J Hand Surg Am 2012;37:1888-94.
30. Alentorn-Geli E, Wanderman NR, Assenmacher AT, Sperling JW, Cofield RH, Sánchez-Sotelo J. Anatomic total shoulder arthroplasty with posterior capsular plication versus reverse shoulder arthroplasty in patients with biconcave glenoids: A matched cohort study. J Orthop Surg (Hong Kong) 2018;26:2309499018768570.
31. Wright MA, Keener JD, Chamberlain AM. Comparison of clinical outcomes after anatomic total shoulder arthroplasty and reverse shoulder arthroplasty in patients 70 years and older with glenohumeral osteoarthritis and an intact rotator cuff. J Am Acad Orthop Surg 2020;28:e222-9.
32. van der Zwaal P, Pijls BG, Thomassen BJ, Lindenburg R, Nelissen RG, van de Sande MA. The natural history of the rheumatoid shoulder: A prospective long-term follow-up study. Bone Joint J 2014;96-B:1520-4.
33. Wang WT, Huang SW, Liou TH, Lin HW. Patients with rheumatoid arthritis were associated with a risk of rotator cuff diseases. J Clin Med 2019;8:129.
34. Lim SJ, Sun JH, Kekatpure AL, Chun JM, Jeon IH. Rotator cuff surgery in patients with rheumatoid arthritis: Clinical outcome comparable to age, sex and tear size matched non-rheumatoid patients. Ann R Coll Surg Engl 2017;99:579-83.
35. Austin DC, Wilbur RR, Rogers TH, Barlow JD, Camp CL, Morrey ME, *et al.* Rotator cuff repair in patients with inflammatory arthritis: Satisfactory midterm outcomes. JSES Int 2023;7:30-4.
36. Boulahia A, Edwards TB, Walch G, Baratta RV. Early results of a reverse design prosthesis in the treatment of arthritis of the shoulder in elderly patients with a large rotator cuff tear. Orthopedics 2002;25:129-33.
37. Sirveaux F, Favard L, Oudet D, Huquet D, Walch G, Molé D. Grammont inverted total shoulder arthroplasty in the treatment of glenohumeral osteoarthritis with massive rupture of the cuff. Results of a multicentre study of 80 shoulders. J Bone Joint Surg Br 2004;86:388-95.
38. Jo YH, Choi SH, Joo IH, Choi S, Jeong SY, Lee BG. Comparison of outcomes after reverse shoulder arthroplasty in patients with rheumatoid arthritis and cuff tear arthropathy. J Shoulder Elbow Surg 2021;30:273-81.
39. Lévigne C, Chelli M, Johnston TR, Trojani MC, Molé D, Walch G, *et al.* Reverse shoulder arthroplasty in rheumatoid arthritis: Survival and outcomes. J Shoulder Elbow Surg 2021;30:2312-24.
40. Mangold DR, Wagner ER, Cofield RH, Sanchez-Sotelo J, Sperling JW. Reverse shoulder arthroplasty for rheumatoid arthritis since the introduction of disease-modifying drugs. Int Orthop 2019;43:2593-600.
41. Kim SH, Wise BL, Zhang Y, Szabo RM. Increasing incidence of shoulder arthroplasty in the United States. J Bone Joint Surg Am 2011;93:2249-54.
42. Liu H, Huang TC, Yu H, Wang Y, Wang D, Long Z. Total shoulder arthroplasty versus reverse total shoulder arthroplasty: Outcome comparison in osteoarthritis patients with or without concurrent rotator cuff deficiency. Medicine (Baltimore) 2022;101:e29896.
43. Miller M, Chalmers PN, Nyfeler J, Mhyre L, Wheelwright C, Konery K, *et al.* Rheumatoid arthritis is associated with increased symptomatic acromial and scapular spine stress fracture after reverse total shoulder arthroplasty. JSES Int 2021;5:261-5.
44. Werthel JD, Schoch BS, van Veen SC, Elhassan BT, An KN, Cofield RH, *et al.* Acromial fractures in reverse shoulder arthroplasty: A clinical and radiographic analysis. J Shoulder Elbow Arthrop 2018;2:247154921877762.
45. Samanta R, Shoukrey K, Griffiths R. Rheumatoid arthritis and anaesthesia. Anaesthesia 2011;66:1146-59.
46. Kim HR, Kim SH. Perioperative and anesthetic management of patients with rheumatoid arthritis. Korean J Intern Med 2022;37:732-9.

47. Ito H, Murata K, Sobue Y, Kojima T, Nishida K, Matsushita I, *et al.* Comprehensive risk analysis of postoperative complications in patients with rheumatoid arthritis for the 2020 update of the Japan College of Rheumatology clinical practice guidelines for the management of rheumatoid arthritis. Mod Rheumatol 2022;32:296-306.
48. Salt E, Wiggins AT, Rayens MK, Morris BJ, Mannino D, Hoellein A, *et al.* Moderating effects of immunosuppressive medications and risk factors for post-operative joint infection following total joint arthroplasty in patients with rheumatoid arthritis or osteoarthritis. Semin Arthritis Rheum 2017;46:423-9.
49. Goodman SM, Springer BD, Chen AF, Davis M, Fernandez DR, Figgie M, *et al.* 2022 American College of Rheumatology/American Association of Hip and Knee Surgeons Guideline for the Perioperative Management of Antirheumatic Medication in Patients with Rheumatic Diseases Undergoing Elective Total Hip or Total Knee Arthroplasty. Arthritis Care Res (Hoboken) 2022;74:1399-408.
50. Bülhoff M, Zeifang F, Welters C, Renkawitz T, Schiltenwolf M, Tross AK. Medium- to long-term outcomes after reverse total shoulder arthroplasty with a standard long stem. J Clin Med 2022;11:2274.

Comparative Analysis of Critical Shoulder Angle and Acromion Index in Patients with or without Rotator Cuff Tear

Deepak Kashyap[1], Vineet Jain[1], Rohini Gupta Ghasi[2], Shubham Ahuja[1]

[1]Sports Injury Centre, VMMC and Safdarjung Hospital, [2]Departments of Radiodiagnosis, VMMC and Safdarjung Hospital, New Delhi, India

Abstract

Background: Recent evidence suggests that a high value of radiographic acromial indices such as critical shoulder angle (CSA) and acromial index (AI) may be associated with a higher incidence of rotator cuff tears (RCTs). The objective of this observational study was to evaluate the relationship between RCTs, CSA, and AI. **Materials and Methods:** We divided 68 patients with shoulder pain into two groups: Group 1, RCT and Group 2, normal cuff. Patients were evaluated with standard true anteroposterior (AP) radiographs. CSA and AI were calculated on true AP X-ray. Twenty-four males and 10 females were selected for Group 1 whereas 23 males and 11 females for Group 2. **Results:** The mean age for Group 1 was 53.23 years and for Group 2 was 47.53 years. CSA findings (mean ± standard deviation [SD]) were 37.5 ± 4.37 for Group 1 and 32.23 ± 3.19 for Group 2. Mean ± SD for AI were 0.72 ± 0.07 and 0.66 ± 0.09 for Groups 1 and 2, respectively. CSA and AI revealed a statistically significant $P < 0.0001$ for both groups. Logistic regression confirmed CSA and AI to be strong predictors of an RCT.
Conclusions: Higher CSA and AI are associated with degenerative RCT.
Level of Study: Level III.

Keywords: Acromion index, critical shoulder angle, degenerative rotator cuff tear

Introduction

The most common cause of shoulder pain is rotator cuff tear (RCT) along with tendinopathy.[1,2] RCT usually starts from trauma. The insufficient healing of microtrauma causes tendon degeneration which leads to degenerative rotator cuff tears (DRCT). These degenerative tears are seen frequently with advancing age and are sometimes asymptomatic with normal, painless, and functional activity.[3] The overall prevalence of RCT in the general population is found to be around 22.1%, which increases with age, and the occurrence of asymptomatic tears is twice as common as symptomatic tears. The prevalence of RCT in males is greater than in females.[4]

Several parameters of the acromion morphology in relation to RCT have been studied such as acromial tilt, modified acromial tilt, acromial slope, acromiohumeral interval, lateral acromial angle, acromial anterior protrusion, acromial inferior protrusion, critical shoulder angle (CSA), and acromion index (AI).[5]

Moor *et al*.[6] observed that the high value of CSA, i.e., >35° was associated with a higher prevalence of RCT, normal individuals had CSA between 30° and 35° and at the same time values <30°(CSA) were seen in osteoarthritis (OA) of the glenohumeral joint. The resulting force vector of the deltoid is directed upward against the rotator cuff with high CSA, leading to DRCT whereas smaller CSA increases the risk for the development of concentric OA by producing a resultant vector force of the deltoid that is unbalanced against the glenoid thus.

A new biomechanical value (acromion index) was introduced by Nyffeler *et al*.[7] as the lateral extension of acromion above the humeral head, he hypothesized that a large lateral extension impinges between an acromion and the higher ascending force of a deltoid muscle which predisposes the supraspinatus tendon to degeneration.

In previous studies, higher values of CSA[6,8-12] and AI[7,13-16] have been found associated with the incidence of RCTs. The

Access this article online	
Quick Response Code:	**Website:** https://journals.lww.com/jajs
	DOI: 10.4103/jajs.jajs_33_23

Address for correspondence: Dr. Deepak Kashyap, A-159, Sector-7, Pappan Kalan, Dwarka, New Delhi - 110 075, India. E-mail: deepak.mamc.10@gmail.com

Submitted: 24-Mar-2023 **Revised:** 25-Feb-2024
Accepted: 23-May-2024 **Published:** 11-Oct-2024

How to cite this article: Kashyap D, Jain V, Ghasi RG, Ahuja S. Comparative analysis of critical shoulder angle and acromion index in patients with or without rotator cuff tear. J Arthrosc Jt Surg 2024;11:198-203.

aim of this study was to determine the relationship between CSA, AI, and RCT in the Indian population.

Materials and Methods

This cross-sectional observational study was conducted from November 2019 to September 2021, in a medical college at a referral sports injury center after ethical clearance from the institutional ethics committee. Patient selection was based on the following inclusion criteria: age group between 30–60 years with nontraumatic shoulder pain, clinically and radiologically diagnosed DRCT (complete/partial thickness with ≥50% tear). Patients having traumatic RCT, any fractures around the shoulder joint, arthritis of the glenohumeral joint (inflammatory, traumatic, and infective), or humeral head collapse due to osteonecrosis were excluded from the study.

A complete history with a physical examination of the selected patients with shoulder pain was done. Clinical diagnosis of RCT was confirmed on magnetic resonance imaging. (Fredericson classification, graded 1–4).

Patients thus selected were divided into two groups after assessment. They were matched for age, sex, and side of involvement.

- Group 1: Cases; patients with shoulder pain and diagnosed RCT
- Group 2: Control; patients with shoulder pain and diagnosed with no RCT.

The patients underwent an X-ray examination of the involved shoulder true anteroposterior (AP) radiographs (Grashey view) and images were digitally captured.

CSA and AI were measured with Jivex dicom viewer version 11.0.3 (VISUS health IT GmbH, Bochum, Germany) free version using the digitally captured images.

Tools of measurement:

- CSA measurement: As described by Moor *et al.*,[6] CSA measurement is done by applying a line connecting the superior and inferior bone margins of the glenoid and an intersecting line drawn from the inferior bone margin of the glenoid to the lateral most border of the acromion [Figure 1].
- AI measurement: As done by Nyffeler *et al.*,[7] AI is calculated by distance from the glenoid plane to the acromion (GA) and the distance from the glenoid plane to the lateral aspect of the humeral head (GU) was measured and the ratio between them calculated as per formula given below [Figure 2].

Acromion index (AI) = GA/GU

Comparison of CSA and AI was done in both groups.

Sample size calculation

As seen in the study of Pandey *et al.*,[8] the mean value of CSA and AI in full-thickness tear was 41.01 ± 3.1 and 0.76 ± 0.01, respectively, and in no tear was 37.28 ± 4.89 and 0.70 ± 0.08, respectively. Taking the study of Pandey *et al*.[8] and their CSA and AI values as a reference, the minimum required sample size with 95% power of the study and 5% level of significance was estimated to be 32 patients in each group so the total sample size was 64 patients.

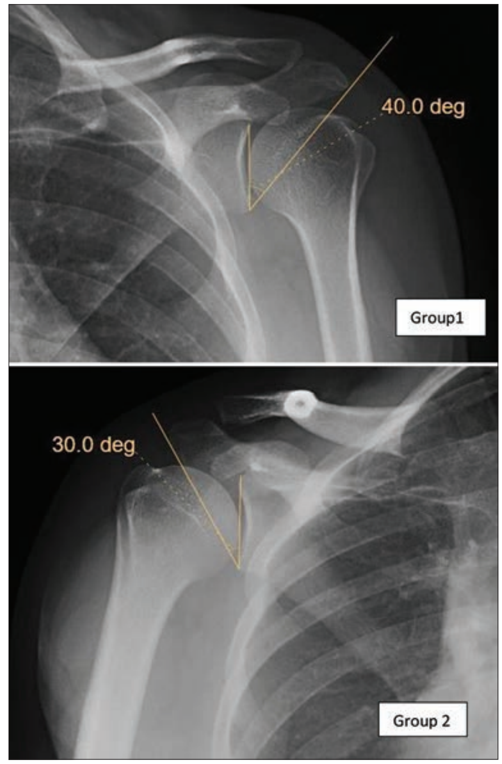


Figure 1: Critical shoulder angle determination in Groups 1 and 2

Inter-rater and test–retest reliability

Intraclass correlation coefficient (ICC)[17] was calculated for assessing the reliability of measurements. For inter-rater reliability, the two-way effects model, and for test–retest, the two-way mixed effect model were used to calculate ICC [Table 1].

Statistical analysis

Categorical variables as number and percentage and continuous variables as mean ± standard deviation and median were presented. The testing of normality of data was done by the Kolmogorov–Smirnov test. Mann–Whitney test was used, if the normality was rejected.

Independent *t*-test was used to compare quantitative variables between the two groups. Fisher's exact test was used to compare qualitative variables. The $P < 0.05$ was considered statistically significant for this study.

The data were entered into MS EXCEL spreadsheet and the Statistical Package for the Social Sciences (SPSS) version 21.0, New York, United States was used to analyze the data.

Results

A total of 68 patients aged between 30–60 years were enrolled in the study. All patients had shoulder pain in common. The case group was named Group 1 containing 34 patients and the control group was named as Group 2 containing 34 patients. Most of the patients were aged between 51 and 60 years where the mean age was 51.35 years in Group 1, while the mean age was 46.23 years in Group 2. Out of a total of 68 patients, 47 were male [Table 2].

The mean value of CSA in Group 1 was 37.5 ± 4.37 and in Group 2 was 32.23 ± 3.19 ($P < 0.0001$) [Table 3]. The mean value of AI in Group 1 was 0.72 ± 0.07 and in Group 2 was 0.66 ± 0.09 ($P < 0.0031$) [Table 4].

Higher values of CSA (>35°) are seen in overall cases of RCT (mean 37.5 ± 4.37), There was a significant difference in both in terms of male and female categories.

Similarly, significantly higher values of AI were seen in males in Group 1 as compared to Group 2. However, there was no significant difference in females.

Discussion

In our cross-sectional observational study, we hypothesized that RCTs are associated with higher values of CSA and AI, and our results confirmed the hypothesis.

The mean age in our study was 51.35 years for Group 1 and 46.23 years for Group 2. Pandey *et al.*,[8] in their study on CSA and AI in the Indian population, reported a mean age of 57.8 years in the full-thickness RCT (FTRCT) group and 53.4 years in the no tears group.

Males constituted the majority (70%) in our study population, which may be due to more reporting of symptomatic RCTs in the male population in India. Pandey *et al.*[8] reported 57.4% males and 42.6% females in their study.

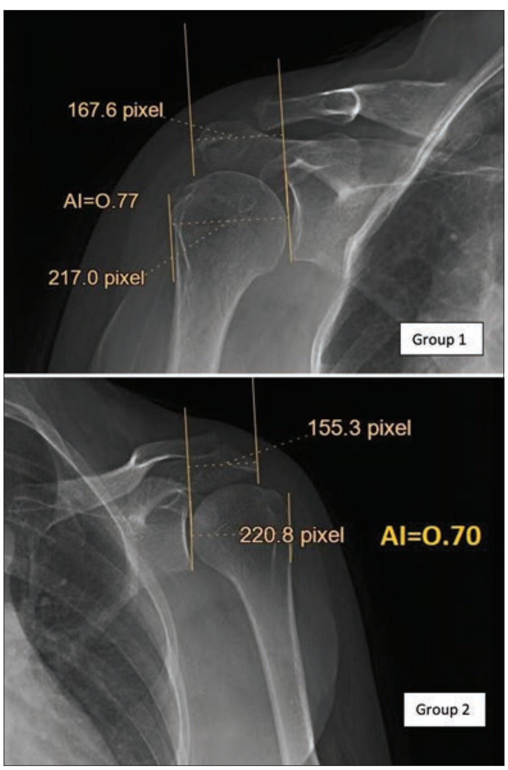


Figure 2: AI determination in Groups 1 and 2

Rotator cuff tears and critical shoulder angle relation

Our study supported previously published evidence that the CSA has significantly higher value in patients with RCTs.[6,8-12] We found a significant difference in mean values of CSA between Groups 1 and 2 (cases and controls) and separately for mean CSA in males and females of both groups. This shows a strong correlation between higher values of CSA with the incidence of RCTs.

Table 1: Inter-rater and test–retest reliability

	ICC	ICC interval
Inter-rater reliability		
Cases (*n*=20)		
CSA	0.97	0.92–0.99
AI	0.95	0.80–0.98
Controls (*n*=20)		
CSA	0.87	0.70–0.94
AI	0.88	0.73–0.95
Test–retest reliability		
Cases (*n*=20)		
CSA	0.99	0.97–1.0
AI	0.96	0.89–0.98
Controls (*n*=20)		
CSA	0.93	0.82–0.97
AI	0.98	0.94–0.99

CSA: Critical shoulder angle, AI: Acromial index, SD: Standard deviation, ICC: Intraclass correlation coefficient

Table 2: Demographic profile

	Group 1	Group 2
Mean age (years)		
Male	50.91	44.95
Female	52.4	48.9
Number of cases		
Male	24	23
Female	10	11
Side involvement		
Right	24	24
Left	10	10

Table 3: Critical shoulder angle (°)

	CSA (mean±SD)	Range	*P*
Comparison between groups			
Group 1 (*n*=34)	37.5±4.37	27−50	<0.0001
Group 2 (*n*=34)	32.23±3.19	27−40	
Comparison between males of both groups			
Group 1 Male (*n*=24)	37.58±4.99	27−50	<0.0001
Group 2 Male (*n*=23)	31.69±2.61	28−39	
Comparison between females of both group			
Group 2 Female (*n*=10)	37.3±2.23	34−40	0.0110
Group 2 Female (*n*=11)	33.33±3.91	27−40	

CSA: Critical shoulder angle, SD: Standard deviation

Table 4: Acromion index (ratio)

	AI (mean±SD)	Range	*P*
Comparison between groups			
Group 1 (*n*=34)	0.72±0.07	0.57–0.87	0.0031
Group 2 (*n*=34)	0.66±0.09	0.5–0.86	
Comparison between males of both groups			
Group 1 male (*n*=24)	0.73±0.07	0.6–0.87	0.0007
Group 2 male (*n*=23)	0.65±0.08	0.5–0.82	
Comparison between females of both groups			
Group 1 female (*n*=10)	0.70±0.07	0.57–0.85	1.00
Group 2 female (*n*=11)	0.70±0.09	0.57–0.86	

AI: Acromial index, SD: Standard deviation

Blonna *et al*.[9] observed an average of CSA of 34° ± 3° in the control group. It was 36° ± 3° in patients with supraspinatus tears, 40° ± 3.5° in patients with supraspinatus and infraspinatus tears, and 28° ± 2° with concentric OA. In their results, there was a positive correlation between CSA and RCTs with an odds ratio of 1.7. Patients of large RCTs had greater CSA ($P = 0.03$). They observed that higher CSA values were consistent with symptomatic RCTs, larger RCTs, and the severity of eccentric OA.

Our findings for CSA are in concurrence with the only published study on the Indian population by Pandey *et al*.[8] which reported that greater CSA and AI are associated with an FTRCT. However, contrary to our findings they reported a mean CSA of 41.01 ± 3.1 in FTRCT and 37.28 ± 4.89 in the no tear group, while in our study, it was 37.5 ± 4.37 and 32.23 ± 3.19, respectively.

This variation may have been due to observer-related variations in CSA measurements, causing differences in radiologic findings. The sample size of their study was 105, while it was 34 in our study group. According to them, CSA is a more powerful index in explaining the effect of acromion morphology in RCTs, than AI.

Unlike Pandey *et al*.,[8] our study reported values of CSA for both cases and control are in concordance with findings reported by previous other studies. Moor *et al*.[6] found a positive correlation of CSA with RCTs and recorded 33.1° as the mean value of CSA for the control group and it was 38º for the RCT group. They concluded that RCTs could be predicted at an angle >35°. 30–35° is the normal range for no pathologies such as RCTs and OA. <30° CSA is related to OA.

Watanabe *et al*.[11] in their study on Japanese population found that the means of the CSA and the AI in the RCT group were significantly larger (36.3° vs. 33.7°, 0.74 vs. 0.68) than Non-RCT group. They also studied lateral acromion angle which did not show a correlation with RCTs. In their study, the cutoff values were found to be 35.0° and 0.72°, and the odds ratios were 3.1 and 2.5, for CSA and AI, respectively. They observed the CSA as a strong risk factor for RCT as compared to the AI. Both study groups (RCT and non-RCT) consisted of 54 consecutive cases in each.

Statistically significant differences between CSA and AI were there in study of Rose-Reneau et al.[12] between the means of the control group (patients without OA and RCTs) and the rotator cuff pathology group ($P < 0.0001$). However, their results were in concordance with Moor *et al*. prediction of the normal range of between 30–35º (mean CSA 32.2º). They further proposed that measuring CSA on radiographs and predicting RCTs can reduce the cost of time-consuming costly investigations.

On the contrary, our study contradicts the study by Bjarnison *et al*.,[18] who found no relation between CSA and RCTs.[18,19] CSA values were to be 33.9° in the RCTs group and 33.6° in the control group. Individuals with a CSA >35° had an odd ratio of 1.12 for developing RCTs. However, between CSA and OA, there was a 2.25 Odds ratio of developing OA when the patient had a CSA of <30º. Patients with an overlap of the anterior and posterior rim of the glenoid fossa of >11 mm were excluded but securing a standardized AP X-ray projection was a limitation of study because of the retrospective setup.

In recent study, Björnsson Hallgren *et al*.[19] did not find any relation between the CSA, AI, and the incidence of OA or RCTs. As per their observation, mean CSA and AI decreased over 20 years with very small differences. There was no difference between the study shoulders and the contralateral shoulder. They questioned the importance of CSA as a prognostic factor for the RCT or glenohumeral OA development and they proposed that lateral acromioplasty probably does not prevent RCTs. The studied group was underpowered to demonstrate a statistically significant difference because it was relatively small.

Rotator cuff tear and AI

We found significant differences between the means of AIs of both Groups 1 and 2 and males of both groups but not in females. Both groups of females had higher AI values. This shows higher values of AIs are associated with the incidence of RCTs in males but not in females. This may be due to the fact that the number of female patients in our study was less.

Our results support results reported by previously published evidence[7,14-16,18,19] that the AI is significantly higher in patients with RCTs. Nyffeler *et al*.[7] reported an average AI of 0.73 ± 0.06 in shoulders with an FTRCT and 0.64 ± 0.06 in asymptomatic, intact rotator cuff shoulders which is marginally close to our mean AI of 0.72 ± 0.07 in Group 1 and 0.66 ± 0.09 in Group 2. They confirmed that a large lateral extension of the acromion, i.e., AI has been seen associated with RCT. In contrast to our study, they found no correlation with gender.

Our results are like those reported by Pandey *et al*.[8] who observed a significant difference in the average value (mean) of AI between the FTRCT and no tear groups. Their mean reported AI values were 0.76 ± 0.01 and 0.70 ± 0.08 for

FTRCT and no tear group while our values were 0.72 ± 0.07 and 0.66 ± 0.09, respectively.

Kum *et al*.[13] also observed the mean AI value as 0.68 in the RCTs group and 0.63 in the control group and found it statistically significant ($P < 0.001$). However, unlike our study, they found a correlation of AI with RCTs in males and females. Their ROC analysis determined 0.66 as the cut-off value of AI. They concluded patients with an AI value higher than 0.66 have a greater chance of having RCT.

Miyazaki *et al*.[15] showed similar results for the Brazilian population (mean AI 0.72) but not consistent with the Japanese population (mean AI 0.68). Brazilian patients with RCTs had shown a greater lateral extension of the acromion unlike those with intact rotator cuffs and this was not seen in the Japanese population. On the contrary, they found that both female Japanese and Brazilian patients with RCT (44 patients and 53 patients, mean AI 0.73 and 0.71, respectively) had a greater AI than that of male patients with RCTs. Whereas our study reported the opposite mean, with an AI for females of 0.70 and a mean AI for males of 0.73 with RCT. AI values were the same in females in both groups of our study.

Maalouly *et al*.[20] found a mean AI of 0.68 and 0.67 in the RCT group and no tear group respectively, the difference not being significant. However, unlike our study, there was no difference between patients with and without RCTs while studying both genders separately. Such results may be due to population-based anatomic differences in different Middle Eastern population such as the Lebanese population.

Hamid *et al*.,[21] did not observe any difference in the AI between patients with and without RCT. The mean AI was 0.691 for subjects with no RCT or partial thickness RCT, and 0.692 for those with FTRCTs ($P = 0.92$) and the overall mean AI was 0.691 ± 0.06 (range, 0.540–0.884). They observed higher AI in women than in men. Their study did not find the acromial morphology as a reliable method to assess the acromion.

Our study acknowledges certain limitations as despite radiographic standardization protocol, 100% accuracy cannot be achieved in various measurements, which may have led to some aberration. The study included only patients coming with complaints of shoulder pain thus missing asymptomatic individuals with RCT. The majority of patients were male, and the sample size was not separately calculated for the male and female populations. There may be some anthropometric differences in measurements across different ethnic groups, so the findings may be limited to the Indian population only.

Conclusions

CSA and AI are associated with a higher incidence of RCT in the Indian population, the finding being in line with published literature across most ethnic groups. Individuals with higher values of CSA and AI are susceptible to having RCT.

Implications

Higher values of CSA and AI are seen as related to RCT hence these factors can predict the development of RCT in the Indian population.

Acknowledgments

All authors participated in the concept and design of the study. RGG and VJ participated in data acquisition. VJ contributed to data acquisition, data analysis, and statistical analysis. DK contributed to all steps of the study. All authors participated in manuscript editing and review.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Urwin M, Symmons D, Allison T, Brammah T, Busby H, Roxby M, *et al.* Estimating the burden of musculoskeletal disorders in the community: The comparative prevalence of symptoms at different anatomical sites, and the relation to social deprivation. Ann Rheum Dis 1998;57:649-55.
2. Ostör AJ, Richards CA, Prevost AT, Speed CA, Hazleman BL. Diagnosis and relation to general health of shoulder disorders presenting to primary care. Rheumatology (Oxford) 2005;44:800-5.
3. Sher JS, Uribe JW, Posada A, Murphy BJ, Zlatkin MB. Abnormal findings on magnetic resonance images of asymptomatic shoulders. J Bone Joint Surg Am 1995;77:10-5.
4. Minagawa H, Yamamoto N, Abe H, Fukuda M, Seki N, Kikuchi K, *et al.* Prevalence of symptomatic and asymptomatic rotator cuff tears in the general population: From mass-screening in one village. J Orthop 2013;10:8-12.
5. Li X, Xu W, Hu N, Liang X, Huang W, Jiang D, *et al.* Relationship between acromial morphological variation and subacromial impingement: A three-dimensional analysis. PLoS One 2017;12:e0176193.
6. Moor BK, Bouaicha S, Rothenfluh DA, Sukthankar A, Gerber C. Is there an association between the individual anatomy of the scapula and the development of rotator cuff tears or osteoarthritis of the glenohumeral joint? A radiological study of the critical shoulder angle. Bone Joint J 2013;95:935-41.
7. Nyffeler RW, Werner CM, Sukthankar A, Schmid MR, Gerber C. Association of a large lateral extension of the acromion with rotator cuff tears. J Bone Joint Surg Am 2006;88:800-5.
8. Pandey V, Vijayan D, Tapashetti S, Agarwal L, Kamath A, Acharya K, *et al.* Does scapular morphology affect the integrity of the rotator cuff? J Shoulder Elbow Surg 2016;25:413-21.
9. Blonna D, Giani A, Bellato E, Mattei L, Caló M, Rossi R, *et al.* Predominance of the critical shoulder angle in the pathogenesis of degenerative diseases of the shoulder. J Shoulder Elbow Surg 2016;25:1328-36.
10. Cherchi L, Ciornohac JF, Godet J, Clavert P, Kempf JF. Critical shoulder angle: Measurement reproducibility and correlation with rotator cuff tendon tears. Orthop Traumatol Surg Res 2016;102:559-62.
11. Watanabe A, Ono Q, Nishigami T, Hirooka T, Machida H. Association between the critical shoulder angle and rotator cuff tears in Japan. Acta Med Okayama 2018;72:547-51.
12. Rose-Reneau Z, Moorefield AK, Schirmer D, Ismailov E, Downing R, Wright BW. The Critical shoulder angle as a diagnostic measure for osteoarthritis and rotator cuff pathology. Cureus 2020;12:e11447.
13. Kum DH, Kim JH, Park KM, Lee ES, Park YB, Yoo JC. Acromion index in Korean population and its relationship with rotator cuff tears. Clin

Orthop Surg 2017;9:218-22.
14. Kim JR, Ryu KJ, Hong IT, Kim BK, Kim JH. Can a high acromion index predict rotator cuff tears? Int Orthop 2012;36:1019-24.
15. Miyazaki AN, Itoi E, Sano H, Fregoneze M, Santos PD, da Silva LA, *et al.* Comparison between the acromion index and rotator cuff tears in the Brazilian and Japanese populations. J Shoulder Elbow Surg 2011;20:1082-6.
16. Balke M, Schmidt C, Dedy N, Banerjee M, Bouillon B, Liem D. Correlation of acromial morphology with impingement syndrome and rotator cuff tears. Acta Orthop 2013;84:178-83.
17. Gupta H, Batta NS, Kataria H, Batra V, Upadhyay AD, Jain V, *et al*. A comparison of the reliability of the patellar tendon-trochlear groove (PTTG) distance and the tibial tuberosity-trochlear groove (TTTG) distance measured on MRI. Malays Orthop J 2020;14:34-41.
18. Bjarnison AO, Sørensen TJ, Kallemose T, Barfod KW. The critical shoulder angle is associated with osteoarthritis in the shoulder but not rotator cuff tears: A retrospective case-control study. J Shoulder Elbow Surg 2017;26:2097-102.
19. Björnsson Hallgren HC, Adolfsson L. Neither critical shoulder angle nor acromion index were related with specific pathology 20 years later! Knee Surg Sports Traumatol Arthrosc 2021;29:2648-55.
20. Maalouly J, Tawk A, Aouad D, Abdallah A, Darwiche M, Abboud G, *et al.* Association of acromial morphological parameters and rotator cuff tears, and evaluation of the influence of age and gender on the parameters and impact on cuff tears: A study on a middle Eastern population. Asia Pac J Sports Med Arthrosc Rehabil Technol 2020;20:17-23.
21. Hamid N, Omid R, Yamaguchi K, Steger-May K, Stobbs G, Keener JD. Relationship of radiographic acromial characteristics and rotator cuff disease: A prospective investigation of clinical, radiographic, and sonographic findings. J Shoulder Elbow Surg 2012;21:1289-98.

Original Article

The Impact of Preoperative Intra-articular Injections on Postoperative Outcomes in Hip Arthroscopy

Parimal Rana, Jane Brennan, Andrea Johnson, Samantha N. Baxter, Justin J Turcotte, Benjamin M Petre
Department of Orthopedics, Luminis Health Anne Arundel Medical Center, Annapolis, MD, USA

Abstract

Introduction: Hip arthroscopy is a minimally invasive procedure commonly performed to treat various hip conditions. Preoperative intra-articular injections, such as local anesthetics and corticosteroids, are frequently used to alleviate pain and as a diagnostic tool before hip arthroscopy. However, studies have shown conflicting information; some demonstrate better patient outcomes, while others have found an increased risk of complications and negative effects on postoperative recovery. This retrospective study evaluated the association between preoperative injections and postoperative outcomes in hip arthroscopy patients. **Materials and Methods:** A retrospective review of 1400 patients who underwent hip arthroscopy between 2014 and 2021 at our institution was performed. The patients were allocated into two cohorts based on whether they received a cortisone injection with local anesthetic within 1 year before the surgery. Outcomes during the study follow-up period (average: 437 days, max: 3018 days) were compared. Further analysis looked at subgroups at 30-day increments. **Results:** The results showed that 35.5% of the patients had received a preoperative injection. Although patients who received injections were more likely to be female (68.3% injected vs. 60.8% not injected, $P = 0.019$) and have asthma (12.5% injected vs. 7.3% not injected, $P = 0.008$), there were no significant differences in 90-day complications, 90-day emergency department visits, 90-day readmissions, any complications (wound infection, re-injury, recurrent pain or weakness, deep vein thrombosis, or pulmonary embolism), prolonged pain or recovery, reoperation, total hip arthroplasty, 6-month Patient-Reported Outcomes Measurement Information System Physical Function, 6-month Hip Dysfunction and Osteoarthritis Outcome Score Joint Replacement, or follow-up time between the injection and noninjection groups. There were no other differences in demographics, comorbidities, or physical function between the groups. **Conclusion:** Our study suggests that preoperative corticosteroid injections with local anesthetics do not significantly affect postoperative outcomes in hip arthroscopy patients or increase the risk of adverse effects. Careful evaluation of these risks and benefits is crucial to minimize potential adverse effects and maximize patient outcomes.

Keywords: Corticosteroid injection, femoroacetabular impingement, hip arthroscopy, intra-articular injection

Introduction

Hip arthroscopy is a minimally invasive procedure commonly performed to treat various hip conditions, such as femoroacetabular impingement syndrome (FAIS) and labral tears.[1,2] Preoperative intra-articular (IA) injections, including local anesthetics and corticosteroids, are frequently utilized to alleviate pain and as a diagnostic tool to confirm the source of hip pain in patients before more invasive procedures.[3-5] However, the impact of these injections on postoperative outcomes and associated risks remains a subject of discussion.

Earlier studies have described contradictory results regarding the effects of corticosteroid and local anesthetic IA injections on patient outcomes. Some studies have shown positive effects, with patients experiencing reduced pain and improved function.[6-8] However, other studies have suggested that corticosteroid injections before surgery may increase the risk of complications or negatively affect postoperative recovery.[9,10] Factors such as the dosage and duration of the steroid have been identified as potential predictors of detrimental outcomes.[9]

IA corticosteroid with local anesthetic therapy has been widespread for managing joint inflammation and pain.

Access this article online

Quick Response Code:

Website: https://journals.lww.com/jajs

DOI: 10.4103/jajs.jajs_92_23

Address for correspondence: Dr. Justin J Turcotte,
2000 Medical Parkway, Suite 503, Annapolis, MD 21401, USA.
E-mail: jturcotte@luminishealth.org

Submitted: 30-Nov-2023 **Revised:** 16-Jan-2024
Accepted: 17-Jan-2024 **Published:** 08-Aug-2024

How to cite this article: Rana P, Brennan J, Johnson A, Baxter SN, Turcotte JJ, Petre BM. The impact of preoperative intra-articular injections on postoperative outcomes in hip arthroscopy. J Arthrosc Jt Surg 2024;11:204-10.

Still, concerns have been raised regarding its potential long-term adverse effects on articular cartilage. Studies have demonstrated the adverse effects of corticosteroids on cartilage health, demonstrating complete loss of chondrocyte viability and compromised cartilage integrity.[9,11,12] Although literature is limited regarding the chondrotoxicity in hip IA injections, local anesthetics used in IA injections have also been implicated in chondrotoxicity, potentially causing cell death and structural changes in the articular cartilage.[10,13-15]

Furthermore, preoperative IA corticosteroid injections have been associated with an increased risk of postoperative infection. The immunosuppressive effect of corticosteroids is thought to contribute to this increased risk. However, studies on the infection rates following hip arthroscopy have reported conflicting results, with some finding an increased risk[16,17] and others showing no significant association.[18] Since previous studies have reported opposing results regarding the effects of preoperative IA injections, there is a need for further investigation to elucidate their potential benefits or risks. We hypothesize that preoperative IA hip injections may have a negative impact on patient outcomes. In this retrospective study, we aimed to evaluate the association between preoperative corticosteroids with local anesthetic injections and postoperative outcomes in a cohort of hip arthroscopy patients at our institution.

Materials and Methods

This study was evaluated by the Western Institutional Review Board and deemed exempt as a review of existing medical records.

Study population

A retrospective review of 1040 patients undergoing hip arthroscopy by 1 board-certified surgeon was performed from January 3, 2014, to December 21, 2021. Patients were grouped by whether they had an image-guided corticosteroid with local anesthetic injection within 1 year preoperatively. Less than 20 patients with hyaluronic acid or platelet-rich plasma were excluded. Three hundred and sixty-nine (35.5%) patients had a preoperative corticosteroid injection within 1 year of their hip arthroscopy. IA corticosteroid injections are indicated for pain management and have a diagnostic role in cases of FAIS, osteoarthritis, and other inflammatory diseases.[19,20] They are, however, contraindicated in septic arthritis, acute fractures, bacteremia, cellulitis near the injection site, or allergies.[21]

Independent variables

The independent variables of concern included age, sex, body mass index (BMI), race, ethnicity, preoperative Patient-Reported Outcomes Measurement Information System Physical Function (PROMIS PF) scores, preoperative Hip Dysfunction and Osteoarthritis Outcome Score Joint Replacement (HOOS JR), and the following comorbidities: diabetes, overweight/obesity, chronic obstructive pulmonary disease, liver disease, asthma, atrial fibrillation, congestive heart failure, coronary artery disease, end-stage renal disease, gastroesophageal reflux disease, hypertension, neoplasm, anemia, depression, anxiety, and bipolar disorder. The selected comorbidities were chosen based on evidence demonstrating their association with adverse outcomes in hip surgeries.[22-26] Eighty-eight and 106 patients completed a PROMIS-PF survey, and 67 and 88 completed a HOOS JR survey at the preoperative and 6-month postoperative time points, respectively.

Study outcomes

The primary outcomes of interest included 90-day complications, 90-day emergency department (ED) visits, and 90-day readmission. The secondary outcomes included any complication, prolonged pain or recovery, postoperative injection, reoperation, total hip arthroplasty (THA), and revision hip arthroscopy at any time during the study follow-up period (average: 437 days). Complications included continued pain, avascular necrosis, progressive OA, wound infection, deep vein thrombosis (DVT)/pulmonary embolism (PE), and labral re-tear. An exploratory analysis of 6-month postoperative PROMIS PF and HOOS JR scores was conducted for patients completing the survey instruments.

Statistical analysis

Univariate analysis, including Chi-square tests and independent sample *t*-tests, was used to determine variances in demographics, comorbidities, functional measures, and postoperative outcomes between those who had preoperative injections and those who did not. Multivariate logistic and linear regression was used to evaluate postoperative outcomes while controlling for sex, asthma, labral reconstruction, psoas release, and number of anchors. Additional analysis based on the timing of the preoperative injection was conducted for injections within 12 months and within 3 months. For the 12-month analysis, <3-month, 3–6-month, and 6–12-month outcomes were compared to no injection outcomes, and for the 3-month analysis, <30-day, 30–60-day, and 60–90-day outcomes were compared to no injection outcomes.

When we performed a power analysis, the study's sample sizes were found to be sufficient to detect medium and large effect sizes for continuous and categorical endpoints, respectively, with 80% power. Cohen's d was calculated by dividing the difference between two means by the data's standard deviation. Cohen specified a "d" of 0.20 to be a small impact size, 0.50 to be a medium effect size, and 0.80 to be a big effect size for continuous endpoints.[27] Cohen's w was defined as a measure of effect magnitude used for Chi-squared testing. Cohen described a "w" of 0.10 to be a small effect size, 0.30 to be a medium effect size, and 0.50 to be a big effect size for categorical endpoints.[27] For continuous and categorical endpoints, the requisite sample sizes to detect large effect sizes were 52 and 64, respectively; for medium effect sizes, it was 128 and 176, respectively; and for small effect sizes, it was 788 and 1570, respectively [Table 1]. For all statistical studies, R Studio (Version 4.2.2 © 2009–2023 RStudio, PBC) was used. At $P < 0.05$, statistical significance was determined.

Table 1: Power analysis - sample size required to detect different effect sizes

Power analysis	Small (d=0.2)	Medium (d=0.5)	Large (d=0.8)
Continuous endpoint	788	128	52
Power analysis	**Small (w=0.1)**	**Medium (w=0.3)**	**Large (w=0.5)**
Categorical endpoint	1570	176	64

Represents total *n*

Results

Of the 1040 hip arthroscopy patients, 369 (35.5%) had an image-guided corticosteroid with local anesthetic injection within 1 year before their scope. Patients who had a preoperative injection were more likely to be female (68.3% vs. 60.8%; P = 0.019) and more likely to have asthma (12.5% vs. 7.3%; P = 0.008). There were no other differences in demographics, comorbidities, or physical function between those who had a preoperative injection and those who did not. Surgically, patients who had a preoperative injection were less likely to have labral reconstruction (4.3% vs. 8.3%; P = 0.021) and had fewer anchors placed (3.6 ± 1.2 vs. 3.9 ± 1.3; P = 0.011) but were more likely to have a psoas release (16.5% vs. 10.1%; P = 0.004) [Table 2].

Postoperatively, there were no significant differences in 90-day complications, 90-day ED visits, 90-day readmissions, any complications (wound infection, re-injury, recurrent pain or weakness, DVT, or PE), prolonged pain or recovery, reoperation, THA, 6-month PROMIS PF, 6-month HOOS JR, or follow-up time between those who had a preoperative injection and those who did not [Table 3]. The rates of revision arthroscopy (6.5% vs. 4.8%, P = 0.297) and the need for postoperative injection (22.8% vs. 19.7%, P = 0.273) were slightly higher in the injection group but not statistically significant. The general complication rate, however, was slightly lower in the injection group but again did not reach statistical significance (5.7% vs. 6.7%, P = 0.603). After controlling for sex, asthma, labral reconstruction, psoas release, and number of anchors, those who had a preoperative injection on average followed up 87 days longer (β = 87.43, 95% confidence interval: 17.01–157.85; P = 0.015). Preoperative injections were not significantly associated with any other outcome measures after risk adjustment.

In addition, when examining outcomes by preoperative injection timing within 12 months, there were no differences in any outcomes for <3-month, 3–6-month, and 6–12-month preoperative injection compared to no injection [Table 4].

Finally, when examining outcomes by preoperative injection timing within 3 months, there were no differences in any outcomes for <30-day, 30–60-day, and 60–90-day preoperative injection compared to no injection [Table 5].

Table 2: Demographics, comorbidities, and patient-reported function by preoperative injection status

	No injection (*n*=671)	Injection (*n*=369)	*P*
Demographics			
Age	39.3±14.9	39.2±14.8	0.885
Female	408 (60.8)	252 (68.3)	**0.019**
BMI	27.5±5.98	26.9±5.49	0.097
Non-White race	81 (12.1)	47 (12.7)	1
Hispanic	21 (3.1)	10 (2.7)	0.761
Comorbidities			
Diabetes	30 (4.5)	13 (3.5)	0.573
Overweight/obese	61 (9.1)	31 (8.4)	0.804
COPD	5 (0.7)	2 (0.5)	1
Liver disease	0	1 (0.3)	0.760
Asthma	49 (7.3)	46 (12.5)	**0.008**
AFIB	4 (0.6)	2 (0.5)	1
CHF	1 (0.1)	0	1
CAD	12 (1.8)	5 (1.4)	0.789
ESRD	3 (0.4)	2 (0.5)	1
GERD	82 (12.2)	49 (13.3)	0.681
HTN	70 (10.4)	35 (9.4)	0.716
Neoplasm	1 (0.1)	0	1
Anemia	1 (0.1)	1 (0.3)	1
Depression	133 (19.8)	86 (23.3)	0.215
Anxiety	151 (22.5)	93 (25.2)	0.365
Bipolar disorder	5 (0.7)	1 (0.3)	0.591
Patient-reported function			
Preoperative PROMIS PF	38.6±6.02	38.9±4.87	0.795
Preoperative HOOS JR	51.7±17.7	59.9±16.3	0.064
Procedure details			
Synovial debridement	556 (82.9)	312 (84.6)	0.538
Labral repair	492 (73.3)	291 (78.9)	0.056
Labral reconstruction	56 (8.3)	16 (4.3)	**0.021**
Labral debridement	5 (0.7)	4 (1.1)	0.830
Resection cam	539 (80.3)	300 (81.3)	0.766
Resection pincer	252 (37.6)	117 (31.7)	0.069
Resection AIIS	1 (0.1)	0	1
Resection lesser trochanter	1 (0.1)	1 (0.1)	1
IT band release/lengthening	112 (16.7)	65 (17.6)	0.770
Bursectomy	113 (16.8)	65 (17.6)	0.817
Gluteus medius repair	39 (5.8)	16 (4.3)	0.383
Psoas release	68 (10.1)	61 (16.5)	**0.004**
Hardware removal	23 (3.4)	8 (2.2)	0.341
Number of anchors	3.9±1.3	3.6±1.2	**0.011**

P<0.05 in bold. Data are expressed as mean±SD or *n* (%). SD: Standard deviation, BMI: Body mass index, COPD: Chronic obstructive pulmonary disease, AFIB: Atrial fibrillation, CHF: Congestive heart failure, CAD: Coronary artery disease, ESRD: End-stage renal disease, GERD: Gastroesophageal reflux disease, HTN: Hypertension, PROMIS PF: Patient-Reported Outcomes Measurement Information System Physical Function, HOOS: Hip Dysfunction and Osteoarthritis Outcome Score, IT: Iliotibial, AIIS: Anterior Inferior Iliac Spine

Discussion

IA corticosteroids and local anesthetic therapy have been utilized to address IA inflammation and pain for decades. This treatment has effectively relieved joint symptoms associated

Table 3: Outcomes by preoperative injection

Outcome	Unadjusted			Adjusted		
	No injection (*n*=671)	Injection (*n*=369)	*P*	Injection OR/β	95% CI	*P*
90-day complication	18 (2.7)	9 (2.4)	0.941	0.97	0.41–2.19	0.950
90-day ED visit	21 (3.1)	15 (4.1)	0.540	1.03	0.49–2.09	0.939
90-day readmission	11 (1.6)	6 (1.6)	1	0.89	0.30–2.39	0.815
Any complication	45 (6.7)	21 (5.7)	0.603	0.59	0.27–1.20	0.166
Prolonged pain/recovery	256 (38.2)	151 (40.9)	0.418	1.25	0.93–1.67	0.139
Postoperative injection	132 (19.7)	84 (22.8)	0.273	1.17	0.81–1.67	0.394
Reoperation	97 (14.5)	55 (14.9)	0.917	1.11	0.75–1.63	0.601
THA	64 (9.5)	30 (8.1)	0.519	0.96	0.58–1.56	0.882
Revision scope	32 (4.8)	24 (6.5)	0.297	1.24	0.68–2.20	0.475
6-month PROMIS PF (β)	43.8±8.64	42.9±8.13	0.602	−1.38	−6.21–3.45	0.571
6-month HOOS JR (β)	74.5±19.2	75.6±16.8	0.784	4.45	−7.80–16.70	0.468
Follow-up time (days) (β)	416.3±484.6	475.1±540.5	0.079	87.43	17.01–157.85	**0.015**

P<0.05 in bold. Data are expressed as mean±SD or *n* (%). Adjusted outcomes control for sex, asthma, labral reconstruction, psoas release, and number of anchors. SD: Standard deviation, CI: Confidence interval, OR: Odds ratio, PROMIS PF: Patient-Reported Outcomes Measurement Information System Physical Function, HOOS: Hip Dysfunction and Osteoarthritis Outcome Score, ED: Emergency department, THA: Total hip arthroplasty

Table 4: Outcomes by preoperative injection timing within 12 months

Outcome	No injection (*n*=671)	<3 months (*n*=148)	*P*	3–6 months (*n*=140)	*P*	6–12 months (*n*=79)	*P*
90-day complication	18 (2.7)	4 (2.7)	1	3 (2.1)	0.919	2 (2.5)	1
90-day ED visit	21 (3.1)	7 (4.7)	0.472	4 (2.9)	1	4 (5.1)	0.566
90-day readmission	11 (1.6)	4 (2.7)	0.593	2 (1.4)	1	0	0.515
Any complication	45 (6.7)	7 (4.7)	0.479	7 (5.0)	0.564	7 (8.9)	0.633
Prolonged pain/recovery	256 (38.2)	66 (44.6)	0.174	58 (41.4)	0.530	27 (34.2)	0.571
Postoperative injection	132 (19.7)	40 (27.0)	0.061	28 (2.0)	1	16 (20.3)	1
Reoperation	97 (14.5)	20 (13.5)	0.868	23 (16.4)	0.641	12 (15.2)	0.995
THA	64 (9.5)	11 (7.4)	0.868	12 (8.6)	0.843	7 (8.9)	1
Revision scope	32 (4.8)	6 (4.1)	0.874	12 (8.6)	0.109	6 (7.6)	0.417
6-month PROMIS PF	43.8±8.64	42.1±8.63	0.462	40.6±6.11	0.231	46.9±8.23	0.324
6-month HOOS JR	74.5±19.2	75.9±17.2	0.800	76.7±16.9	0.780	74.2±19.9	0.968
Follow-up time (days)	416.3±484.6	456.2±484.2	0.357	477.8±569.3	0.232	516.6±593.4	0.152

Data are expressed as mean±SD or *n* (%). SD: Standard deviation, PROMIS PF: Patient-Reported Outcomes Measurement Information System Physical Function, HOOS: Hip Dysfunction and Osteoarthritis Outcome Score, ED: Emergency department, THA: Total hip arthroplasty

Table 5: Outcomes by preoperative injection timing within 3 months

Outcome	No injection (*n*=671)	<30 days (*n*=22)	*P*	30–60 days (*n*=61)	*P*	60–90 days (*n*=65)	*P*
90-day complication	18 (2.7)	0	0.913	3 (4.9)	0.565	1 (1.5)	0.869
90-day ED visit	21 (3.1)	0	0.833	4 (6.6)	0.297	3 (4.6)	0.781
90-day readmission	11 (1.6)	0	1	1 (1.6)	1	3 (4.6)	0.229
Any complication	45 (6.7)	0	0.429	5 (8.2)	0.882	2 (3.1)	0.382
Prolonged pain/recovery	256 (38.2)	9 (40.9)	0.969	28 (45.9)	0.293	29 (44.6)	0.375
Postoperative injection	132 (19.7)	5 (22.7)	0.935	17 (27.9)	0.175	18 (27.7)	0.170
Reoperation	97 (14.5)	2 (9.1)	0.691	8 (13.1)	0.924	10 (15.4)	0.985
THA	64 (9.5)	0	0.252	4 (6.6)	0.591	7 (10.8)	0.919
Revision scope	32 (4.8)	1 (4.5)	1	3 (4.9)	1	2 (3.1)	0.756
6-month PROMIS PF	43.8±8.64	42.1±8.20	0.816	40.4±9.34	0.324	44.3±8.61	0.888
6-month HOOS JR	74.5±19.2	80.6±0	0.756	68.2±18.7	0.459	82.9±14.9	0.248
Follow-up time (days)	416.3±484.6	576.3±619.2	0.243	452.1±486.7	0.577	420.5±429.1	0.943

Data are expressed as mean±SD or *n* (%). SD: Standard deviation, PROMIS PF: Patient-Reported Outcomes Measurement Information System Physical Function, HOOS JR: Hip Dysfunction and Osteoarthritis Outcome Score Joint Replacement, ED: Emergency department, THA: Total hip arthroplasty

with osteoarthritis, structural abnormalities, and inflammatory conditions. This study considered the association between preoperative IA injections and postoperative outcomes in patients undergoing hip arthroscopy at our institution. Our findings indicate that 35.5% of hip arthroscopy patients had received a combination of a local anesthetic and corticosteroid injection within 1 year before their hip arthroscopy. However, when investigating postoperative outcomes, we observed no significant differences between patients who had a preoperative injection and those who did not.

Earlier studies have presented opposing results regarding the impact of preoperative corticosteroid injections on postoperative outcomes for patients undergoing hip arthroscopy for FAIS. Research has shown their safety and effectiveness in this patient population.[28-30] However, contrasting findings have suggested that these injections might heighten the risk of complications or negatively influence recovery after surgery. Typically, FAIS patients of younger age, male sex, lower BMI, Tönnis grade of 0, and positive pain relief from preoperative IA hip injections are considerably more likely to report positive outcomes after hip arthroscopy than their counterparts.[28] The response to IA steroid injections has been shown in multiple studies to predict patient-reported outcomes following arthroscopic intervention in patients with FAIS due to the diagnostic and therapeutic nature of the injections.[29,31] Nonresponse to injections has been shown to be a strong negative predictor of surgical outcome in multiple studies.[5,30] It is logical to infer that if the cause of the pain is not related to FAI, even a highly effective procedure would not provide relief to the patient. A prospective study by Barastegui *et al*. also showed that hip arthroscopy after injection in young football players was a safe and effective treatment of FAIS, improving hip pain and function with a 100% return to play by 5.93 ± 2.09 months.[1]

Other studies argue that nonoperative treatments, such as preoperative steroid injections, are overutilized, which may hinder operative outcomes and pose adverse risks.[32] Two novel machine learning analysis studies found that preoperative hip injections, among other factors, were predictive of failing to achieve clinically meaningful outcomes postoperatively.[33,34] Identifying these positive and negative predictors of outcomes can help assist in the management algorithm for patients with FAI and other hip pathologies. Preoperative IA corticosteroid injections have also been reported numerous times in literature to increase the risk of postoperative infection, though limited studies have been performed on the hip.[16,35-38] In particular, Wang *et al*. found a 2- to 6-fold increase in the incidence of infection after hip arthroscopy when a preoperative IA hip injection was given within 3 months of surgery.[39] One of the proposed pathogenic mechanisms of this increase is the immunosuppressive effect of corticosteroids. On the contrary, Rogers *et al*.'s study, 2019, demonstrated that preoperative IA injections did not significantly correlate with increased postoperative complications or revision surgery.[18] Byrd *et al*. and Varady *et al*. also found no increase in infection rates in patients who got an IA <3 months before their surgery.[40,41] This corresponds more closely to the findings observed in our study, where no heightened risk or alterations in outcomes were identified.

Despite the diverse evidence regarding the effects of IA injections on surgical outcomes, they remain an important treatment option for patients suffering from FAIS, as these patients often report reduced pain and improved function after a steroid injection.[6] Hence, IA injections are often used and sometimes required by insurance companies before hip arthroscopy to confirm and isolate the origin of the hip pain, sometimes negating the need for surgery.[18] Lambert *et al*., in a placebo-controlled trial, observed 50% or more improvement in the Western Ontario and McMaster Universities Arthritis Index pain scale in 61% of patients receiving corticosteroid injections compared to only 14% of the placebo group.[7] Ebert *et al*. recruited 44 patients with FAIS who received a guided IA injection of a corticosteroid and local anesthetic and saw a significant increase in all hip range of motion tests and most isometric strength measures lasting up to 2 years after the initial injection.[8] Corticosteroids can also attenuate nociceptive signaling by suppressing the excitability of nerve fibers and decreasing the release of pain-inducing substances, leading to reduced intensity and frequency of joint pain, equating to better patient satisfaction.[42] These studies coincide with the current literature that IA corticosteroids effectively reduce pain and synovial hypertrophy, increase cell growth, and help protect and recover from chondral damage when used correctly.[6,9]

There has been ongoing concern regarding corticosteroid's potential long-term adverse effects on articular cartilage. Although literature regarding the hip is limited, the impact of corticosteroids on articular cartilage has been shown to be influenced by the duration and dosage of treatment, with lower doses and shorter durations showing beneficial effects. In comparison, higher doses and longer durations have been associated with detrimental effects.[9] An *in vitro* study using canine tissue found complete loss of chondrocyte and synoviocyte viability with a single dose of betamethasone, methylprednisolone, or triamcinolone.[10] These effects can lead to cartilage degradation, decreased production of extracellular matrix components, and compromised cartilage integrity.[9] These findings may explain the negative outcomes in some of the studies mentioned.

Our study has several limitations that should be acknowledged. It was conducted retrospectively, which introduces inherent limitations regarding data collection and potential selection biases. Prospective studies with standardized protocols would provide more robust evidence. Second, our data are from a single surgeon and institution, which may not represent the general population. Although we controlled for various demographic and clinical factors, unmeasured confounders, such as variability in follow-up, higher prevalence of asthma and possible associated steroid use, lack of data on repeat procedures at other institutions, and incomplete patient reporting, could influence the outcomes. A notable limitation is the potential existence of selection bias in determining which patients received injections and the specific medication combinations administered. We were unable to discern the reasons behind patients receiving injections or the specifics of the injected medications, including their number, frequency, or types. It is crucial to note that our study primarily aimed to assess the relationship between injections and surgical outcomes rather than evaluate the efficacy of the injections themselves. Finally, this study focuses on short-term outcomes; however, this allows the opportunity for future studies. Despite these limitations, our study also has strength due to the use of a large study sample, a diverse but well-distributed patient population, and the use of rigorous statistical analyses and adjustments for potential confounding factors.

Conclusion

Our study demonstrates that preoperative corticosteroid injections within 1 year before hip arthroscopy were not associated with meaningful differences in postoperative outcomes. Careful evaluation of these risks and benefits is crucial to minimize potential adverse effects and maximize patient outcomes.

Financial support and sponsorship

Nil.

Conflicts of interest

Dr. Petre is a paid consultant for Smith and Nephew Inc. (unrelated to the current work). No other authors have relevant conflicts to disclose.

References

1. Barastegui D, Seijas R, Alentorn-Geli E, Ferré-Aniorte A, Laiz P, Cugat R. Hip arthroscopy is a successful treatment for femoroacetabular impingement in under-16 competitive football players: A prospective study with minimum 2-year follow-up. Arch Orthop Trauma Surg 2023;143:2641-6.
2. Trigg SD, Schroeder JD, Hulsopple C. Femoroacetabular impingement syndrome. Curr Sports Med Rep 2020;19:360-6.
3. Haws BE, Condidorio CG, Adler KL, Giordano BD. Diagnostic intra-articular injection with provocative functional testing predicts patient-reported outcomes following hip arthroscopy: A prospective investigation. J Hip Preserv Surg 2022;9:158-64.
4. Kivlan BR, Martin RL, Sekiya JK. Response to diagnostic injection in patients with femoroacetabular impingement, labral tears, chondral lesions, and extra-articular pathology. Arthroscopy 2011;27:619-27.
5. Lynch TS, Steinhaus ME, Popkin CA, Ahmad CS, Rosneck J. Outcomes after diagnostic hip injection. Arthroscopy 2016;32:1702-11.
6. Park JS, Jang YE, Nahm FS, Lee PB, Choi EJ. Efficacy of intra-articular steroid injection in patients with femoroacetabular impingement. Korean J Pain 2013;26:154-9.
7. Lambert RG, Hutchings EJ, Grace MG, Jhangri GS, Conner-Spady B, Maksymowych WP. Steroid injection for osteoarthritis of the hip: A randomized, double-blind, placebo-controlled trial. Arthritis Rheum 2007;56:2278-87.
8. Ebert JR, Raymond AC, Aujla RS, D'Alessandro P. The effect of a formal nonoperative management program combining a hip injection with structured adjunctive exercise rehabilitation in patients with symptomatic femoroacetabular impingement syndrome. Am J Sports Med 2023;51:694-706.
9. Wernecke C, Braun HJ, Dragoo JL. The effect of intra-articular corticosteroids on articular cartilage: A systematic review. Orthop J Sports Med 2015;3(5).
10. Sherman SL, Khazai RS, James CH, Stoker AM, Flood DL, Cook JL. *In vitro* toxicity of local anesthetics and corticosteroids on chondrocyte and synoviocyte viability and metabolism. Cartilage 2015;6:233-40.
11. Dragoo JL, Braun HJ, Kim HJ, Phan HD, Golish SR. The *in vitro* chondrotoxicity of single-dose local anesthetics. Am J Sports Med 2012;40:794-9.
12. Chu CR, Coyle CH, Chu CT, Szczodry M, Seshadri V, Karpie JC, *et al.* *In vivo* effects of single intra-articular injection of 0.5% bupivacaine on articular cartilage. J Bone Joint Surg Am 2010;92:599-608.
13. Asan CY, Ağyüz G, Canpolat DG, Demirbas AE, Asan M, Yay A, *et al.* Chondrotoxic effects of intra-articular injection of local anaesthetics in the rabbit temporomandibular joint. Int J Oral Maxillofac Surg 2022;51:1337-44.
14. Jayaram P, Kennedy DJ, Yeh P, Dragoo J. Chondrotoxic effects of local anesthetics on human knee articular cartilage: A systematic review. PM R 2019;11:379-400.
15. Mwale C, Sunaga T, Wang Y, Bwalya EC, Wijekoon HM, Kim S, *et al.* *In vitro* chondrotoxicity of bupivacaine, levobupivacaine and ropivacaine and their effects on caspase activity in cultured canine articular chondrocytes. J Vet Med Sci 2023;85:515-22.
16. Belk JW, Keeling LE, Kraeutler MJ, Snow MG, Mei-Dan O, Scillia AJ, *et al.* Risk of infection in knee arthroscopy patients undergoing corticosteroid injections in the perioperative period. Orthop J Sports Med 2021;9(8).
17. Forsythe B, Agarwalla A, Puzzitiello RN, Sumner S, Romeo AA, Mascarenhas R. The timing of injections prior to arthroscopic rotator cuff repair impacts the risk of surgical site infection. J Bone Joint Surg Am 2019;101:682-7.
18. Rogers MJ, Adeyemi TF, Kim J, Maak TG. Understanding preoperative demographics and risk factors for early revision surgery in patients undergoing hip arthroscopic surgery: A large database study. Orthop J Sports Med 2019;7(6).
19. Kullenberg B, Runesson R, Tuvhag R, Olsson C, Resch S. Intraarticular corticosteroid injection: Pain relief in osteoarthritis of the hip? J Rheumatol 2004;31:2265-8.
20. Pasculli RM, Callahan EA, Wu J, Edralin N, Berrigan WA. Non-operative management and outcomes of femoroacetabular impingement syndrome. Curr Rev Musculoskelet Med 2023;16:501-13.
21. Tafti D, Schultz D. Hip Joint Injection. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan. Available from: https://www.ncbi.nlm.nih.gov/books/NBK559023/. [Last accessed on 2023 Jul 24].
22. Kennedy NI, Thompson AB, Hartigan DE. Editorial commentary: Hip arthroscopy outcomes may have a gender bias. Arthroscopy 2023;39:2228-30.
23. Martin RL, Harris JD, Ellis T, Kollmorgen R. Comparison of the PROMIS and iHOT-12 in determining satisfaction levels after hip arthroscopy for FAIS. Orthop J Sports Med 2023;11(5).
24. Gupta A, Redmond JM, Hammarstedt JE, Lindner D, Stake CE, Domb BG. Does obesity affect outcomes after hip arthroscopy? A cohort analysis. J Bone Joint Surg Am 2015;97:16-23.
25. Freshman RD, Salesky M, Cogan CJ, Lansdown DA, Zhang AL. Association between comorbid depression and rates of postoperative complications, readmissions, and revision arthroscopic procedures after elective hip arthroscopy. Orthop J Sports Med 2021;9(9).
26. Roger C, Debuyzer E, Dehl M, Bulaïd Y, Lamrani A, Havet E, Mertl P. Factors associated with hospital stay length, discharge destination, and 30-day readmission rate after primary hip or knee arthroplasty: Retrospective cohort study. Orthop Traumatol Surg Res 2019;105:949-55.
27. Cohen J. Statistical Power Analysis for the Behavioral Sciences. New York, NY: Routledge; 1988.
28. Sogbein OA, Shah A, Kay J, Memon M, Simunovic N, Belzile EL, *et al.* Predictors of outcomes after hip arthroscopic surgery for femoroacetabular impingement: A systematic review. Orthop J Sports Med 2019;7(6).
29. Mujahed T, Hassebrock JD, Makovicka JL, Pollock JR, Wilcox JG, Patel KA, *et al.* Preoperative intra-articular steroid injections as predictors of hip arthroscopy: 2-year outcomes. Orthop J Sports Med 2021;9(11).
30. Ayeni OR, Farrokhyar F, Crouch S, Chan K, Sprague S, Bhandari M. Pre-operative intra-articular hip injection as a predictor of short-term outcome following arthroscopic management of femoroacetabular impingement. Knee Surg Sports Traumatol Arthrosc 2014;22:801-5.
31. Martins EC, Gomes DA, de Brito Fontana H, Fernandes DA. Does response to preoperative intra-articular anesthetic injections predict outcomes of femoroacetabular impingement syndrome? Arch Orthop

Trauma Surg 2023;143:6283-94.
32. Malik AT, Sridharan M, Bishop JY, Khan SN, Jones GL, Neviaser AS, *et al*. Health care utilization and costs in the year prior to arthroscopic rotator cuff repair. Orthop J Sports Med 2020;8(7).
33. Kunze KN, Polce EM, Clapp IM, Alter T, Nho SJ. Association between preoperative patient factors and clinically meaningful outcomes after hip arthroscopy for femoroacetabular impingement syndrome: A machine learning analysis. Am J Sports Med 2022;50:746-56.
34. Nwachukwu BU, Beck EC, Lee EK, Cancienne JM, Waterman BR, Paul K, *et al.* Application of machine learning for predicting clinically meaningful outcome after arthroscopic femoroacetabular impingement surgery. Am J Sports Med 2020;48:415-23.
35. Kaspar S, de V de Beer J. Infection in hip arthroplasty after previous injection of steroid. J Bone Joint Surg Br 2005;87:454-7.
36. Harris JD. Editorial commentary: Be careful with preoperative injections prior to hip arthroscopy-use a three-month threshold to reduce infection risk. Arthroscopy 2017;33:1995-7.
37. Lai Q, Cai K, Lin T, Zhou C, Chen Z, Zhang Q. Prior intra-articular corticosteroid injection within 3 months may increase the risk of deep infection in subsequent joint arthroplasty: A meta-analysis. Clin Orthop Relat Res 2022;480:971-9.
38. Saracco M, Ciriello V, D'Angelo F, Zagra L, Solarino G, Logroscino G. Do prior intra-articular injections impact on the risk of periprosthetic joint infection in patients undergoing total hip arthroplasty? A meta-analysis of the current evidences with a focus on the timing of injection before surgery. EFORT Open Rev 2023;8:459-67.
39. Wang D, Camp CL, Ranawat AS, Coleman SH, Kelly BT, Werner BC. The timing of hip arthroscopy after intra-articular hip injection affects postoperative infection risk. Arthroscopy 2017;33:1988-94.e1.
40. Byrd JW, Bardowski EA, Civils AN, Parker SE. The safety of hip arthroscopy within 3 months of an intra-articular injection. J Bone Joint Surg Am 2019;101:1467-9.
41. Varady NH, Amen TB, Abraham PF, Chopra A, Freccero DM, Smith EL, *et al.* Image-guided intra-articular hip injections and risk of infection after hip arthroscopy. Am J Sports Med 2021;49:2482-8.
42. Coronel MF, Labombarda F, González SL. Neuroactive steroids, nociception and neuropathic pain: A flashback to go forward. Steroids 2016;110:77-87.

The Association between the Duration of Anterior Cruciate Ligament Rupture-reconstruction with Meniscal Lesions and Knee Functional Outcomes

Ahmad Ghoochani Khorasani[1], Cyrus Afshar[1], SeyedHadi Aghili[2,3], Mehri Farhang Ranjbar[4], Amirhossein Golshaninejad[5]

[1]Research Center for Trauma in Police Operations, Directorate of Health, Rescue and Treatment, Police Headquarter, [2]Neurosurgery Department, Imam Khomeini Hospital Complex, Tehran University of Medical Sciences, [3]Department of Neurosurgery, Valiasr Hospital, [4]Department of Support and Services Management, Institute of Management and Organizational Resources, Policing Science and Social Studies Research Institute, [5]Bone Joint Related Tissues Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran

Abstract

Background: Given the controversial correlation between the duration of anterior cruciate ligament (ACL) rupture-reconstruction and knee functional outcomes reported in previous studies, this study aimed to investigate the correlation between the duration of ACL rupture-reconstruction with knee meniscal lesions and functional outcomes. **Patients and Methods:** This retrospective cohort study was conducted on 221 patients with ACL rupture who underwent ACL reconstruction at a referral hospital in Tehran, Iran, from April 2021 to May 2023. Demographic characteristics and data about the duration of ACL rupture reconstruction were collected using the patients' clinical documents. The status of knee meniscal lesions had been evaluated using magnetic resonance imaging report or operation note. After that, knee functional outcomes had been assed using Osteoarthritis Outcome Score scale. The correlation between the duration of ACL rupture-reconstruction with knee meniscal lesions and functional outcomes was evaluated using the multivariate regression test. **Results:** Most patients were male, with a mean age of 28.38 ± 7.33 years. The correlation between the duration of ACL rupture-reconstruction and knee meniscal lesions was statistically significant ($P = 0.026$); however, the correlation between the duration of ACL rupture-reconstruction with the KOOS questionnaire scale score and all its dimensions as a scale for assessing knee outcomes was not significant ($P > 0.05$). **Conclusion:** Although early ACL reconstruction is accompanied by reduced knee meniscal lesions, this cannot improve knee functional outcomes.

Keywords: Anterior cruciate ligament, anterior cruciate ligament rupture, knee functional outcomes, knee joint, knee meniscal lesions, reconstruction timing

Introduction

The knee joint is one of the most important joints, which plays a fundamental role in performing various lower limb actions.[1] This joint is inherently an unstable joint, and its stability is mainly due to its ligaments.[2] The anterior cruciate ligament (ACL)[3] is one of these ligaments that provides stability and prevents knee displacement during activity.[4,5]

ACL rupture is one of the most common ligament injuries in the knee joint,[6] which includes approximately 100–200 thousand cases in athletic people annually.[5] Its incidence in the United States is about 250,000 ruptures per year.[7] Routine treatment for ACL rupture is a surgical reconstruction;[8] however, reconstruction timing has remained controversial.[4,9,10] It is widely believed that the duration of ACL rupture-reconstruction is an important predictor in determining ACL results.[6] Previous studies showed contradictory results; Smith *et al*. found no significant difference between the clinical outcomes of patients undergoing early ACL reconstruction compared to those delayed.[9] Manandhar *et al*. found no differences in terms of functional outcomes in early and delayed ACL reconstructions.[6] Deabate *et al*. stated that the duration of ACL

Access this article online

Quick Response Code:

Website: https://journals.lww.com/jajs

DOI: 10.4103/jajs.jajs_95_23

Address for correspondence: Dr. Amirhossein Golshaninejad, School of Medicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
E-mail: amirgolshan75@yahoo.com

Submitted: 05-Dec-2023 **Revised:** 12-Apr-2024
Accepted: 13-May-2024 **Published:** 11-Oct-2024

How to cite this article: Khorasani AG, Afshar C, Aghili S, Ranjbar MF, Golshaninejad A. The association between the duration of anterior cruciate ligament rupture-reconstruction with meniscal lesions and knee functional outcomes. J Arthrosc Jt Surg 2024;11:211-5.

rupture-reconstruction did not affect the ultimate functional outcomes after surgery.[11] In contrast, Bottoni *et al*. said that early ACL reconstruction after injury yields excellent clinical outcomes,[12] and Lee *et al*. stated that early ACL reconstruction had acceptable clinical outcomes and stability compared to delayed reconstruction.[13]

Objective

Considering the reported controversial correlation between ACL rupture-reconstruction duration interval and ultimate functional outcomes in the previous studies, this study aimed to evaluate the correlation between the duration of ACL rupture-reconstruction with knee meniscal lesions and functional outcomes.

Patients and Methods

Study design and participants

This retrospective cohort study was conducted on 221 patients who suffered ACL rupture and underwent ACL reconstruction at Referral Hospital in Tehran, Iran, between April 2021 and May 2023. Written informed consent, as approved by the NAJA Applied Studies Center of Health and Rescue Deputy Ethics Committee, was obtained from all participants before entering the task procedure.

The inclusion criteria comprised patients who underwent ACL reconstruction and had no history of previous ACL reconstruction or any other knee surgery. Patients with incomplete information in the clinical document and ACL rupture accompanying medial, lateral, and posterior cruciate ligament tears were excluded. Demographic characteristics and data about ACL rupture-reconstruction duration were collected using the patient's clinical document through the hospital information system and, if necessary, by patients' phone calls. To evaluate the presence or absence of knee meniscal lesions, the patient's knee magnetic resonance imaging (MRI) report or operation note was achieved through the patients' clinical documents and reported by an orthopedic specialist. To assess knee functional outcome after surgery, patients completed the Knee Injury and Osteoarthritis Outcome Score (KOOS) questionnairethrough telephone or in-person visits 5 days after the surgery based on previous research.[14] Data were collected, and the correlation between ACL rupture-reconstruction time with knee meniscal lesions and functional outcomes was evaluated using statistical tests.

Data collection

For data collection, a checklist was used, which included characteristics such as age, gender, knee side, and duration of ACL rupture-reconstruction. Findings related to the presence or absence of knee meniscal lesions were collected using the patient's MRI report in the clinical document or reported findings in the operation note by surgeon observation during arthroscopy.

Knee functional outcomes following surgery were collected using the KOOS questionnaire. This questionnaire includes four dimensions of symptoms, pain ,activities of daily living (ADL) ,and sports/recreational activities related to the knee joint. The following formula was used to calculate the total KOOS and its domains.

$$100-\frac{((\text{Mean Score})*100)}{4}$$

In this way, the score of each dimension was calculated by replacement in the noted formula. For the KOOS total score calculation, the mean score of all questions was replaced instead of the mean score of each dimension. The score range for each dimension varies between 0 and 100, with a score of 0 indicating the high severity of the problem and 100 no problem.[15]

Statistical analysis

The data analysis was performed using the software IBM SPSS Statistics for Windows, version 27 (IBM Corp., Armonk, N.Y., USA). We conducted tests, including Chi-square, univariate, and multivariate logistic regression tests to examine the correlation, between the duration of ACL rupture reconstruction and knee meniscal lesions. Additionally, we evaluated the association between ACL rupture reconstruction duration and KOOS scale score using an ANOVA test. To determine significance, $P < 0.05$ was considered statistically significant.

Results

Results demonstrated that most patients were male, married, and self-employed, with a mean age of 28.38 ± 7.33 years and academic education. The most common injury location was the right knee [Table 1].

The clinical findings of the studied patients are summarized in Table 2; the findings indicate that most patients did not have meniscal lesions and had an ACL rupture-reconstruction time interval of more than 3 months. Additionally, the symptoms dimension had the greatest mean score of the KOOS dimensions [Table 2].

Table 1: Demographic characteristics of studied patients

Variable	Subvariable	Frequency, *n* (%)
Gender	Male	194 (87.8)
	Female	27 (12.2)
Marital status	Unmarried	133 (60.2)
	Married	88 (39.8)
Education	Academic	101 (45.7)
	Nonacademic	120 (52.3)
Knee side	Right	125 (56.6)
	Left	96 (43.4)
Job	Employee	102 (46.1)
	Self-employed	114 (51.6)
	Housewife	3 (1.4)
	Retired	2 (0.9)
Age (year)	Mean±SD (minimum–maximum)	28.38±7.33 (18–59)

SD: Standard deviation

The study found a statistically significant difference in the frequency distribution of patients with and without knee meniscal lesions across different time intervals of ACL rupture-reconstruction; however, there was no statistically significant difference in the mean score of the KOOS scale and its dimensions, including Symptoms, Pain, ADL, Sport/Rec, and QoL, across different time intervals of ACL rupture-reconstruction [Table 3].

The correlation between ACL rupture-reconstruction time and knee meniscal lesions was assessed using univariate and multivariate logistic regression. Univariate regression demonstrated that the correlation between ACL rupture-reconstruction time intervals and knee meniscal lesions was statistically significant, and longer ACL rupture-reconstruction duration caused more meniscal lesions. When we adjusted variables for confounders such as gender, age, and knee side, multivariate regression showed that considering <3-week ACL rupture-reconstruction time intervals as a reference, the time intervals of 3–6 weeks, 6 weeks to 3 months, and more than 3 months were the independent predictors for more knee meniscal lesions, with an odds ratio of 2.96, 3.48, and 4.25 times compared to <3-week time interval, respectively [Table 4]. Furthermore, based on previous studies, early (in the 3 weeks) and delayed (after 6 weeks) intervals could be considered the cutoffs for ACL rupture-reconstruction duration.[16]

Discussion

Our results demonstrated that longer ACL rupture-reconstruction duration was significantly an independent predictor for more knee meniscal lesions. This finding is in line with the previous studies that have shown that the knee meniscal lesion incidence in cases of ACL tears increases with time passage. Paletta *et al*.

Table 2: Clinical characteristics of studied patients; meniscal lesions, anterior cruciate ligament rupture-reconstruction time intervals, and Knee Injury and Osteoarthritis Outcome Score

Variable	Subvariable	Frequency, *n* (%)	
Meniscal lesions	Yes	83 (37.6)	
	No	138 (62.4)	
ACL rupture-reconstruction time intervals	<3 weeks	55 (24.9)	
	3–6 weeks	62 (28.1)	
	6 weeks–3 months	39 (17.6)	
	>3 months	65 (29.4)	
Scale	**Dimension**	**Mean±SD**	**Minimum–maximumn**
KOOS	Symptoms	52.24±14.13	14.29–82.14
	Pain	46.59±18.79	13.89–97.22
	ADL	44.61±22.72	22.06–95.59
	Sport/Rec	26.27±24.16	18.75–90
	QOL	41.28±15.08	20–90
	Total score	42.57±17.04	8.33–92.26

SD: Standard deviation, ADL: Activities of daily living, QoL: Quality of life, ACL: Anterior cruciate ligament, KOOS: Knee Injury and Osteoarthritis Outcome Score

Table 3: The association of anterior cruciate ligament rupture-reconstruction time intervals, with meniscal lesions and Knee Injury and Osteoarthritis Outcome Score

Variable	Subvariable	Meniscal lesions		*P*
		No, *n* (%)	Yes, *n* (%)	
ACL rupture-reconstruction time intervals	<3 weeks (*n*=55)	43 (78.2)	12 (21.8)	0.026*
	3–6 weeks (*n*=62)	39 (62.9)	23 (37.1)	
	6 weeks–3 months (*n*=39)	22 (56.4)	17 (43.6)	
	>3 months (*n*=65)	34 (52.3)	31 (47.7)	

KOOS dimension	ACL rupture-reconstruction time intervals, mean±SD				*P*
	<3 weeks	3–6 weeks	6 weeks–3 months	>3 months	
Symptoms	52.79±14.19	54.75±11.72	49.08±14.13	51.26±14.75	0.231**
Pain	50.05±21.94	48.11±18.45	41.16±16.56	45.47±17.00	0.124**
ADL	48.20±20.98	48.12±23.91	39.25±20.98	41.42±23.36	0.097**
Sport/Rec	25.9±22.85	26.37±22.94	21.41±26.33	29.38±25.08	0.448**
QOL	43.63±16.17	41.12±16.48	38.07±12.75	41.38±13.96	0.377**
Total	44.93±17.17	45.17±17.46	41.34±16.25	41.09±17.88	0.432**

*Chi-square, **ANOVA. ACL: Anterior cruciate ligament, KOOS: Knee Injury and Osteoarthritis Outcome Score, SD: Standard deviation, QoL: Quality of life, ADL: Activities of daily living

Table 4: The correlation between anterior cruciate ligament rupture-reconstruction duration and meniscal lesions (yes/no) using univariate and multivariate logistic regression

ACL rupture-reconstruction duration	Unadjusted				Adjusted			
	OR	*P*	95% CI		OR	*P*	95% CI	
			Lower	Upper			Lower	Upper
<3 weeks	Reference				Reference			
3–6 weeks	2.11	0.074	0.92	4.80	2.96	0.020	1.18	7.42
6 weeks–3 months	2.76	0.027	1.12	6.81	3.48	0.012	1.31	9.24
>3 months	3.26	0.004	1.46	7.30	4.25	0.001	1.76	10.25

OR: Odds ratio, CI: Confidence interval, ACL: Anterior cruciate ligament

stated that ACL rupture is associated with more knee meniscal lesions.[17] Tandogan *et al*. demonstrated that the longer time of ACL injury is significantly associated with greater knee secondary meniscal lesions.[18] In a study by O'Connor *et al*. conducted to investigate the factors related to additional knee injuries following ACL injury, the results showed that ACL rupture-reconstruction duration is one of the related factors to causing more knee meniscal lesions.[19] Another study showed that patients with ACL injury time of more than 2 years demonstrated knee meniscal lesion incidence 18-fold more than patients with <1 month.[20] Binfield *et al*. conducted a study to investigate the patterns of meniscal tears associated with ACL lesions in athletes, which indicated that a longer duration of ACL rupture-reconstruction was an independent predictor for more knee meniscal lesions.[21]

ACL rupture reduces knee stability and can interrupt the patient's movement, increase the risk of subsequent meniscus damage, and premature degeneration of the knee joint.[3] ACL rupture causes the knee to move forward in an unstable direction and the tibia to move abnormally around the femur. Not only does this movement eventually lead to joint meniscal erosion and premature arthritis, but it also increases the risk of damage to other knee elements.[22] It seems that one of the common reasons for the increasing meniscal damage and the creation of secondary lesions with time passage of ACL rupture is the increase of repeated trauma caused by anterior instability, which time passage causes joint wear and meniscal damage. Furthermore, the existing literature suggests that the timing of ACL injury and reconstruction significantly impacts meniscal damage. Early reconstruction may potentially mitigate meniscal damage, while delayed reconstruction or prolonged injury duration may lead to more substantial meniscal loss and damage. This underscores the importance of considering the timing of intervention in managing meniscal damage associated with ACL injuries.[20,23]

In this study, the KOOS scale score was conducted to assess the knee functional outcomes. The results showed that the time from ACL rupture to reconstruction did not affect functional outcomes. This finding is in line with the study by Raviraj *et al*. that stated ACL reconstruction had similar clinical and functional outcomes at ACL rupture-reconstruction time of fewer than 2 weeks compared to longer times.[24] Manandhar *et al*. found no clinical differences between early and delayed ACL reconstructions concerning the range of motion and knee function outcomes.[6] In their clinical trial study, Frobell *et al*. showed that an early ACL reconstruction strategy was not superior to a delayed one.[25] Previous systematic reviews and meta-analysis studies proved that the correlation between ACL rupture-reconstruction time and knee function outcomes is insignificant.[9,11,26,27]

On the other hand in contrast with our study, Bottoni *et al*. stated that early ACL reconstruction leads to better knee clinical outcomes and motion range.[12] In a 5-year follow-up, Chen *et al*. stated that early ACL reconstruction provides a better advantage compared to delayed type in terms of treatment and rehabilitation.[4] A review and meta-analysis study found that early ACL reconstruction has acceptable clinical outcomes and stability compared to delayed type.[13] A study by Ahlén and Lidén found that at a 2-year postoperative follow-up, patients who underwent early reconstruction had significantly better outcomes in terms of activity and exercise levels than those who underwent delayed reconstruction. The clinical relevance of this study is that early ACL reconstruction may be useful if patients want to lead a better daily life or continue to exercise at a higher level.[28]

Perhaps one of the most robust reasons for the lack of correlation between ACL rupture-reconstruction time and knee function following ACL reconstruction surgery is that this procedure is commonly conducted in patients with a similar approach. In this procedure, the rupture and defects in the length and consistency of the ACL in all patients are repaired during the operation, and practically, all patients, whether with a short or long injury period, have the same and similar conditions in their knees following the surgery, and this can be one of the main reasons for the lack of difference in postoperative outcomes for patients.

Conclusion

The correlation between ACL rupture-reconstruction times with the knee meniscal lesions was significant, while regarding knee function outcomes was not. We conclude that although early ACL reconstruction was associated with reduced knee meniscal lesions, it could not improve knee functional outcomes.

Limitations of the study

A major problem with this study was the lack of patient cooperation in completing the KOOS scale. Addressing this issue through incentives and planning according to the patient's preferred program may help address this deficiency. The data collection tool for this study was a patients' self-reported questionnaire, which was intricately influenced by individual, social, and environmental variables. Although a reliable tool was used in this study, the possibility of measurement error cannot be ignored. Additionally, personal, social, psychological, and family differences were uncontrollable variables in the present study that may have influenced the results. Furthermore, recruitment bias could be present because of the 221 eligible patients, most of whom are male. Furthermore, meniscal status as an important factor influencing knee functional outcome was not provided in this study, and future works could address it to provide a more comprehensive evaluation of the factors influencing knee functional outcomes post-ACL reconstruction.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Gupton M, Imonugo O, Terreberry RR, anatomy, bony pelvis and lower limb, knee. In: StatPearls. Treasure Island (FL): StatPearls Publishing LLC.; 2023.
2. Cuéllar R, Ruiz-Ibán MA, Cuéllar A. Anatomy and biomechanics of the unstable shoulder. Open Orthop J 2017;11:919-33.
3. Raines BT, Naclerio E, Sherman SL. Management of anterior cruciate ligament injury: What's in and What's out? Indian J Orthop 2017;51:563-75.
4. Chen J, Gu A, Jiang H, Zhang W, Yu X. A comparison of acute and chronic anterior cruciate ligament reconstruction using LARS artificial ligaments: A randomized prospective study with a 5-year follow-up. Arch Orthop Trauma Surg 2015;135:95-102.
5. Larwa J, Stoy C, Chafetz RS, Boniello M, Franklin C. Stiff landings, core stability, and dynamic knee valgus: A systematic review on documented anterior cruciate ligament ruptures in male and female athletes. Int J Environ Res Public Health 2021;18:3826.
6. Manandhar RR, Chandrashekhar K, Kumaraswamy V, Sahanand S, Rajan D. Functional outcome of an early anterior cruciate ligament reconstruction in comparison to delayed: Are we waiting in vain? J Clin Orthop Trauma 2018;9:163-6.
7. Filbay SR, Grindem H. Evidence-based recommendations for the management of anterior cruciate ligament (ACL) rupture. Best Pract Res Clin Rheumatol 2019;33:33-47.
8. Peltier A, Lording TD, Lustig S, Servien E, Maubisson L, Neyret P. Posteromedial meniscal tears may be missed during anterior cruciate ligament reconstruction. Arthroscopy 2015;31:691-8.
9. Smith TO, Davies L, Hing CB. Early versus delayed surgery for anterior cruciate ligament reconstruction: A systematic review and meta-analysis. Knee Surg Sports Traumatol Arthrosc 2010;18:304-11.
10. Flint JH, Wade AM, Giuliani J, Rue JP. Defining the terms acute and chronic in orthopaedic sports injuries: A systematic review. Am J Sports Med 2014;42:235-41.
11. Deabate L, Previtali D, Grassi A, Filardo G, Candrian C, Delcogliano M. Anterior cruciate ligament reconstruction within 3 weeks does not increase stiffness and complications compared with delayed reconstruction: A meta-analysis of randomized controlled trials. Am J Sports Med 2020;48:1263-72.
12. Bottoni CR, Liddell TR, Trainor TJ, Freccero DM, Lindell KK. Postoperative range of motion following anterior cruciate ligament reconstruction using autograft hamstrings: A prospective, randomized clinical trial of early versus delayed reconstructions. Am J Sports Med 2008;36:656-62.
13. Lee YS, Lee OS, Lee SH, Hui TS. Effect of the timing of anterior cruciate ligament reconstruction on clinical and stability outcomes: A systematic review and meta-analysis. Arthroscopy 2018;34:592-602.
14. Salavati M, Akhbari B, Mohammadi F, Mazaheri M, Khorrami M. Knee injury and osteoarthritis outcome score (KOOS); reliability and validity in competitive athletes after anterior cruciate ligament reconstruction. Osteoarthritis Cartilage 2011;19:406-10.
15. van de Graaf VA, Wolterbeek N, Scholtes VA, Mutsaerts EL, Poolman RW. Reliability and validity of the IKDC, KOOS, and WOMAC for patients with meniscal injuries. Am J Sports Med 2014;42:1408-16.
16. Vermeijden HD, Yang XA, Rademakers MV, Kerkhoffs GM, van der List JP, DiFelice GS. Early and delayed surgery for isolated ACL and multiligamentous knee injuries have equivalent results: A systematic review and meta-analysis. Am J Sports Med 2023;51:1106-16.
17. Paletta GA Jr., Levine DS, O'Brien SJ, Wickiewicz TL, Warren RF. Patterns of meniscal injury associated with acute anterior cruciate ligament injury in skiers. Am J Sports Med 1992;20:542-7.
18. Tandogan RN, Taşer O, Kayaalp A, Taşkiran E, Pinar H, Alparslan B, *et al*. Analysis of meniscal and chondral lesions accompanying anterior cruciate ligament tears: Relationship with age, time from injury, and level of sport. Knee Surg Sports Traumatol Arthrosc 2004;12:262-70.
19. O'Connor DP, Laughlin MS, Woods GW. Factors related to additional knee injuries after anterior cruciate ligament injury. Arthroscopy 2005;21:431-8.
20. Murrell GA, Maddali S, Horovitz L, Oakley SP, Warren RF. The effects of time course after anterior cruciate ligament injury in correlation with meniscal and cartilage loss. Am J Sports Med 2001;29:9-14.
21. Binfield PM, Maffulli N, King JB. Patterns of meniscal tears associated with anterior cruciate ligament lesions in athletes. Injury 1993;24:557-61.
22. Myer GD, Ford KR, Hewett TE. Rationale and clinical techniques for anterior cruciate ligament injury prevention among female athletes. J Athl Train 2004;39:352-64.
23. Riordan EA, Frobell RB, Roemer FW, Hunter DJ. The health and structural consequences of acute knee injuries involving rupture of the anterior cruciate ligament. Rheum Dis Clin North Am 2013;39:107-22.
24. Raviraj A, Anand A, Kodikal G, Chandrashekar M, Pai S. A comparison of early and delayed arthroscopically-assisted reconstruction of the anterior cruciate ligament using hamstring autograft. J Bone Joint Surg Br 2010;92:521-6.
25. Frobell RB, Roos EM, Roos HP, Ranstam J, Lohmander LS. A randomized trial of treatment for acute anterior cruciate ligament tears. N Engl J Med 2010;363:331-42.
26. Matthewson G, Kooner S, Rabbani R, Gottschalk T, Old J, Abou-Setta AM, *et al*. Does a delay in anterior cruciate ligament reconstruction increase the incidence of secondary pathology in the knee? A systematic review and meta-analysis. Clin J Sport Med 2021;31:313-20.
27. Ferguson D, Palmer A, Khan S, Oduoza U, Atkinson H. Early or delayed anterior cruciate ligament reconstruction: Is one superior? A systematic review and meta-analysis. Eur J Orthop Surg Traumatol 2019;29:1277-89.
28. Ahlén M, Lidén M. A comparison of the clinical outcome after anterior cruciate ligament reconstruction using a hamstring tendon autograft with special emphasis on the timing of the reconstruction. Knee Surg Sports Traumatol Arthrosc 2011;19:488-94.

Clinicoradiological and Arthroscopic Correlation of Meniscal Injuries

Jay Yashavant Date, Nitin Bhalerao, Chandrasen Chaughule, Sanket Tanpure

Department of Orthopaedics, Dr. Vithalrao Vikhe Patil Medical College and Hospital, Ahmednagar, Maharashtra, India

Abstract

Background: Menisci in knee joint serve very important functions of distributing joint stresses and stabilizing the joint. Meniscus tears are on the rise because of increased sports participation. Along with detailed history taking, the physical examination and special investigations such as magnetic resonance imaging (MRI) are required to diagnose meniscal injuries. A diagnostic arthroscopy is considered as the gold standard. Owing to heavy work duties, overdependence on MRI without due clinical examination is on the rise. The aim of our study was to correlate the findings of clinically diagnosed meniscal tears with its radiological and arthroscopic findings and to find out the reliability of clinical examination and MRI in meniscal injuries considering arthroscopy as the gold standard. **Materials and Methods:** It was a prospective, longitudinal study performed over 12 months. All patients fulfilling inclusion criteria underwent clinical examination and MRI scan; the data obtained were evaluated and correlated with arthroscopic findings. Using necessary equations sensitivity, specificity and accuracy were calculated. **Results:** The clinical examination showed sensitivity, specificity, and accuracy of 75%, 90.62%, and 83.33%, respectively, when correlated with arthroscopy. MRI scan showed sensitivity, specificity, and accuracy of 82.86%, 92%, and 86.67%, respectively, when correlated with arthroscopy. **Conclusion:** MRI and clinical examination are comparably sensitive, specific, and accurate for diagnosing meniscal injuries with a subtle preference toward MRI. Author recommends a thorough clinical examination should suffice, but having a MRI scan beforehand is always beneficial in the absence of other concerns to do MRI.

Keywords: Arthroscopy, knee, lateral meniscus, magnetic resonance imaging, medial meniscus, meniscal

Introduction

Menisci are the fibrocartilaginous tissues between the lower limb bones tibia and femur[1] and are responsible for joint fluid distribution, articular cartilage nutrition, and shock absorption. Menisci also help in increasing the articular surface area, thereby reducing and distributing the stresses and stabilizing the joint.

Localized medial or lateral joint line tenderness is the most important clinical finding in meniscal injuries. McMurray in 1942 proposed a test in *British Journal of Surgery*[2] known as McMurray's test which is now commonly used for examining knee and diagnosing meniscal injuries by orthopedic surgeons worldwide. Previously, clinical examination is the only way to diagnose meniscus and ligamentous derangements of the knee.

Kean *et al*.[3] in 1983 and Li *et al*.[4] in 1984 explored the potential of magnetic resonance imaging (MRI) in knee derangements. There have been discrepancies in the clinically diagnosed meniscal tears and radiologically diagnosed meniscal tears, especially in multi-ligamentous injuries. De Smet and Graf in a study of 400 records made a conclusion that in anterior cruciate ligament injury sensitivity of MRI scans was decreased.[5] Arthroscopy is the gold standard for diagnosing the meniscus injuries. Lundberg *et al*.[6] found 74% and 66% sensitivity and specificity, respectively, for medial and 50% and 84% for lateral meniscus (LM). They showed arthroscopy is the best diagnostic modality for acute knee injuries. On contrary, Mohan and Gosal[7] found 88% diagnostic accuracy of clinical examination for medial meniscus (MM) while for LM it was 92% and concluded that the diagnosis of meniscus tears by clinical examination is as reliable as the diagnosis by MRI.

Access this article online

Quick Response Code:

Website: https://journals.lww.com/jajs

DOI: 10.4103/jajs.jajs_89_23

Address for correspondence: Dr. Jay Yashavant Date,
At Otur, Junnar, Pune - 412 409, Maharashtra, India.
E-mail: drjaydate@gmail.com

Submitted: 20-Nov-2023 **Revised:** 04-Aug-2024
Accepted: 22-Aug-2024 **Published:** 11-Oct-2024

How to cite this article: Date JY, Bhalerao N, Chaughule C, Tanpure S. Clinicoradiological and arthroscopic correlation of meniscal injuries. J Arthrosc Jt Surg 2024;11:216-21.

Figure 1: (a and b) Magnetic resonance imaging picture of a grade III meniscal tear (bucket handle type longitudinal tear) and, (c) Same patient's arthroscopic picture showing displaced bucket handle tear in femoral intercondylar notch

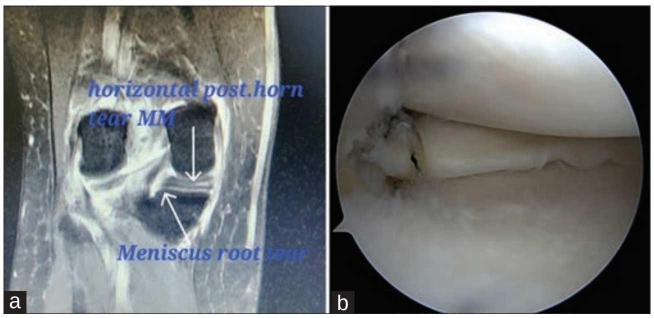


Figure 2: (a) Magnetic resonance imaging evidence medial meniscus posterior root tear and medial meniscus posterior horn horizontal tear while (b) Postrepaired status of the same root tear and postmeniscectomy status of inferior lip of the posterior horn

Figure 3: (a and b) Medial meniscus posterior horn tear signals (grade III) on Magnetic resonance imaging in a patient with clinically no joint line tenderness while (c and d) No arthroscopic evidence of the same thus necessitating the aim of this study

Arthroscopy has far more advantages than disadvantages. It can be used for both diagnostic and therapeutic purposes. It is minimally invasive and cosmetically advantageous. Arthroscopy when compared with arthrotomy reduces surgical site morbidity, and offers smoother rehabilitation.[8,9]

In modern days, because of heavy work duties and overdependence on higher investigations, patients are often asked for MRI scan without due clinical assessment. Furthermore, diagnostic accuracy of clinical examination is often questioned. Many times, MRI scans owing to their high sensitivity, show pathology even in clinically normal and asymptomatic patients that makes them unreliable for establishing the diagnosis [Figures 1-3].[9]

The aim of our study was to correlate the findings of clinically diagnosed meniscal tears with its radiological and arthroscopic findings and to find out reliability of clinical examination and MRI in meniscal injuries considering arthroscopy as the gold standard. Furthermore, we aimed to determine if it is possible to bypass MRI after a thorough clinical examination and directly perform arthroscopy in suspected cases, thereby reducing the time to intervene and financial burden of MRI on patients with poor socioeconomic status in countries like India.

Materials and Methods

It was a prospective, longitudinal study performed over 12 months.

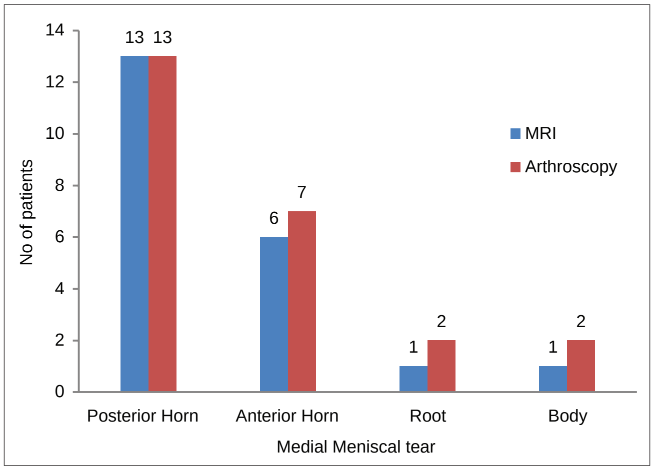
The study population included all the patients coming to the orthopedic clinic with injury to the knee. A total number of 60 patients were included in the study.

The inclusion criteria involved patients above 18 years and below 60 years of age:

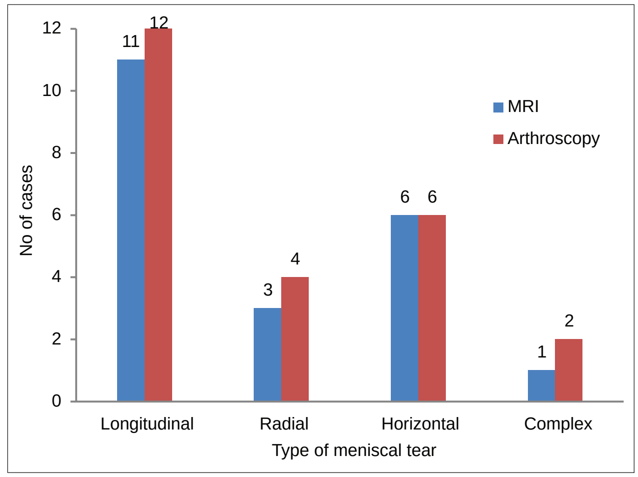
1. Having clinically diagnosed lateral and/or MM tears
2. Having radiologically (MRI) diagnosed lateral and/or MM tears
3. Undergoing either diagnostic or therapeutic arthroscopy for meniscus tear
4. With radiologically diagnosed lateral or MM tear willing to undergo arthroscopy with well informed and written consent.

The exclusion criteria were as follows:

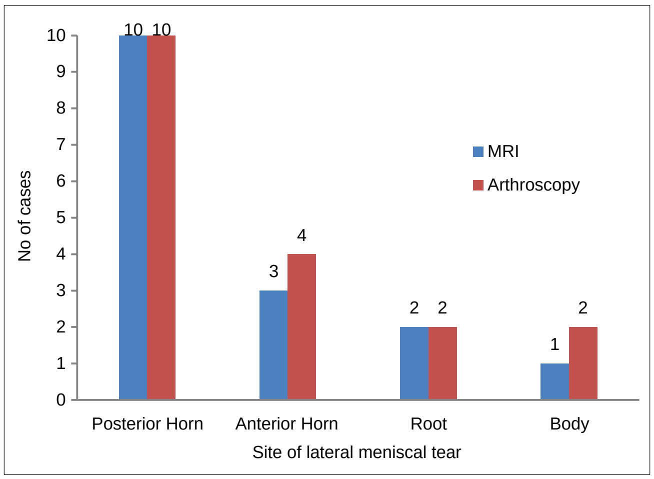
1. Gross osteo-arthritis of the knee where arthroscopy was not possible
2. Associated bleeding/coagulation disorders
3. Infected joint
4. Patients with ankylosed knee
5. Patients who have undergone previous arthroscopy
6. Patients not giving consent to be part of the study
7. Patients with contraindication to undergo MRI.



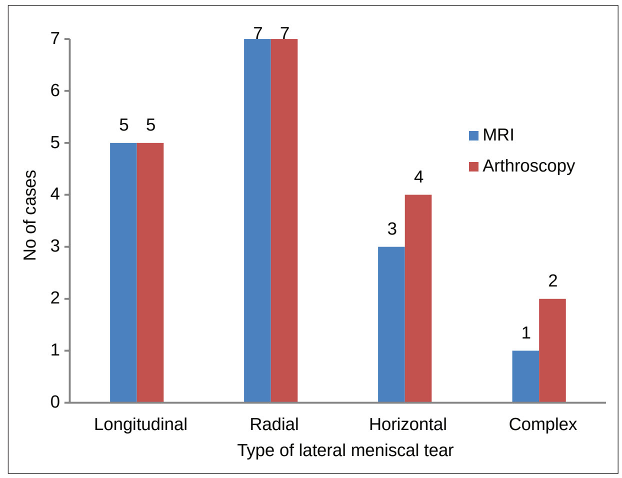
Graph 1: Site of medial Meniscal tear by various modalities



Graph 2: Type of medial Meniscal tear by various modalities



Graph 3: Site of Lateral Meniscal tear by various modalities



Graph 4: Type of Lateral Meniscal tear by various modalities

After acquiring the careful history regarding the injury mechanism, patients underwent clinical examination and those fulfilling the study criterion were referred to the radiology department for MRI evaluation.

Joint line tenderness and McMurray's test were used as the parameters for clinical evaluation.

The evidence, location, type, and grade of tear were used as the parameters to evaluate the injury on MRI and arthroscopy.

The same 1.5 Tesla MRI machine was used for all the patients.

All the arthroscopies as well as the clinical examinations were done by the same orthopedic surgeon.

Imaging characteristics of the knee menisci on MR imaging and arthroscopy were evaluated and correlated with the clinical profile. All the data were entered in Excel sheets. A probability value ("*P*" value) of ≤0.05 at 95% confidence interval was considered as statistically significant.

Results

Majority of patients belonged to the age group of 21–30 years (31.67%) followed by 31–40 years (26.66%). The study population involved 80% males and 20% females (male:female = 4:1). It was observed that 35% patients underwent MRI within 1 week of duration of symptoms (35%) followed by between 1 and 2 weeks of duration (26.67%). The patients above 6 months of duration were 6.67% only. Forty-one patients presented with acute trauma while 19 patients were late presenters from episode of trauma. Clinical evaluation showed that out of 60 subjects, McMurray test was positive among 21 (35%) patients and joint line tenderness was positive among 24 (40%) patients. The secondary signs were also looked for and showed joint effusion in 15 patients, meniscal cyst in 4 patients, medial collateral ligament edema in 2 patients, and 2 patients showed subchondral marrow edema on MRI.

The sensitivity and specificity of clinical examination were found to be 75% and 90.62%, respectively. The clinical examination showed accuracy of 83.33% as compared with arthroscopy findings [Table 1].

The sensitivity and specificity of MRI were found to be 82.86% and 92%, respectively. The MRI showed accuracy of 86.67% as compared with arthroscopy findings [Table 2].

Majority of patients were diagnosed with Grade III tear. 17 and 16 cases were observed to be grade three tears in arthroscopy and MRI, respectively [Table 3].

Discussion

Our objective was to correlate the findings of clinically diagnosed meniscal tears with its radiological and arthroscopic findings and to find out the reliability of clinical examination and MRI in meniscal injuries considering arthroscopy as the gold standard. Conflicting results emerged from previous studies by the review of the literature.

Majority of patients in our study belonged to the age group of 21–30 years (31.67%) followed by 31–40 years (26.66%). Antinolfi *et al*.[10] compared and correlated the clinical, MRI, and arthroscopic findings observed among 80 patients having ages 17 and 49 years (mean, 28.4 years). Similar findings were observed by Asif Rahman *et al*.[11] where the age range was 22 and 66 years and mean age was 37 years.

In our study, males constituted 80% of the study population and remaining 20% were females with the ratio being 4:1. B. R. Mohan *et al*.[7] in their study about reliability of clinical examination in meniscus injury included 130 patients with 69% males and 31% females. This finding goes in accordance with a review of literature that shows more male predilection than females in meniscal injuries.[11,12]

Out of 60 patients, McMurray test was positive among 35% patients and joint line tenderness was positive among 40% patients. B. R. Mohan *et al*.[7] in their study about reliability of clinical examination included 130 patients, of which 102 patients suggested medial meniscal tears (78%) and 28 patients suggested LM tears on clinical examination. In our study, we observed that MM tears tend to be more common than LM tears, which was also concluded in a study by Vande Berg *et al*.[13] In review of literature, many other studies have shown medial meniscal injury to be more common than LM injury.[10,14]

We observed that majority of patients were diagnosed with MM posterior horn tear (13 cases) in arthroscopy and MRI both both [Graph 1 and Table 4]. In MM injuries, majority of patients had longitudinal tear (52.94%) followed by horizontal tear (29.41%) while only 5.88% had complex tear [Graph 2 and Table 5]. In case of LM, majority of patients showed posterior horn tear on both MRI and arthroscopy [Graph 3 and Table 6]. Radial tears were more common followed by longitudinal tear in LM while only one patient showed complex tear on MRI and two patients were found to have complex tear in arthroscopy [Graph 4 and Table 7]. In menisci, according to Frobell *et al*.,[15] body and posterior horns are the most common tear locations in both the menisci.

Table 1: Correlation of clinical findings and arthroscopy findings of meniscal tear

Clinical findings	Arthroscopy findings		Total
	Positive	Negative	
Present	21	3	24
Absent	7	29	36
Total	28	32	60

Table 2: Correlation of magnetic resonance imaging findings and arthroscopy findings of meniscal tear

MRI findings	Arthroscopy findings		Total
	Positive	Negative	
Present	29	2	31
Absent	6	23	29
Total	35	25	60

MRI: Magnetic resonance imaging

Table 3: Distribution according to grade of meniscal tears by various modalities

Grade of meniscal tears	MRI	Arthroscopy
Grade I	6	7
Grade II	9	11
Grade III	16	17
Total	31	35

MRI: Magnetic resonance imaging

Table 4: Distribution according to the site of medial meniscal tears by various modalities

Site of medial meniscal tears	MRI	Arthroscopy
Posterior horn	13	13
Anterior horn	6	7
Root	1	2
Body	1	2
Total	21	24

Included isolated and combined. MRI: Magnetic resonance imaging

The sensitivity of clinical examination was 75% and specificity was 90.62%. The clinical examination showed accuracy of 83.33% as compared with arthroscopy findings. In a study by Ajaykumar *et al*.[12] on clinico-radiological and arthroscopic correlation of meniscal injuries, MM tear showed sensitivity, specificity, accuracy of 76.47%, 48.65%, and 60%, respectively, and LM tear showed sensitivity, specificity, and accuracy of 84.62%, 100%, and 96.92%, respectively. Similarly, Antinolfi *et al*.[10] compared and correlated clinical, MRI, and arthroscopic findings and observed that physical examination had better sensitivity (91% vs. 85%), specificity (87% vs. 75%), and accuracy (90% vs. 82%) than MRI for medial meniscal tears. Mohan *et al*.[9] showed the accuracy of clinical examination as 88% for MM and 92% for LM and concluded that clinical examination is as reliable as the MRI scan in meniscal injuries. According

Table 5: Distribution according to the type of medial meniscal tears by various modalities

Type of medial meniscal tears	MRI	Arthroscopy
Longitudinal	11	12
Radial	3	4
Horizontal	6	6
Complex	1	2
Total	21	24

Included isolated and combined. MRI: Magnetic resonance imaging

Table 6: Distribution according to the site of lateral meniscal tears by various modalities

Site of lateral meniscal tears	MRI	Arthroscopy
Posterior horn	10	10
Anterior horn	3	4
Root	2	2
Body	1	2
Total	16	18

Included isolated and combined. MRI: Magnetic resonance imaging

Table 7: Distribution according to the type of lateral meniscal tears by various modalities

Type of lateral meniscal tears	MRI	Arthroscopy
Longitudinal	5	5
Radial	7	7
Horizontal	3	4
Complex	1	2
Total	16	18

Included isolated and combined. MRI: Magnetic resonance imaging

to Dr. Bhattacharyya *et al.*,[16] when more than one test is used for clinical examination on the same patient, clinical examination proved to be comparable to MRI scans while diagnosing meniscal injuries.

The sensitivity of MRI was 82.86% and specificity was 92%. MRI showed accuracy of 86.67% as compared with arthroscopy findings. Rangger *et al*.[17] in their study of 121 patients recommended that MRI should be done before performing knee arthroscopy in all those cases in which the clinical examination showed suspected meniscus injury. Positive clinical and MRI findings constitute an even better idea regarding proceeding for arthroscopy rather than only clinical or MRI.[18]

Our study showed grade three injuries to be the more common in meniscus injuries. This goes in accordance with a study by Arumugam *et al*.[19] who studied MRI evaluation of acute internal derangements of knee (IDK) and observed that Grade III lesions were the most common accounting to 45%.

Literature shows that 5.6%–36% patients with asymptomatic knees have false-positive MRI findings with diagnostic error of 10%–20%. These inaccuracies are further increase above 40 years of age. Our results are in accordance with this literature as clinical examination offers slight edge than MRI in our study.[20,21] However, a delay between MRI and arthroscopy may be the cause for false positives as this delay may allow menisci to heal and intra-meniscal signal may persist giving us false-positive signal.[22]

We used a 1.5 T MRI machine that showed sufficiently accurate images for identifying and diagnosing meniscal abnormalities. Magee and Williams concluded that 3 T and 1.5 T MRI machines compared favorably in sensitivity and specificity for knee injuries.[23] MRI being a highly sensitive and accurate diagnostic modality has dramatically improved our ability to detect meniscus abnormalities, but further studies are needed to determine the true diagnostic performance of different field strength scanners in case of IDKs. Van Dyck *et al*.[24] suggested that 3.0 Tesla MRI did not improve the diagnostic accuracy significantly.

There is a paucity of published studies evaluating the incidence and breakdown of meniscus injuries of the knees with respect to multiple criteria such as epidemiology, incidence, site, type, and grade of injury in both lateral and medial menisci, especially in Asian countries such as India where traditional postures such as squatting and cross-legged sitting are prevalent in daily activities and cultural practices. These positions can exert considerable load on the knee joints, potentially contributing to meniscal injuries. A lack of data and variability in treatment combined with differences in access to healthcare and treatment options leads to many unnecessary knee arthroscopies, which are invasive procedures with their own set of risk and complications. Our study conclusion is crucial in such scenarios.

The limitation to this study was small sample size and there was an inherent verification bias as only patients referred for MRI were included in this study. This bias affected all patients as they all underwent MRI before arthroscopy that might have influenced the decision to perform arthroscopy.

Conclusion

From our study, we conclude that MRI and clinical examination are comparably sensitive, specific and accurate for diagnosing meniscal injuries with a subtle preference towards MRI. Clinical examination alone is fairly dependable alone to go ahead with arthroscopies in patients with contraindications to MR. Bypassing MRI as an investigation in meniscus injury management saves time as well as financial burden on the patients in countries such as India. Having said that MRI has its own advantages such as incidental findings of concomitant cruciate ligament injuries and other IDKs which in turn give us time to preplan and be well prepared in advance if going through arthroscopy. Hence, the author recommends a thorough clinical examination should suffice but having a MRI scan beforehand is always beneficial in the absence of any concerns to undergo MRI scan.

Ethical approval

Institutional ethics committee approval was obtained for this study.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Beaupré A, Choukroun R, Guidouin R, Garneau R, Gérardin H, Cardou A. Knee menisci. Correlation between microstructure and biomechanics. Clin Orthop Relat Res 1986. p. 72-5.
2. McMurray TP. The semilunar cartilages. Br J Surg 1942;29:407-14.
3. Kean DM, Worthington BS, Preston BJ, Roebuck EJ, McKim-Thomas H, Hawkes RC, *et al.* Nuclear magnetic resonance imaging of the knee: Examples of normal anatomy and pathology. Br J Radiol 1983;56:355-64.
4. Li KC, Henkelman RM, Poon PY, Rubenstein J. MR imaging of the normal knee. J Comput Assist Tomogr 1984;8:1147-54.
5. De Smet AA, Graf BK. Meniscal tears missed on MR imaging: Relationship to meniscal tear patterns and anterior cruciate ligament tears. Am J Roentgenol 1994;162:905-11.
6. Lundberg M, Odensten M, Thuomas KA, Messner K. The diagnostic validity of magnetic resonance imaging in acute knee injuries with hemarthrosis. A single-blinded evaluation in 69 patients using high-field MRI before arthroscopy. Int J Sports Med 1996;17:218-22.
7. Mohan BR, Gosal HS. Reliability of clinical diagnosis in meniscal tears. Int Orthop 2007;31:57-60.
8. Kim S, Bosque J, Meehan JP, Jamali A, Marder R. Increase in outpatient knee arthroscopy in the United States: A comparison of national surveys of ambulatory surgery, 1996 and 2006. J Bone Joint Surg Am 2011;93:994-1000.
9. Pawan S, Lalit J, Gupta N. Sensitivity and specificity of MRI in detecting meniscal tears, confirmed subsequently with arthroscopy. Int J Orthop Sci 2017;3:838-40.
10. Antinolfi P, Crisitiani R, Manfreda F, Bruè S, Sarakatsianos V, Placella G, *et al.* Relationship between clinical, MRI, and arthroscopic findings: A guide to correct diagnosis of meniscal tears. Joints 2017;5:164-7.
11. Rahman A, Nafees M, Akram MH, Andrabi AH, Zahid M. Diagnostic accuracy of magnetic resonance imaging in meniscal injuries of knee joint and its role in selection of patients for arthroscopy. J Ayub Med Coll Abbottabad 2010;22:10-4.
12. Ajaykumar SP, Varma KM, Arya S, Manni D, Ranjith AC, Kumar GS. Correlation of clinical, radiological and arthroscopic findings of meniscal and anterior cruciate ligament injuries of knee. Int J Orthop Sci 2017;3:92-5.
13. Vande Berg BC, Malghem J, Poilvache P, Maldague B, Lecouvet FE. Meniscal tears with fragments displaced in notch and recesses of knee: MR imaging with arthroscopic comparison. Radiology 2005;234:842-50.
14. Patel I, Chandru V, Nekkanti S, Renukarya R, Reddy VV, Gopalakrishna SV. Clinical, magnetic resonance imaging, and arthroscopic correlation in anterior cruciate ligament and meniscal injuries of the knee. J Orthop Trauma Rehabil 2018;24:52-6.
15. Frobell RB, Lohmander LS, Roos HP. Acute rotational trauma to the knee: Poor agreement between clinical assessment and magnetic resonance imaging findings. Scand J Med Sci Sports 2007;17:109-14.
16. Bhattacharyya S, Kumar S, Sarkar PS, Saha N, Mukhopadhyay KK. Clinical, MRI and arthroscopic correlation in meniscal injuries. Int J Orthop Sci 2018;4:1034-6.
17. Rangger C, Klestil T, Kathrein A, Inderster A, Hamid L. Influence of magnetic resonance imaging on indications for arthroscopy of the knee. Clin Orthop Relat Res 1996. p. 133-42.
18. Shetty C, Rathod G, Raut N, Borole P, Gawali V. Co-relation between MRI and arthroscopy findings in diagnosis of meniscus injuries based on location of the meniscus tear and radial position. Int Surg J 2022;9:612-5.
19. Arumugam V, Ganesan GR, Natarajan P. MRI evaluation of acute internal derangement of knee. Open J Radiol 2015;5:66-71.
20. Kocabey Y, Tetik O, Isbell WM, Atay OA, Johnson DL. The value of clinical examination versus magnetic resonance imaging in the diagnosis of meniscal tears and anterior cruciate ligament rupture. Arthroscopy 2004;20:696-700.
21. LaPrade RF, Burnett QM 2nd, Veenstra MA, Hodgman CG. The prevalence of abnormal magnetic resonance imaging findings in asymptomatic knees. With correlation of magnetic resonance imaging to arthroscopic findings in symptomatic knees. Am J Sports Med 1994;22:739-45.
22. Felli L, Garlaschi G, Muda A, Tagliafico A, Formica M, Zanirato A, *et al.* Comparison of clinical, MRI and arthroscopic assessments of chronic ACL injuries, meniscal tears and cartilage defects. Musculoskelet Surg 2016;100:231-8.
23. Magee T, Williams D. 3.0-T MRI of meniscal tears. Am J Roentgenol 2006;187:371-5.
24. Van Dyck P, Vanhoenacker FM, Lambrecht V, Wouters K, Gielen JL, Dossche L, *et al.* Prospective comparison of 1.5 and 3.0-T MRI for evaluating the knee menisci and ACL. J Bone Joint Surg Am 2013;95:916-24.

Original Article

Reliability of the Lever Sign Test in the Diagnosis of Anterior Cruciate Ligament Injuries: A Cross-Sectional Study with Interobserver Analysis

Surya Teja Malasani, Gadhamsetty Sai Ganesh, Munis Mohamed Ashraf, B. Pavithra, Navin Balasubramanian

Department of Orthopaedics, Saveetha Medical College and Hospital, Saveetha Institute of Medical and Technical Sciences, Chennai, Tamil Nadu, India

Abstract

Introduction: Anterior cruciate ligament (ACL) injuries are known to have a high rate of occurrence among athletes. The growing prevalence of these injuries demands research in this field to determine clinically reliable diagnostic techniques. **Aims:** The goal of this study was to compare the diagnostic accuracy of the lever sign test with other frequently used manual tests, such as the anterior drawer and Lachman test, and to evaluate the sensitivity and specificity of the lever sign test in the diagnosis of ACL injuries. **Study Design:** The study was conducted for a period of 1 year, from November 2021 to November 2022, among 100 patients presenting to orthopedic outpatient department in a tertiary care center with complaints of acute knee pain after a trauma to the knee. **Materials and Methods:** A thorough history, physical examination, and three manual tests for diagnosing an ACL tear were performed by an intern, orthopedic resident, and consultant after obtaining consent. Arthroscopy of the injured knee was taken as the reference standard. **Results:** Of 100 patients, 53 were surgical and 67 were nonsurgical; the mean patient age was 33 years (range, 16 + 6.38 years). The overall accuracy of the lever sign test was 83% (85% sensitivity and 81% specificity); the accuracy was almost similar at arrival and under anesthesia (at arrival 86%, under anesthesia 80%), when performed by interns, postgraduates, and consultants. **Conclusion:** The lever sign test is easier to perform, equally efficacious, and reliable in diagnosing ACL injuries when compared to the other conventionally used manual tests.

Keywords: Anterior cruciate ligament injuries, anterior drawer test, Lachman test, Lelli's test, lever sign test

Introduction

The anterior cruciate ligament (ACL) can tear if the injury is way beyond its tensile strength. Although the precise mechanism is unknown, it is believed that ACL injuries can lead to the early onset of osteoarthritis.[1] ACL tears can occur in a number of ways, including direct contact such as a football tackle, abrupt changes in direction, stopping suddenly, or slowing down when ACL tears can occur in a number of ways, including direct contact like a football tackle, abrupt changes in direction or stops, slowing down while sprinting, or poor landings from a jump.[1]

In several studies, including the one conducted by Benjaminse *et al*., the ACL has been said to have a high rate of injury among athletes for a long time now, and its growing prevalence necessitates research in the field of ACL for identifying reliable clinically diagnosable techniques and thereby aiding in efficient and orderly management.[2]

Access this article online

Quick Response Code:

Website: https://journals.lww.com/jajs

DOI: 10.4103/jajs.jajs_34_23

After obtaining a thorough history, a clinical examination was carried out using basic manual tests such as the Lachman test and anterior drawer test (ADT), which were initially described in the 1970s. In case of partial tears, these tests can be falsely normal, because of the stability provided by the remaining fibers.[3] Sometimes, due to swelling or reactive synovitis in acute knee injuries, patients may also develop pain resistance and be guarded due to fear of pain.[4] The initial assessment of ACL injuries is sometimes carried out by emergency medicine

Address for correspondence: Dr. Surya Teja Malasani, 28-2-46, Surya Mansion 1st Floor, Opp. Lalitha Jewellers, Mattam Veedhi, Rajahmundry - 533 103, Andhra Pradesh, India. E-mail: surya.malasani@gmail.com

Submitted: 31-Mar-2023 **Revised:** 11-Apr-2024
Accepted: 02-May-2024 **Published:** 11-Oct-2024

How to cite this article: Malasani ST, Ganesh GS, Ashraf MM, Pavithra B, Balasubramanian N. Reliability of the lever sign test in the diagnosis of anterior cruciate ligament injuries: A cross-sectional study with interobserver analysis. J Arthrosc Jt Surg 2024;11:222-7.

and primary care physicians, which might sometimes lead to misdiagnosis. In a study conducted by Guillodo *et al*., misdiagnosis of ACL injuries was done in 74% of acute knee injuries by emergency medicine physicians due to the difference in training level.[5] In such circumstances, magnetic resonance imaging (MRI) might prove useful, with sensitivity and specificity between 94% and 98%, in confirming an ACL tear.[6,7]

In recent years, several other tests have been developed for better clinical evaluation of ACL tears. One such test is Alessandro Lelli's "lever sign test" which is said to be an easy-to-perform clinical test and to have more potency when compared to the other three tests in partial and complete tears, irrespective of the interval from trauma to time of presentation at the hospital.[8]

The effectiveness of Lelli's test in diagnosing ACL injuries has only been subject to very few studies, each with differing conclusions.[9]

This study was conducted to evaluate the diagnostic accuracy of Lelli's test with other frequently used manual tests such as the ADT and Lachman test, as well as the sensitivity and specificity of the test to diagnose ACL injuries. The MRI findings of the injured knee are used as the reference standard.

Materials and Methods

Design

The trial was blinded and nonrandomized, the examiners were not aware of the patient's wounded leg before the assessments. All three tests were carried out initially at the time of arrival, later again, they were conducted under anesthesia before operating on the patient, with the intern conducting them first, followed by the orthopedic resident and consultant. The findings of each test were recorded and not revealed to the others. MRI data were compared to all of the findings. Definitive ACL status was determined by MRI for nonsurgical patients and with arthroscopy for surgical patients. Patients were divided into three group patients with no tear, partial tear, and complete tear [Flow Chart 1]. This study seeks to ascertain the interobserver association between the diagnostic acuity of the MRI results and the tests performed by the examiners.

Patients

This study was conducted at a tertiary center over a period of 1 year, from November 2021 to November 2022, a total of 100 patients with acute knee injuries were included in the study. Patients with comorbidities such as open injuries, systemic disorders, malignancies, and a previous history of rupture of ACLs were excluded from the study. Patients above the age of 16 with a history of trauma to the knee were included. Patients fitting the inclusion criteria were included in the study.

All the patients underwent 3T MRI T1, T2-weighted fat suppression sequences, and patients diagnosed with ACL tears, who underwent surgery within the stipulated time were included under the surgical cohort. Patients who required surgery but did not undergo surgery or delayed surgical procedures were included under the nonsurgical cohort.

Clinical tests

The examiners were blinded to the patient's history, side of injury, and MRI findings before the examination. Three tests were performed on the patients at arrival and before operating the patient under anesthesia by an intern, postgraduate, and consultant after obtaining consent.

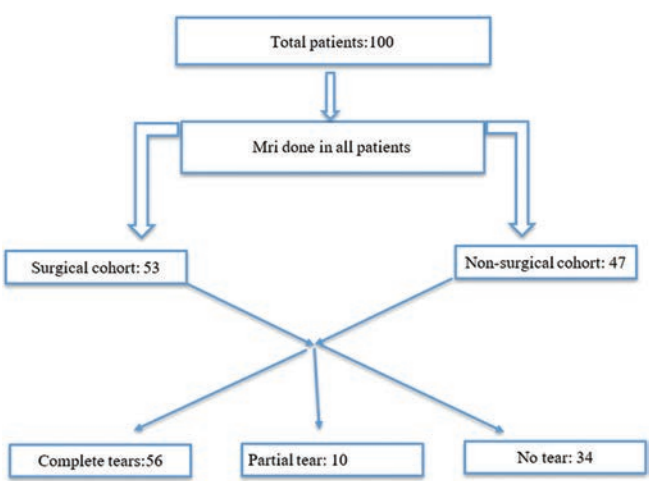
Lever sign test

The test resembles a seesaw, with the physician's fist placed under the patient's proximal calf acting as the fulcrum and the leg serving as the lever. A normal leg goes up when the examiner applies pressure to the distal third of the quadriceps [Figure 1].

Gravity and the clinician's hand downward pressure are downward forces acting over the leg.

As instructed by Lelli *et al*., the patient is made to lie supine with their legs completely extended during the test[10] [Figure 2].

The examiner stands at the side of the knee with his hand as a fulcrum beneath the proximal 1/3rd calf muscle, and the patient's distal femur end is pushed downward.



Flow Chart 1: Patient flow chart

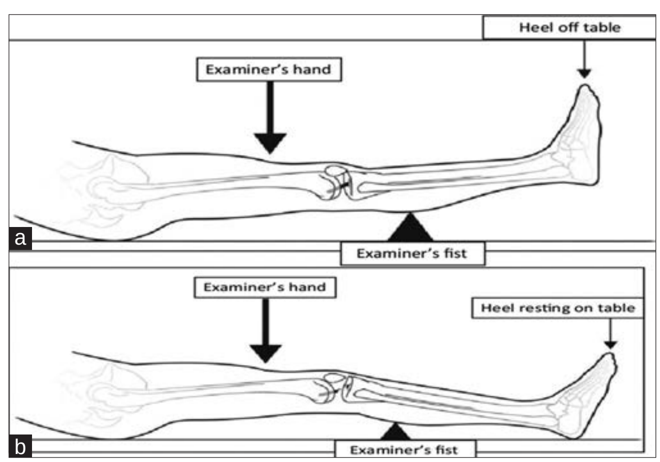


Figure 1: Lelli's test. (a) intact acl; (b) Acl tear

Interpretation

The test is negative if the heel rises when downward force is exerted over the quadriceps. The test is positive if a heel raise does not occur.

Lachman test

The test is performed by keeping the patient in a supine position with the knee in 20°–30° of flexion, examiner stabilizes the femur with one hand and, with the other, tries to translate the tibia anteriorly, and the test is compared with the unaffected side [Figure 3].

If there is more anterior translation of the proximal tibia than on the uninjured side and there is also a lack of a clear endpoint, the test is deemed positive. Endpoints are nominally categorized as A (firm, hard endpoint) or B (soft endpoint), ranging from "hard' to "soft" (absent, soft endpoint). When there is an abrupt endpoint preventing additional anterior translation of the tibia on the femur, it is considered a hard endpoint. A forward translation of the tibia without definite, firm, or clear endpoints is referred to as having a soft endpoint.

Anterior drawer test

The test is carried out with the patient in the supine position and the knee flexed to 45°–90° by stabilizing the foot with the thigh of the examiner, and the patient's tibia is translated anteriorly [Figure 4].

The test is considered positive if there is more translation compared with the normal side or if there is an absence of a firm endpoint.

Statistical analysis

Data were entered in Microsoft Excel spreadsheet, and SPSS Software was used to analyze the data (Version 23.0) (Statistical Package for the Social Sciences) IBM Corp,USA. Descriptive statistics were used to analyze the data, including frequency, percentages, mean, standard deviation, and 95% confidence interval. To determine the inter-examiner reliability, Kappa statistics and the Chi-square test were performed, and for sensitivity, specificity, positive predictive value, negative predictive value, and accuracy, respective mathematical formulas were used from the two-by-two tables obtained from cross tabs of SPSS output. Nonparametric tests were done for the categorical data in the study. A Wilcoxon sign rank test (a nonparametric variant of paired t-tests) was performed to analyze the difference between the test results by each group at arrival and under LA. To analyze the difference between test results with partial and complete tears of the ACL, the Mann–Whitney test (nonparametric variant of independent *t*-test) was performed. A Kruskal–Wallis test was done to analyze the differences between the test results among the intern, orthopedic resident, and consultant groups with a significance level < 0.05 ($P < 0.05$).

Figure 2: Performing Lelli's test

Figure 3: Performing Lachmann test

Figure 4: Performing anterior drawer test

Results

Sociodemographic details

In the present study, 64% of males and 36% of females participated with partial or complete ACL tears [Figure 5]. The mean age of the study participants was 33 (16 ± 6.38). Of 100 patients, 53 were surgical and 47 were nonsurgical; the mean patient age was 33 years (range, 16 + 6.38 years). The overall accuracy of the lever sign test was 83% (85% sensitivity and 81% specificity); the accuracy was almost similar at arrival and under anesthesia (at arrival 86%, under anesthesia 80%) when performed by interns, postgraduates, and consultants.

Mode and site of anterior cruciate ligament tear

The injured knee was on the left side in 50 patients (50%) and right in 50 patients (50%) [Figure 6]. Among the study participants, 30% of ACL tears were due to road traffic accidents, 54% were due to sports injury, and 16% were due to twisting injury [Figure 7].

All patients underwent MRIs as soon as they were evaluated. For patients diagnosed with ACL tears who underwent surgery, arthroscopic findings were taken as a reference standard and for

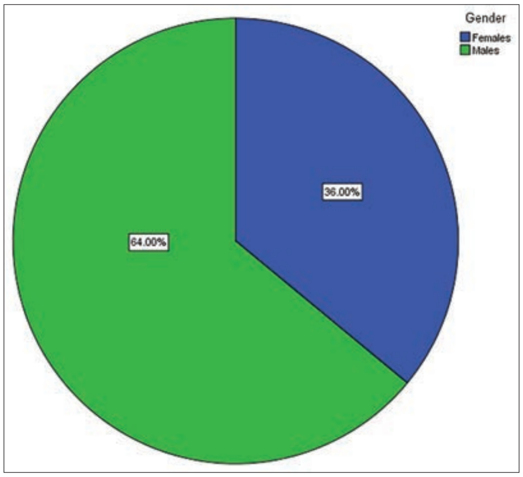


Figure 5: Gender distribution

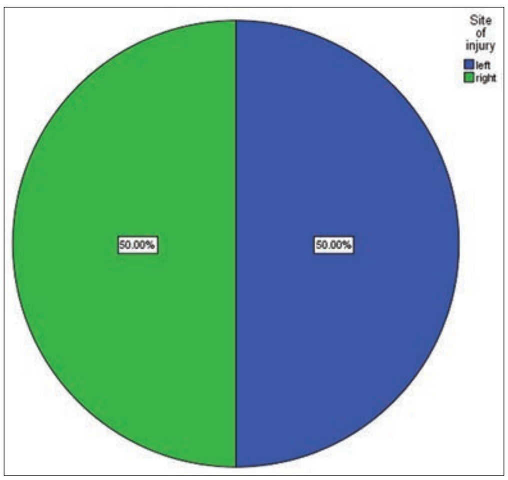


Figure 6: Side of injury

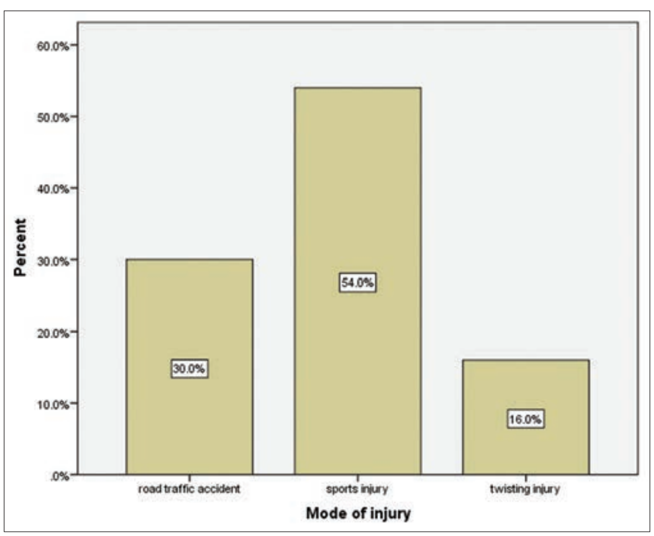


Figure 7: Distribution of mode of injury

patients under nonsurgical cohort, MRI is taken as reference standard.

Clinical test results

The sensitivity and specificity of the three manual clinical tests to diagnose ACL tear is tabulated in Table 1.

The kappa coefficient was substantial in lever sign test and was moderate in Lachman and ADT meaning test results were the same when performed by an intern, orthopedic resident, and consultant [Table 2].

Sensitivity of Lelli's test at arrival and under anesthesia was 89.2%and 82.29%, respectively. In this study, sensitivity was equal for Lachmann and ADT (i.e., 100%) and for Lelli's, it was 85%. The specificity was also found to be 81% for Lelli's 66% and 57% for Lachmann and ADT, respectively. The accuracy of Lelli's was found to be higher overall, i.e.,83% when compared to the other two tests which had accuracy of 78% (Lachmann) and 72% (ADT). Lelli's test also proved beneficial in diagnosing partial ACL tears [Table 3].

Discussion

In several studies, including the study by Crawford *et al*.,[6] due to its excellent sensitivity and specificity, which range from 94% to 98%, MRI has proven to be very helpful in the detection of ACL tears. In the current study, for evaluating the diagnostic efficacy of the lever sign test in ACL tears, arthroscopic findings were used as the reference standard in the surgical cohort and MRI in nonsurgical cohort. Regardless of the time of presentation, the lever sign test results were found to be in accordance with the diagnosis of ACL rupture made by MRI, as proposed by Alessandro Lelli in his study.[11]

In the present study, MRI was positive for an ACL tear in almost all the patients taken up for surgery, sensitivity was equal for Lachmann and ADT (i.e. 100%), and for Lelli's, it was 85%. The specificity was also found to be 81% for Lelli's 66% and 57% for ADT, respectively. The accuracy of Lelli's was found to be higher overall, i.e. 83%, when compared to the other two tests, which had an accuracy of 78% (Lachmann) and 72% (ADT).

Similarly, in a study by[12] Lichtenberg *et al*., lever sign test showed 100% specificity, but the specificity of ADT and Lachman test were 94% and 91%, respectively.[13] Jarbo *et al*. study's indicated that the Lachman test had the highest sensitivity at 90%, followed by the ADT at 88%, while the lever sign test had the lowest sensitivity at 63%.[13] On the contrary, the Lachman test had the maximum specificity of 96% which was followed subsequently by the ADT and lever sign test with specificities of 94% and 90%, respectively, in the study by Thapa *et al*.,[14] this could be because of the difference in the inclusion criteria of the patient group among the two studies.

Due to pain, edema, and hemarthrosis, acute injuries typically present a significant level of difficulty in the diagnosis. The lever sign test, according to Alessandro Lelli's study, is 100% sensitive in situations of acute ACL damage. When compared to the ADT and Lachman tests, which have sensitivity rates of

Table 1: Sensitivity and specificity of all three tests at arrival and under anesthesia

	At arrival (*n*=100)					Under anesthesia (*n*=53)				
	Sensitivity	Specificity	PPV	NPV	Accuracy	Sensitivity	Specificity	PPV	NPV	Accuracy
Lever sign test	89.51	83.45	73.48	94.53	86	82.29	80.17	67.98	88.51	80
Lachman test	100	67.56	62.21	100	79	100	65.78	59.21	100	77
ADT	100	58.96	55.61	100	73	100	56.18	54.05	100	71

PPV: Positive predictive value, NPV: Negative predictive value, ADT: Anterior drawer test

Table 2: Kappa coefficient

	n	kappa	Qualification	Sensitivity	Specificity	PPV (%)	NPV (%)	Accuracy (%)	*P*
Lever sign test	100	0.639	Substantial	85.29	81.81	70.73	91.52	83	0.000
Lachman test	100	0.578	Moderate	100	66.67	60.71	100	78	0.000
ADT	100	0.480	Moderate	100	57.57	54.83	100	72	0.000

PPV: Positive predictive value, NPV: Negative predictive value, ADT: Anterior drawer test

Table 3: *P* value for Lelli's test in diagnosing partial tears

	Partial ACL tear	Mean rank	Sum of ranks	Mann–Whitney *U* value	*P*
Lever sign test	Absent	50.06	4505.00	410	0.002*
	Present	54.50	545.00		
Lachman test	Absent	49.67	4470.00	375	0.04*
	Present	58.00	580.00		
ADT	Absent	49.33	4440.00	345	0.541
	Present	41.00	430.00		

ACL: Anterior cruciate ligament, ADT: Anterior drawer test, *refer to statistically significant

57.1% and 55.1%, respectively, in the current study, the lever sign test had the highest sensitivity of 83.67%. In contrast to the results of our investigation, similar to this present study, few authors have evaluated the efficacy of the lever sign test in acute cases of ACL tear, Massey *et al*. have found the sensitivity of lever sign test to be 90%, and Jarbo *et al.* found the sensitivity to be 63% in their studies.

In a study by Gürpinar *et al*., the authors established that meniscal tears can alter the stability of the knee and can affect the results of clinical tests done to check the integrity of ACL.[4] Few other studies have also found a similar relationship. According to the study done by Speziali *et al*., when patients had both ACL and meniscal injuries, the test's reliability decreased.[15] Similarly, in the study conducted by Massey *et al*., when there were simultaneous ACL and meniscal tears, the lever sign's diagnostic efficacy dropped from 89% to 74%.[16] In this present study, such associations affecting the diagnostic accuracy of the clinical tests were not assessed because of the inclusion criteria.

In our study, three tests were performed on the patients at arrival and before operating the patient under anesthesia by an intern, post postgraduate, and consultant. The accuracy was 86% at arrival and 80% under anesthesia, which was quite similar.

Like any other study, this one also has a few limitations. As the female patients included in this study were fewer, the differences among various age groups and genders were not assessed. As the number of cases of partial ACL tears included in this study is low, the assessment of the lever sign test in regard to its diagnostic accuracy in partial and complete ACL tears requires further evaluation. The outcome of this study may not be applicable to different clinical scenarios because it was conducted with a small sample size in a single hospital. The diagnostic accuracy of these tests can be generalized only to clinical setups with an almost similar set of patients. Future studies can be done with a larger sample size and in multiple clinical setups, like the study conducted by Jarbo *et al*., wherein they investigated the diagnostic accuracy of the lever sign test, Regardless of the time of presentation, the lever sign test results were found to be in accordance with the diagnosis of ACL rupture made by MRI, as proposed by Alessandro Lelli in his study.[17,18]

Nevertheless, this study also gives reliable information on the diagnostic accuracy of the lever sign test in assessing the integrity of ACL, has high interobserver reliability, and proves to be highly useful in current times as there are only a few studies, notably by Deveci *et al*., Lelli *et al*., Jarbo *et al*., and Thapa *et al*., investigating the diagnostic accuracy of the lever sign test in assessing the integrity of the ACL.

Conclusion

In our study, when compared to other commonly used manual procedures, it has been shown that the lever sign test is easy to perform, equally effective, and reliable in detecting ACL tears. A practitioner with varying levels of experience and a reasonable degree of reliability can perform this. The lever sign test can thus be employed in clinical settings for assessing the integrity of the ACL.

Financial support and sponsorship

Self.

Conflicts of interest

There are no conflicts of interest.

References

1. Beynnon BD, Johnson RJ, Abate JA, Fleming BC, Nichols CE. Treatment of anterior cruciate ligament injuries, part I. Am J Sports Med 2005;33:1579-602.
2. Benjaminse A, Gokeler A, van der Schans CP. Clinical diagnosis of an anterior cruciate ligament rupture: A meta-analysis. J Orthop Sports Phys Ther 2006;36:267-88.
3. DeFranco MJ, Bach BR Jr. A comprehensive review of partial anterior cruciate ligament tears. J Bone Joint Surg Am 2009;91:198-208.
4. Gürpınar T, Polat B, Polat AE, Çarkçı E, Öztürkmen Y. Diagnostic accuracy of lever sign test in acute, chronic, and postreconstructive ACL injuries. Biomed Res Int 2019;2019:363-367.
5. Guillodo Y, Rannou N, Dubrana F, Lefèvre C, Saraux A. Diagnosis of anterior cruciate ligament rupture in an emergency department. J Trauma 2008;65:1078-82.
6. Crawford R, Walley G, Bridgman S, Maffulli N. Magnetic resonance imaging versus arthroscopy in the diagnosis of knee pathology, concentrating on meniscal lesions and ACL tears: A systematic review. Br Med Bull 2007;84:5-23.
7. Lefevre N, Naouri JF, Bohu Y, Klouche S, Herman S. Sensitivity and specificity of bell-hammer tear as an indirect sign of partial anterior cruciate ligament rupture on magnetic resonance imaging. Knee Surg Sports Traumatol Arthrosc 2014;22:1112-8.
8. Deveci A, Cankaya D, Yilmaz S, Özdemir G, Arslantaş E, Bozkurt M. The arthroscopical and radiological corelation of lever sign test for the diagnosis of anterior cruciate ligament rupture. Springerplus 2015;4:830.
9. Zantop T, Brucker PU, Vidal A, Zelle BA, Fu FH. Intraarticular rupture pattern of the ACL. Clin Orthop Relat Res 2007;454:48-53.
10. Lelli A, Di Turi RP, Spenciner DB, Dòmini M. The "lever sign": A new clinical test for the diagnosis of anterior cruciate ligament rupture. Knee Surg Sports Traumatol Arthrosc 2016;24:2794-7.
11. Moses B, Orchard J, Orchard J. Systematic review: Annual incidence of ACL injury and surgery in various populations. Res Sports Med 2012;20:157-79.
12. Lichtenberg MC, Koster CH, Teunissen LP, Oosterveld FG, Harmsen AM, Haverkamp D, *et al*. Does the lever sign test have added value for diagnosing anterior cruciate ligament ruptures? Orthop J Sports Med 2018;6:232-236.
13. Jarbo KA, Hartigan DE, Scott KL, Patel KA, Chhabra A. Accuracy of the lever sign test in the diagnosis of anterior cruciate ligament injuries. Orthop J Sports Med 2017;5:232-237.
14. Thapa S, Lamichhane A, Mahara D. Accuracy of Lelli test for anterior cruciate ligament tear. J Inst Med 2015;37:94-7.
15. Speziali A, Placella G, Tei MM, Georgoulis A, Cerulli G. Diagnostic value of the clinical investigation in acute meniscal tears combined with anterior cruciate ligament injury using arthroscopic findings as golden standard. Musculoskelet Surg 2016;100:31-5.
16. Massey PA, Harris JD, Winston LA, Lintner DM, Delgado DA, McCulloch PC. Critical analysis of the lever test for diagnosis of anterior cruciate ligament insufficiency. Arthroscopy 2017;33:1560-6.
17. Logan MC, Williams A, Lavelle J, Gedroyc W, Freeman M. What really happens during the Lachman test? A dynamic MRI analysis of tibiofemoral motion. Am J Sports Med 2004;32:369-75.
18. Torg JS, Conrad W, Kalen V. Clinical diagnosis of anterior cruciate ligament instability in the athlete. Am J Sports Med 1976;4:84-93.

Meniscotibial Ligament Tear and Meniscocapsular Detachment of Anterior Horn of the Lateral Meniscus

Siddharth Gupta, Inderpreet Singh Oberoi, Rajeev Yadav, Vivek Vaibhav, Devendra Singh Solanki

Department of Orthopaedics, Artemis Hospitals, Gurgaon, Haryana, India

Abstract

The meniscotibial ligament (MTL) tear, along with a meniscocapsular separation, is a very rarely diagnosed injury pattern often missed on magnetic resonance imaging (MRI). The meniscus becomes hypermobile and can cause anterior knee pain, instability, and frequent locking. A 29-year-old female patient presented to the outpatient department with a history of a noncontact injury 3 months ago. Her Tegner Lysholm Knee Score was 41/100. On examination, there was lateral joint line tenderness and a positive McMurray test with a clicking sensation. MRI was performed, which showed torn fascicles in the anterior horn of the lateral meniscus. Knee arthroscopy confirmed that MTL was completely torn along with meniscocapsular detachment. A Scorpion jaw (Arthrex, Naples, FL) loaded with 2-0 FiberWire was used to take three bites from the meniscus. These ends of sutures were loaded on a 2.9 mm PushLock anchor and inserted at the tibia border. An 18G needle was loaded with a monofilament nitinol loop suture and passed through the capsule into the joint. A suture retriever was used to pick suture ends and pass through the loop. The monofilament loop was then pulled to pass the FiberWire ends from the capsule. All six FiberWire ends were passed through the capsule and three knots were tied from outside to reattach the capsule. This kind of injury can lead to anterolateral instability of the knee. Diagnosis of this lesion is very challenging and crucial. Biomechanical instability has prompted us to pay specific attention to its investigation and management. The described repair technique gives good results due to rigid fixation and the postoperative rehabilitation is also fast.

Keywords: Arthroscopy, meniscocapsular, meniscotibial

Introduction

Combined meniscotibial ligament (MTL) tear, along with meniscocapsular separation, is a very rarely diagnosed injury pattern often missed on magnetic resonance imaging (MRI).[1] Common insertion of both the MTL and capsule has been described by some authors.[2] Injury over this insertion can lead to this kind of rare pattern. The meniscus becomes hypermobile due to the detachment injury. This laxity can cause severe discomfort to the patient due to anterior knee pain, instability, and frequent locking. Most of the current literature focuses on the peripheral meniscal tears in the red zone but not specifically on the meniscocapsular and meniscotibial separations, which are very difficult to diagnose, not only radiologically but also by arthroscopic means.

Lateral meniscus tears are commonly associated with acute anterior cruciate ligament (ACL) tears and, if missed, can lead to a failed ACL surgery due to constant instability.[3] Repair of this injury is technically challenging but necessary for a good outcome. Due to the low sensitivity of MRI, preoperative diagnosis is not possible. Hence, arthroscopic evaluation remains the gold standard for diagnosis. The exploration of the anterolateral corner of the knee is very important during every diagnostic arthroscopy.

We report a case based on the repair technique of the MTL tear and meniscocapsular separation of the anterior horn of the lateral meniscus.

Video available on: https://journals.lww.com/jajs

Access this article online

Quick Response Code:

Website: https://journals.lww.com/jajs

DOI: 10.4103/jajs.jajs_71_23

Address for correspondence: Dr. Siddharth Gupta, Department of Orthopaedics, Artemis Hospitals, Gurgaon, Haryana, India. E-mail: drsiddharthgupta92@gmail.com

Submitted: 29-Aug-2023 **Revised:** 30-Jan-2024
Accepted: 13-May-2024 **Published:** 08-Aug-2024

How to cite this article: Gupta S, Oberoi IS, Yadav R, Vaibhav V, Solanki DS. Meniscotibial ligament tear and meniscocapsular detachment of anterior horn of the lateral meniscus. J Arthrosc Jt Surg 2024;11:228-30.

Case Report

A 29-year-old female patient presented to the outpatient department with a history of a noncontact injury due to a fall while walking followed by twisting around 3 months ago. She had complaints of knee pain, mild swelling, occasional feelings of instability, and frequent locking. She was not able to walk on stairs or squat. Furthermore, she required a cane to walk occasionally. Her Tegner Lysholm Knee Score[4] was 41/100. On examination, there was lateral joint line tenderness and a positive McMurray test with a clicking sensation. MRI was performed, which showed torn fascicles in the anterior horn of the lateral meniscus [Figure 1].

Informed consent was taken from the patient after explaining the procedure. Knee arthroscopy was performed using standard anteromedial and anterolateral portals. The lateral meniscus was confirmed to be hypermobile. On close examination, MTL was completely torn. Furthermore, a meniscocapsular detachment was seen, which confirmed a grave injury [Figure 2]. Debridement was done using a shaver device. A Scorpion jaw (Arthrex, Naples, FL) loaded with 2-0 FiberWire was used to take a bite from the meniscus. Three such bites were taken. These six ends of sutures were loaded on a 2.9 mm PushLock anchor (Arthrex, Naples, FL). It was inserted at the tibia border after drilling. Meniscotibial attachment was done. After this, an 18G needle was loaded with a monofilament nitinol loop suture and passed through the capsule into the joint. A suture retriever was used to pick the suture end and pass through the loop. The monofilament loop was then pulled to pass the FiberWire ends from the capsule. This was repeated six times for all sutures. All six FiberWire ends were passed through the capsule and three knots were tied from outside using another skin incision. Meniscus and capsule reattached [Figure 3 and Video 1].

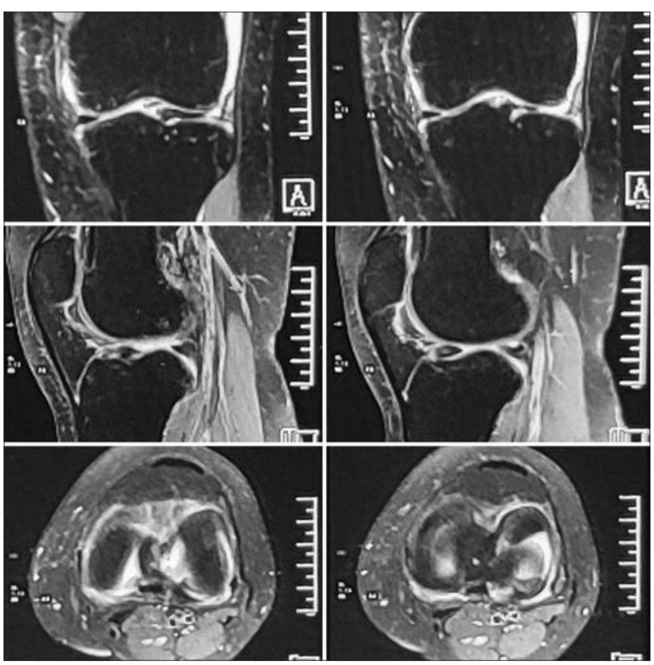


Figure 1: Magnetic resonance imaging: Coronal, sagittal, and axial cuts showing torn fascicles in the anterior horn of the lateral meniscus

Normal anatomy of the meniscotibial and meniscocapsular attachments has been shown in this normal snippet [Video 2]. The rehabilitation during the first 3 weeks focused on edema control and quadriceps-activation exercises. Protected weight-bearing was advised for the first 4 weeks as tolerable. The patient was able to successfully resume sporting activities after 6 postoperative months. The last follow-up was 1 year after surgery, and the patient was satisfied with the functional improvement (Tegner Lysholm Knee Score was 100/100).

Discussion

Meniscocapsular tears of the anterior horn of the lateral meniscus are often missed on MRI scans, even by experienced radiologists.[1] It is a very rare injury, especially when combined with a MTL tear. Several hypotheses have been described in the literature regarding the injury mechanism but nothing concrete has been recorded. This kind of injury can lead to anterolateral instability of the knee. When these lesions are missed by the clinician, complications include increased tibiofemoral contact pressure and a reduced contact area, leading to early osteoarthritic changes.[5] It can be very debilitating for the patient because, eventually, it becomes very difficult to perform daily activities.

The meniscocapsular ligament and MTL have a common insertion site as observed by many authors. An injury at this common insertion site can result in the disruption of both the MTL and meniscocapsular ligament. This site is referred to as the meniscosynovial junction.[2] The MTL appears to be the primary stabilizer of the meniscus. Thus, it acts as a true "belt" for the meniscus.[6] The diagnosis of this lesion is a challenge in itself, and its biomechanical importance has prompted us to pay particular attention to its investigation and management.

Left untreated or undiagnosed, these tears can lead to increased pressure on the knee joint, reduced contact area, and

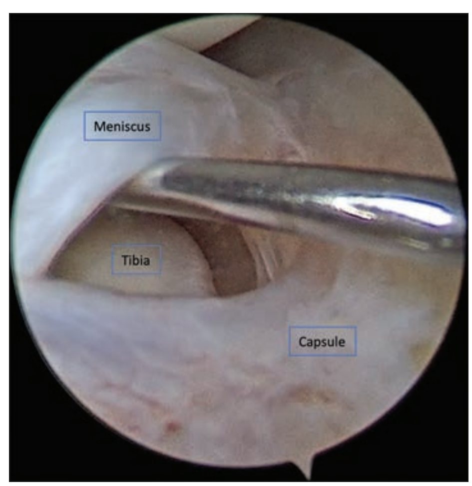


Figure 2: Arthroscopic view showing meniscotibial ligament tear and meniscocapsular detachment

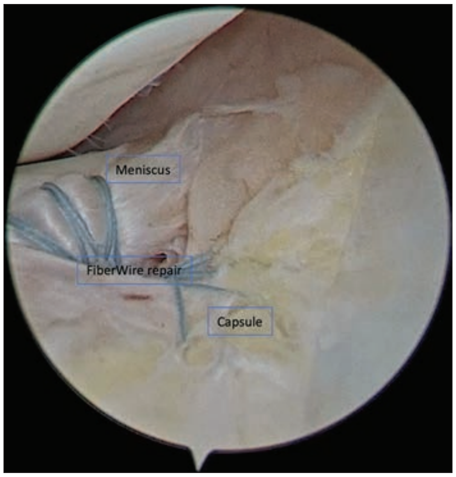


Figure 3: Arthroscopic view after repairing meniscocapsular and meniscotibial ligament

potentially accelerate the onset of osteoarthritis. Addressing these tears often requires specialized diagnostic techniques and surgical interventions tailored to repair both the MTL and meniscocapsular ligaments, aiming to restore stability and function to the knee while minimizing the risk of long-term complications.

We have described the arthroscopic technique to diagnose as well as repair this kind of injury pattern using FiberWire and suture anchor. This technique gives good results due to rigid fixation and quick postoperative rehabilitation. Different techniques have been described for the repair of the MTL, but none have described such a technique to repair both the MTL and meniscocapsular ligament in such a rigid manner.

Conclusion

The combined meniscocapsular separation and MTL tear in the anterior horn of the lateral meniscus is a rare and often misdiagnosed condition. This complex injury can lead to instability, pain, and joint complications. The arthroscopic repair technique outlined here, using FiberWire sutures and suture anchors, offers a robust solution for diagnosis and treatment. By addressing both ligament tears with stable reattachment, this method ensures effective rehabilitation and functional recovery. This case underscores the importance of thorough exploration during arthroscopy and contributes to the knowledge of managing intricate meniscal injuries for improved patient outcomes.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given her consent for her images and other clinical information to be reported in the journal. The patient understands that her name and initials will not be published and due efforts will be made to conceal her identity, but anonymity cannot be guaranteed.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. George J, Saw KY, Ramlan AA, Packya N, Tan AH, Paul G. Radiological classification of meniscocapsular tears of the anterolateral portion of the lateral meniscus of the knee. Australas Radiol 2000;44:19-22.
2. DePhillipo NN, Moatshe G, Chahla J, Aman ZS, Storaci HW, Morris ER, *et al.* Quantitative and qualitative assessment of the posterior medial meniscus anatomy: Defining meniscal ramp lesions. Am J Sports Med 2019;47:372-8.
3. Bellabarba C, Bush-Joseph CA, Bach BR Jr. Patterns of meniscal injury in the anterior cruciate-deficient knee: A review of the literature. Am J Orthop (Belle Mead NJ) 1997;26:18-23.
4. Lysholm J, Gillquist J. Evaluation of knee ligament surgery results with special emphasis on use of a scoring scale. Am J Sports Med 1982;10:150-4.
5. Alomar AZ. Novel type of medial meniscus ramp lesion: A case report and surgical technique. J Surg Case Rep 2021;2021:rjab538.
6. Peltier A, Lording T, Maubisson L, Ballis R, Neyret P, Lustig S. The role of the meniscotibial ligament in posteromedial rotational knee stability. Knee Surg Sports Traumatol Arthrosc 2015;23:2967-73.

Printed and published by Wolters Kluwer India Pvt. Ltd. on behalf of International Society for Knowledge for Surgeons on Arthroscopy and Arthroplasty and printed at Balaji Art, Bhandup (W), Mumbai, India. and published at A-202, 2nd Floor, The Qube, C.T.S. No. 1498A/2 Village Marol, Andheri (East), Mumbai - 400 059, India