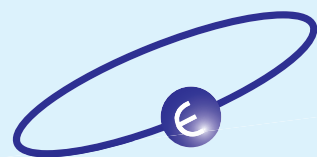


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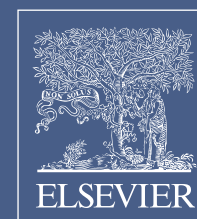
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Journal of Arthroscopy and Joint Surgery (JAJS) is committed to bring forth scientific manuscripts in the form of original research articles, current concept reviews, meta-analyses, case reports and letters to the editor. The focus of the Journal is to present wide-ranging, multi-disciplinary perspectives on the problems of the joints that are amenable with Arthroscopy and Arthroplasty. Though Arthroscopy and Arthroplasty entail surgical procedures, the Journal shall not restrict itself to these purely surgical procedures and will also encompass pharmacological, rehabilitative and physical measures that can prevent or postpone the execution of a surgical procedure. The Journal will also publish scientific research related to tissues other than joints that would ultimately have an effect on the joint function.

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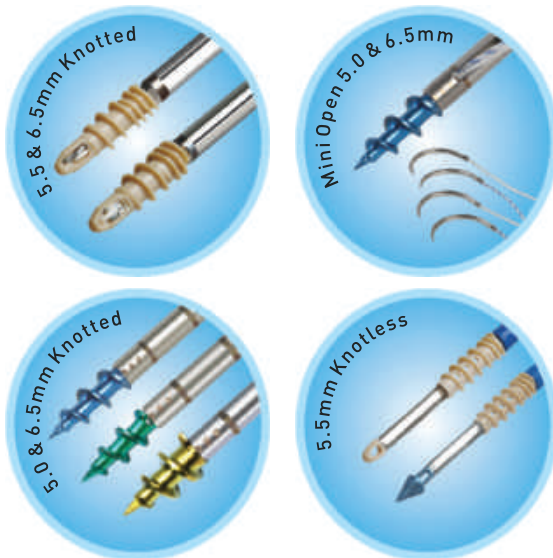


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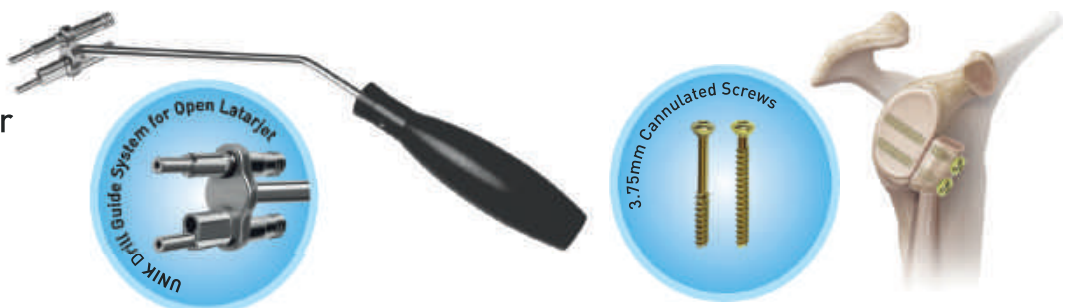


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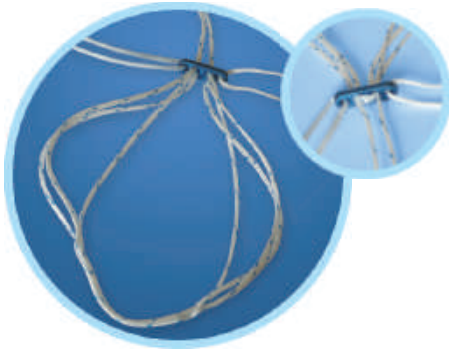
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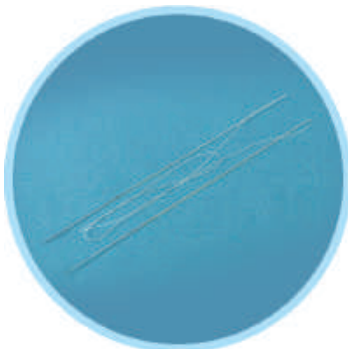


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Review article

Arthroscopy and COVID-19: Impact of the pandemic on our surgical practices



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ABSTRACT

The aim of this article is to study systematically current evidence on status of arthroscopic surgeries during the COVID-19 pandemic. We aim to study (1) changes in global arthroscopic practices, (2) recommendations on reducing risk to patients and health care workers (HCW), (3) changes in follow-up protocols of these patients.

Systematic search was carried out by two different reviewers using three different online databases for all studies published in the English language before April 2020. The total number of abstracts screened initially was 314. After screening of these abstracts, a total of 13 studies were included for the systematic review.

Numbers of orthopaedic injuries have seen a sharp fall during this time. Most elective surgical facilities were also closed at this time. Most studies have recommended telemedicine as an essential medium of providing continued care to patients during COVID-19. Studies have recommended that a conservative approach should be preferred for most patients with ligament injuries, and alternative procedures that have less requirement for an operating room should be explored. Common recommendation in all studies is that procedures of more elective nature should be postponed to a safer time frame when the transmission of COVID-19 virus in the population has declined. When surgeries are resumed, there is a need for triage of arthroscopy procedures from more important or urgent to less important ones. Elective surgical procedures should preferably be started with patients with no co-morbidities and lesser risk of peri-operative complications.

All patients undergoing surgery and health care personnels should have some screening for disease. Attempts should be made to have shortest hospital stay. Choice of anaesthetic procedure should emphasize on minimal aerosolization of the virus. Regional anaesthesia is the preferred choice as far as possible. Most guidelines have recommended that patient follow up should be made telephonically or on video-conferencing.

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1. Introduction

The novel coronavirus disease 2019 (COVID-19), caused by the severe acute respiratory syndrome coronavirus 2 (SARS Cov-2), started in Wuhan district of China in late 2019 and has made a huge dent on global economy. It has presented unexpected challenges to healthcare institutions worldwide. High infectivity and

low mortality of the infected patients make it a suitable agent for a pandemic. To contain spread of the virus most nations have implemented lockdowns, social distancing and quarantine. Healthcare resources have been diverted to cater the COVID-19 infected patients.¹ This has led to shut down of many elective surgeries and outpatient services. With time, most nations have realized that war with this infection is not easy. It is expected to continue for a long time and essential services need to carry on.

Guidelines have been issued for many surgical disciplines on resuming patient care. Several such guidelines have been issued for patients needing orthopaedic care. In orthopaedics mostly life or

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limb saving surgeries are being performed.² Management of other injuries that potentially impair function and quality of life remains a challenge. The arthroscopic surgeries are the standard of care for many ligament and soft tissue injuries. There is still an ambiguity regarding the indications and protocols of arthroscopic surgeries amidst the pandemic.

The aim of this article is to study systematically current evidence on status of arthroscopic surgeries during the COVID-19 pandemic. We aim to study (1) changes in global arthroscopic practices, (2) recommendations on reducing risk to patients and health care workers (HCW), (3) changes in follow-up protocols of these patients.

2. Material and methods

Systematic search was carried out in confirmation with Cochrane Collaboration, Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Literature search was carried out by two different reviewers using three different online databases: PubMed (<http://www.ncbi.nlm.nih.gov/pubmed>), EMBASE (<http://www.elsevier.com/online-tools/embase>), and Google Scholar, for all studies published in the English language before 31 May 2020. Search was carried out using terms: (“COVID-19” “coronavirus”) AND (“Arthroscopy”, “ligament injuries”, “Orthopaedics”, “ligament injury”, “Knee injuries”). References of all the included studies were also screened. ‘Similar articles’ and ‘cited by’ option on PubMed were also used. Websites of following orthopaedic or medical societies were also searched for available guidelines: British orthopaedic association, American association of orthopaedic surgeons, American college of surgery, Royal college of surgeons, ESSKA and SICOT.

Search was not limited by the type of study. All studies irrespective of level of evidence were included for this review. Literature on this topic is expected to be recent. Many guidelines on orthopaedic surgeries are expected to include recommendations on arthroscopic surgeries. Hence, we also screened studies on orthopaedic practices during COVID-19. Data was extracted from the included studies by 2 independent reviewers.

3. Results

The total number of abstracts screened initially was 314. After screening of these abstracts, a total of 13 studies (Table 1) were included for the systematic review. Fig. 1 shows the PRISMA flow-diagram for the literature search. There were eight review articles, four guidelines from experts and one editorial commentary.

3.1. Impact on elective clinics and surgeries

Numbers of orthopaedic injuries have seen a sharp fall during this time.^{1,2} Most studies in the review agreed that all major elective surgeries are shut during this period.^{3–11} Though the number of sports injuries have decreased, facilities to manage them early have also decreased tremendously. Massey et al.⁴ has suggested that extend to which elective operating is shut should depend upon the needs of the respective hospital. Rationalization of resource utilization to cater to COVID-19 pandemic should be kept in kind. They suggested that length of stay can also be considered along with urgency of the surgical procedure in deciding which procedures should be allowed to be performed.

3.2. Telemedicine tool

Most studies have recommended telemedicine as an essential medium of providing continued care to patients during COVID-

19.^{3–5, 7–9, 12} It has become difficult for patients to reach hospitals to seek care and for hospitals to provide a safe environment for the non-infected patients. Safety of HCWs is also at stake, which can prove more dangerous in terms of spread of the infection. Surgical consent prior to surgery is also recommended by authors to be made on a virtual platform to avoid or shorten hospital visit and exposure to a greater number of people.¹²

3.3. Back-trail to conservative treatment

Studies have recommended that a conservative approach should be preferred for most patients with ligament injuries, and alternative procedures that have less requirement for an operating room (OR) should be explored.^{5, 8, 13} This will reduce the risk of exposure to patients and HCW and will also reduce burden on hospital resources which are already working at a stretched capacity.

3.4. Delay is desirable

Before any procedure is contemplated, impact of delay on primary surgical outcomes should be considered. Whereas urgent procedures may not be delayed, for example arthroscopic lavage for septic arthritis, procedures of more elective nature should be postponed to a safer time frame when the transmission of COVID-19 virus in the population has declined and the peak of new cases has fallen. The exact fate of this virus is unknown, and this uncertainty may continue to linger for some more time.¹⁰ A balanced approach has to be adopted, for not risking health and life of the patients and HCW and at the same time not depriving patients of the timely required surgeries.

Most studies agree that there are only a few indications for acute treatment of knee ligament injuries.^{3, 4, 8, 10, 12–14} Most single ligament injuries like anterior cruciate ligament (ACL) or posterior cruciate ligament injuries are generally managed in a delayed fashion with good outcomes.¹⁰ Trend to operate early on these injuries is more recent. It has not shown any benefit in literature, and had to defend itself from reported complications of early surgery.¹⁵ Patients operated acutely and those operated after six weeks of injury have been shown to have similar outcomes.^{16–18} In patients with repeated instability episodes, incidence of cartilage changes and meniscal tears have been shown to increase 1 year after the injury.^{19, 20} Meniscal injuries similarly are generally given a trial of conservative treatment, unless it presents with an acute locked knee.^{8, 10, 13, 14, 21}

Combined guideline from the British orthopaedic association and other orthopaedic societies of British origin⁹ has recommended that ligament injuries of the knee may be managed with bracing in preference to early ligament reconstruction. A removable brace should be preferred to a cast for extremity injuries. A specific follow up duration is not recommended for these patients, but a patient-initiated follow up is recommended.

Ding et al.¹³ defined surgical timings of various arthroscopic procedures based on a review of the literature. Acute tendon rupture was the only condition needing surgery in less than a week. Other indications that needed treatment within 3 weeks included anterior/posterior cruciate ligament avulsion injuries, multi-ligament knee injury, displaced osteochondral fractures, acute/severe rotator cuff tears and acute types III, IV, V, and VI acromioclavicular joint dislocations.

3.5. Triage of surgical procedures

Many authors have recommended that there is a need for triage of arthroscopy procedures from more important or urgent to less important.^{3–5, 8, 10–14, 21} Al-Jabir et al.⁵ recommended that

Table 1
Summary of the Literature on Arthroscopy Practices in COVID-19 Pandemic

S.No	Study	Year	Region	Study design	Methodology	Results regarding arthroscopic surgery/ligament injuries
1	Sarac NJ et al. ¹¹	2020	North America	Review (in US states)	Internet search engine	Procedure performed during COVID 19 outbreak at The Ohio State University. Displaced meniscal tears associated with locked knee Select acute ligament disruptions Tendon lacerations and Ruptures
2	Farrell et al. ⁸	2020	Australia, Canada	Review		Recommendation for pediatric orthopaedic patients Knee ligament injuries/Patellar managed by brace for 7–10 days, then commence ROM and directed written physiotherapy program. Teleconference at week 6 Dislocations and directed written physiotherapy MRI at month 3 to 4—late program reconstruction. ACL and shoulder reconstruction surgeries to be postponed. Locked knee/Bucket-Handle meniscal tear Admit for surgery-Arthroscopy ± repair Urgent surgical procedure-Use surgical Recommendations. Give written physiotherapy Instructions. Teleconference at week 6—with advice depending on surgery performed. Osteochondritis dissecans-Postpone Surgery.
3	Ding B.T.K et al. ¹³	2020	Singapore	Review	Database search (PubMed, Embase, Scopus, web of science, google scholar)	Described time frame for the surgery. Knee: Acute tendon ruptures (patellar or quadriceps) surgery in <1 week, Dislodged osteochondral fractures surgery in <2 weeks, Multi-ligament knee injury surgery in 2–4 weeks, Anterior/posterior cruciate ligament avulsion injuries surgery in <3 weeks (<2 weeks for tendinous avulsion), Meniscus tears surgery in <12 weeks. Shoulder: Acute/severe rotator cuff tears surgery in <3 weeks Recommendations for resuming elective surgery
4.	Mouton C et al. ¹²	2020	ESSKA	Recommendations		
5	Al-Jabir A et al. ⁵	2020	United Kingdom	Review		Recommended non-operative management of ligamentous knee injury patients.
6.	British Orthopaedic Association ⁹	2020	BOA, OTS, BSSH, BAPRAS, BSCOS, The British Association of Hand Therapists United Kingdom	Recommendations		Ligamentous injuries of the knee may be managed with bracing in preference to early ligament reconstruction.
7.	Gilat R. and Cole B.J ⁷	2020	North America	Editorial Commentary		
8.	Massey P.A et al. ⁴	2020	North America	Review		Categorized major orthopaedic surgeries by how long they can safely be delayed. Classified ligament and tendon repair or reconstruction surgeries as Priority C (expedited within 2 weeks) and Priority D (Within 3 months)
9.	de Caro F et al. ¹⁰	2020	Italy, Switzerland, Belgium	Review		Recommendations to return to orthopaedics operating rooms, Multilevel approach to clinics
10.	Liebensteiner M.C et al. ³	2020	Austria, Germany, Switzerland	Review	Online survey	A drastic reduction in arthroscopic procedures like rotator cuff repair and cruciate ligament reconstruction and an almost total shutdown of elective total joint arthroplasty was reported. Described ligament knee injuries as “Surgically Necessary” for Elective- Urgent Procedures
11.	DePhillipo N·N et al. ¹⁴	2020	North America	Recommendations		Locked knee with entrapped meniscus as level 2 surgery (with 1–2 weeks)
12.	Al-Rashed A et al. ²¹	2020	Kuwait	Recommendations		Multi ligamentous knee injury, Acute ACL with meniscal injury in young patient as level 4 surgery (delayed up to 3months) Knee Arthroscopic/open reconstructive procedures for meniscus/ligaments/tendons, Shoulder Arthroscopic/open reconstructive procedures for labrum/rotator cuffs, AC joint, capsule plication, Cartilage reconstruction procedures as level 5 surgery (delayed more than 3 months)
13.	Zagra L et al. ⁶	2020	Italy, Poland	Review	Data from the hospital	Reported decrease in number of patients planned for orthopaedic surgeries. Surgeries for Acute tendon lesion was authorized by Regional Authorities since March 14th 2020.

procedures can be triaged as those leading to threat to patient life if not performed immediately, those leading to permanent organ dysfunction if not performed and those with a risk of rapidly progressing severe symptoms and disease progression if not performed.

Guidelines of Kuwait association of surgeons divided orthopaedic procedures in levels of urgency.²¹ Septic joints (when managed arthroscopically) formed the only foremost indication for surgery. This was followed by locked knee with entrapped

meniscus. They were followed by multi-ligamentous knee injury and acute ACL with meniscal injury in young patient. All other reconstructive arthroscopic procedures were in the last recommended level of priority.

Sarac et al.¹¹ studied guidelines on elective surgeries by different states in USA. Most guidelines issued by the state were not clear on orthopaedic surgeries. They have recommended postponing of procedures which were not time-sensitive and did not endanger life, cause permanent dysfunction of extremity or risk progression

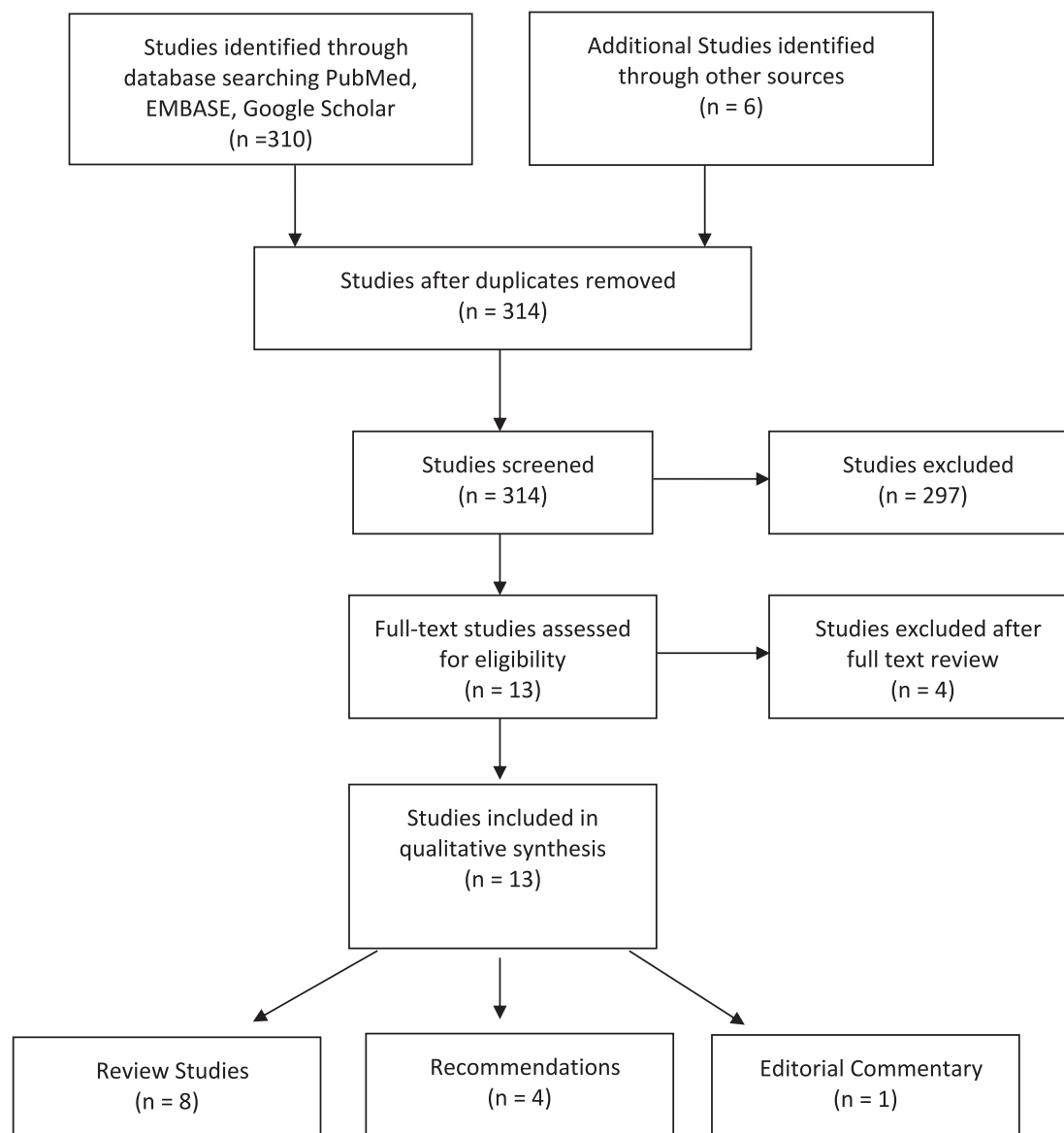


Fig. 1. PRISMA flow diagram

to severe symptoms. They also stated that procedures can be classified into categories according to priority. The procedures that they recommended to continue included displaced meniscal tears associated with locked knee, selected acute ligament injuries and tendon ruptures.

Similarly, DePhillipo et al.¹⁴ identified locked knees, bucket-handle tears of the menisci, acute knee injury, acute tendon ruptures (patellar or quadriceps), dislodged osteochondritis-dissecans lesions and anterior/posterior cruciate ligament osseous avulsion fractures as indications for urgent surgeries. These were identified as conditions that if untreated can lead to long-term disability and/or chronic pain.

Farrell et al.⁸ identified locked knee/bucket-handle meniscal tear as an indication for acute surgery. Other conditions such as paediatric ACL reconstructions, shoulder reconstructions and osteochondritis-dissecans were recommended to be followed up for surgery after the COVID-19 pandemic was over as the results of delayed treatment were as good as acute treatment.

Massey et al.⁴ also recommended triage of these patients for

arthroscopic surgery. They identified external fixation of knee dislocations as the only indication of emergency surgeries in patients with sports injuries. Ligament avulsion repair, locked knee from displaced meniscal tear, tendon ruptures, acute loose body removal and complete acromioclavicular joint dislocation as injuries to be operated in 2 weeks. ACL reconstruction, Multi-ligamentous knee reconstruction, Rotator cuff repair in young patients and Recurrent shoulder dislocation stabilization were recommended to be performed within 3 months.

Emergency department busy in management of patients with symptoms of COVID-19 infection cannot be a suitable place for evaluation and management of these patients. A separate clinic for emergency and out-patient management of these injuries in hospital should be created.¹⁰

3.6. When to resume surgery

Safety of patients, their attendants and healthcare professionals are the core consideration before routine surgical activities can be

resumed. Guidelines from ESSKA¹² have recommended that elective operating facility should be started in an area isolated from the general hospital catering to COVID-19 infected or un-screened patients. This could be a separate building or a separate institution catering to surgeries. Recommendations also include weekly testing of health care professional involved in delivery of care to the patients.

Surgical patients should be risk-stratified according to age, comorbidities and ASA grade.^{5,12} Elective surgical procedures should preferably be started with patients with no co-morbidities and lesser risk of peri-operative complications. Surgical Risk of COVID-19 exposure in these patients should be ascertained.

Liebensteiner et al.³ conducted online survey of orthopaedic surgeons in the German-speaking arthroscopy societies. There were 1399 responses. There were 10–30% responses that arthroscopies were still being performed. It varied with joints and indications. Response in favour of offering ACL reconstructions to patients were 25%. About 50% of the respondents said that rotator cuff repair was not being performed. Postoperative follow-up was severely affected. Routine clinical follow-up after surgery was available with only 57.1% of the participants and 11.9% of them were no longer following their operated patients.

3.7. COVID-testing before surgery

Up to 80% of people with COVID-19 showed mild or no symptoms at all.²² Routine preoperative screening for symptom is recommended.^{4,10,12,14} All patients undergoing surgery should have some screening for disease. ESSKA guidelines¹² have recommended that those patients who are not known to have been exposed or infected should get a COVID-RT-PCR (Reverse transcription polymerase chain reaction) test 48–72 h before surgery. For infected patients, surgery should be delayed for six weeks. Patients who are infected and have co-morbidities, these elective surgeries should be delayed for a longer time to reduce peri-operative morbidity. In patients who have signs and symptoms consistent with infection but have initially tested negative for COVID-19, or those who had been exposed to a COVID-19 positive patient but are asymptomatic, a repeat screen or a CT (Computed Tomography) scan should be considered before elective surgery. de Caro¹⁰ recommended that all patients be screened one day prior to surgery. They recommended CT scan as an effective and time-saving modality of screening. They also recommended that all HCWs be screened before facilities for elective surgery are opened.

Another important aspect regarding disease screening in arthroscopic surgeries is regarding use of allografts. It is being contemplated that COVID-19 testing of donors may be required in future and for recipients consent for risk of transmission of infectious diseases should include COVID-19 virus also.⁵

3.8. Peri-operative protection of patients and HCW

A risk-benefit assessment should be performed for each patient based on the urgency of the surgery. Surgeries with doubtful clinical efficacy need to be avoided. This is particularly important for procedures in elderly. Modifiable risk factors such as diabetes mellitus should be controlled prior to admission to reduce hospital stay.^{10,12} Risk of operating on an asymptomatic patient positive for SARS-CoV-2 is not clear.

For patients who have tested positive for COVID-19, arthroscopic surgery can be safely deferred. One possible indication for arthroscopy in such patients can be arthroscopic drainage of septic arthritis. Arthroscopic lavage can be preferred to open procedure in these patients. In such scenarios negative pressure rooms are recommended.²³ They should also be strongly considered for patients

who have a positive symptom screening where results of tests are not known.

Attempt should be made to minimize duration of hospital admission.^{4,8,10,12} Patients can be safely called on the day of surgery, once evaluation has been completed in the clinic. Target should be to deliver day care surgery as far as possible.^{4,10} A large number of arthroscopic patients are amenable to day care procedures. Multimodal pain management to avoid break-through pain and readmissions due to pain should be considered. Some hospitals may allow day care procedures to be carried on during this time as it places lesser stress on hospital resources and need for in-patient beds.⁴

Choice of anaesthetic procedure should emphasize on minimal aerosolization of the virus.¹⁰ Regional anaesthesia is the preferred choice as far as possible.^{4,10,12} It is preferable that patients also wear a surgical mask throughout the procedure.²⁴

3.9. Rehabilitation of patients under treatment

Sports injuries managed conservatively or operatively need a prolonged period of rehabilitation. Follow-up of patients after management of injuries or after surgical procedures is expected to be affected. In the survey by Liebensteiner et al.³ only 35.1% of the surgeons believed that their patients still had access to outpatient physical therapy. Most physical therapy facilities have shut down during this pandemic.

Most guidelines have recommended that patient follow up should be made telephonically or on video-conferencing as far as possible.^{8,12,25} Home-based virtual rehabilitation program after ACL reconstruction have been used in past and have shown to be well accepted by patients and result in good outcomes.²⁶

4. Discussion

Results of this review shows that facilities for arthroscopy have been severely affected by COVID-19 pandemic and resuming them will have to be gradual and phased. Tele-consultation should be encouraged. Patients should be risk-stratified. Elderly patients may be at a higher risk of morbidity and mortality from infections. Arthroscopic procedures should be avoided in these patients as far as possible in present scenario. Procedures such as rotator cuff disorders which was a frequent indication of arthroscopy in these patients can be managed non-operatively, and possibility of rehabilitation or local injections explored. It has made us to reflect upon and revise our surgical paradigm in many ways.

COVID-19 pandemic brought the world to a complete stand still in no time. COVID-19 had an unprecedented effect on medical care throughout the world. With the continuously increasing numbers of cases and mortality, there were lockdowns and “stay-at-home” restrictions globally. Impact of COVID-19 pandemic on sports injuries may be seen in two ways. On one hand all major sporting events in the world saw a halt. Recreational activities were also grounded. There are restrictions on gyms, parks and sports complexes. Thus, the number of injuries has decreased, but so have the facilities to treat them. There is a shift of manpower and resources from elective ORs to intensive care units to look after the virus infected patients.

There are several other notable findings regarding surgical practices. Concentration of virus in the bone and joint fluid may be less, but the fluid coming out from joint is potentially contaminated with blood. Adequate measures should be adopted during draping of patients to prevent spillage of this fluid in the OR. Adequate water-impermeable personal protective equipment including respiratory masks and eye protection shields are necessary to all staff working in the OR. A separate drainage cannula with suction

attached to it through a separate portal may be used during the procedure to reduce risk of contamination of the surgical apparels and the floor of the OR. Floor suction devices should be in place to wipe off any spills of irrigation fluid. Trained surgeons and staff should participate in these surgeries to reduce surgical time. Surgeons should use technique most familiar with the assistants and staff and expected to give consistent results in shortest possible time. Arthroscopic surgeons frequently encounter that their gown, face-mask and shoe-cover are compromised from the splashed blood-mixed irrigation fluid. Exposure should be avoided by following adequate doffing practices.

There is a risk of transmission of virus from smoke arising from electrocautery.¹⁰ The Royal College of Surgeons has warned that surgical smoke and intra-operative aerosol generation during laparoscopic procedures may risk exposure to health care personnel to COVID-19 in the operative room.²⁷ The situation might be different for arthroscopic procedures as they are performed with fluid insufflation of the spaces and joints. Though electrocautery is sparingly used during arthroscopy, its use can be avoided in open parts of the procedure such as graft harvest or collateral ligament reconstruction by use of tourniquets. Adequate sterilization of arthroscopic equipment should be ensured.

Socio-economic impact on the patients with sports injuries also cannot be denied.²⁸ Two contradicting scenarios have been seen in our experience. On one hand global economy has faced the wrath of lockdown and many patients are finding it difficult to afford treatment. On the other hand, some people might see home-stay and lock-down as an opportunity for getting done surgical procedures such as ligament reconstructions which require a certain period of rest. At this time safety of patients and HCW should be the foremost consideration.

We are still limited in our knowledge of this new virus. Many statements are observations from experience on COVID-rather than evidence from high quality studies. Enormous heterogeneity between articles was seen and only limited literature was available on the topic. Thus, we agree with de Caro et al.¹⁰ that a summary of findings is presented and a systematic review in true sense may not be possible at present.

5. Summary

- Health care has seen shut down of many elective surgeries and outpatient services.
- Socio-economic impact on the patients with sports injuries.
- A conservative approach should be recommended for most patients with acute ligament injuries
- Stratification of Arthroscopic surgeries based on urgency of its need is recommended.
 - Immediate Arthroscopic procedures: arthroscopic lavage for septic arthritis, locked knee with entrapped meniscus
 - Urgent Arthroscopic procedures (Within 3 weeks): Acute tendon rupture, dislodged osteochondritis-dissecans lesions and anterior/posterior cruciate ligament osseous avulsion fractures, acute/severe rotator cuff tears in young adults and acute types III, IV, V, and VI acromioclavicular joint dislocations.
 - Delayed or conservative Management: Paediatric ACL reconstructions, shoulder reconstructions, osteochondritis-dissecans, ACL ligament injury
- Hospital Measures:
 - A separate clinic for emergency and out-patient management.
 - Routine preoperative screening for symptoms.
 - Patients not known to be exposed or infected: COVID-RT-PCR test 48–72 h before surgery.

- For COVID-19 infected patients: Surgery delayed for 6 weeks or longer if possible.
- Operating Room Measures:
 - Regional anaesthesia is the preferred choice.
 - Adequate draping of patients to prevent spillage of fluid.
 - Adequate water-impermeable personal protective equipment.
 - Separate drainage cannula with suction inside the joint.
 - Floor suction devices.
 - Procedure to be done by trained surgeons and staff using most familiar techniques.
- Tele-consultation is recommended telemedicine as an essential medium of providing continued care

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Contribution of the author

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Review article

Patient reported outcome measures review: Are current outcomes assessment tools sensitive enough to assess the reasons for patients' "unhappiness"?[☆]



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ABSTRACT

In an effort to improve patient quality of life after total knee arthroplasty, there is a growing focus on patient reported outcome measures (PROMs) to help clinicians gauge procedure success. Many existing PROMs are subject to the ceiling effect as the measures tested do not apply to younger patients and a more active older population with higher levels of function. Patient survey questions may lack the sensitivity and specificity to properly evaluate high performing total knee arthroplasty implants in high demand populations. Recently developed PROMs improve the ability to differentiate outcomes between patients with high levels of function but need to be tested on a wider scale. While objective measures and physician reports are still important, further work is needed to create PROMs that explain why certain patients are not satisfied with their total knee arthroplasty. The aim of this review is to evaluate the ability of current orthopaedic PROMs to detect patient "unhappiness".

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1. Introduction

Total Knee Arthroplasty (TKA) is a financially and clinically effective treatment for the management of symptomatic end-stage knee arthritis. It relieves pain and improves mobility and quality of life. TKA demand is expected to increase significantly over the coming years, with an estimated increase of up to 637% between 2005 and 2030 in the USA. This is due to a combination of factors, including an ageing population, changing patient expectations and increasing population BMI.¹

It is important to monitor outcomes of TKA in a quantitative,

reproducible and clinically feasible manner. This is vital to assess quality of practice, for comparison of implants and the development of technologies and techniques. In excess of 100 outcome instruments exist in healthcare. Wilson and Cleary proposed a classification scheme of five levels of outcomes: biological and physiological variables (level one), symptom status (level two), functional status (level three), general health perceptions (level four), and overall quality of life (level five).² The concepts are in order of increasing complexity and difficulty to define and measure. From a patient perspective, quality of life is most crucial as this is what they aim to improve with any treatment or intervention.

Traditionally TKA success has been assessed using factors deemed important to orthopaedic surgeons such as implant survival, radiographical appearance and findings on objective clinical assessment. These assess outcomes in the first two or three Wilson and Cleary levels. There is now increasing emphasis on patient-centred care and satisfaction and therefore a need to assess the impact of TKA on the latter Wilson and Cleary levels.

Despite overall success of TKA, patient satisfaction is not unanimous and many report residual symptoms. A study of 10,000

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Abbreviations

TKA	Total knee arthroplasty
THA	Total hip arthroplasty
PROMs	Patient-reported outcome measures
HRQoL	Health-related quality of life
SF-36	Short form survey – 36
QALYs	Quality adjusted life years
PCS	Physical component score
MCS	Menta component score
AKS	American Knee Society
WOMAC	Western Ontario and McMaster Osteoarthritis Index
OKS	Oxford knee score
OKS-APQ	Oxford knee score – activity and participation questionnaire
KOOS	Knee injury and osteoarthritis outcome score
HAAS	High activity arthroplasty score
PREMs	Patient-reported experience measures

patients included in the England and Wales National Joint Registry (NJR) found that a significant proportion had on-going issues: 57% had problems with kneeling, 20% had persistent pain and 17% had pain on walking.³ Less than 10% of patients reported no knee problems following TKA. Physician-reported outcomes are susceptible to optimism bias, and surgeons are usually more satisfied with the results of arthroplasty surgery than patients.⁴ In order to understand and assess reasons for apparent patient dissatisfaction, patient reported outcome measures (PROMs) have been developed. Terwee et al. propose that to do this well, PROMs should possess content validity, internal consistency, criterion validity, construct validity, reproducibility (agreement and reliability), responsiveness, floor and ceiling effects, and interpretability.⁵ Their specific foci vary, but PROMs utilised in orthopaedics tend to assess symptom status, functional status, and general health perceptions.

PROMs are widely used in both clinical practice and in research. In this review the PROMs most commonly used in orthopaedics are discussed and evaluated for their ability to assess patient satisfaction and, where necessary, the reasons for patient “unhappiness”.

2. Health-related quality of life

The measurement of health-related quality of life (HRQoL) is necessary to compare quality of care provision and for resource allocation across medical specialties and institutions.

The 36-item Short Form Survey (SF-36) was developed by RAND corporation as part of their Medical Outcomes study of patients in three US cities. The study aimed to investigate determinants of variations in patient healthcare outcomes. The survey contains eight scaled scores for dimensions affecting health-related quality of life to generate a single index measure of health. The SF-36 acts as a patient-reported survey of HRQoL which can be self-administered.⁶ This survey and its derivatives are often used in health economics in the calculation of quality adjusted life years (QALYs). The SF-12 is a shorter form which has been developed from this and allows accurate calculation of Physical and Mental Health Component Scores (PCS and MCS), reducing time and resource commitments.⁷ It has been shown to be as accurate as the longer version (SF 36) although with reduction in number of parameters assessed, the information available is limited and one may lose information on important aspects of patient health.

Another widely used HRQoL measurement is the EQ-5D. It was

first introduced as a postal survey that evolved into a version with five descriptive questions was produced, covering five dimensions of health state. This can also be combined with the EQ-VAS, which consists of a visual analogue scale of self-perceived health state scored from 0 to 100. The EQ-5D and EQ-VAS have been found to show significant agreement with the SF-36 and SF-12 surveys, but have been shown to be less sensitive to differences in HRQoL associated with less severe morbidity.⁸ This is in part due to the ceiling effect seen with many of the PROMs.

PROMs which assess HRQoL allow a holistic assessment of patients. They can be used to determine the global impact of TKA on patients as a whole. However, by their nature the resultant PROMs score is very multifactorial. Factors independent of the TKA influence outcomes, and these changes may indeed outweigh any caused directly by the procedure. Martin et al. found that, compared with more specific PROMs scores, SF-36 was significantly less responsive to interventions in patients with musculoskeletal disorders.⁹ Further, McGuigan et al. showed no significant change in patient health perception when measured using SF-36 following TKA or THA despite positive outcomes, and an inability to predict post-operative improvement on an individual basis using SF-36 score.¹⁰ This further confirms that existing PROMs and various outcome assessment tools may not be sensitive and specific enough to identify key improvements in quality of life from a patient's perspective.

3. Joint and disease-specific PROMs

PROMs which are joint or disease-specific are the most commonly used in orthopaedic research. Some earlier PROMs were initially developed as questionnaires to focus on symptoms and functional limitations expected as a direct result of joint dysfunction secondary to arthritis. Their use has subsequently been expanded for the comparison of arthroplasty patients pre- and post-operatively. Others were developed specifically for arthroplasty patients. The resultant score provides a measure of the effectiveness of the procedure in improving specific criteria. The PROMs use functional status and specific symptoms as a proxy for patient satisfaction following arthroplasty. Some scores combine patient's perception of outcomes, clinical function as well as surgeon/health care practitioners' assessments. One example of such a score is the American Knee Society (AKS) score, which includes an objective and a functional element to how it is scored. The objective score (maximum 100 points) assesses a patient's pain and adds information on range of movement, stability of the knee and limb alignment. It deducts points for flexion deformity, leg mal-alignment and extension lag. The functional element assesses patient's ability to walk, negotiate stairs and deducts points for use of a walking aid. Although overall useful, AKS can be difficult to interpret at times as pain is very subjective and the way questions are phrased, they can be interpreted in different ways by different patients.

The Western Ontario and McMaster Osteoarthritis Index (WOMAC) contains seven symptom questions (five for pain, two for stiffness) and 17 functional status questions. It was designed as a disease-specific set of questionnaires to evaluate patients with osteoarthritis. The potential of the WOMAC score to measure outcomes following interventions including TKA was recognised, and it has been extensively tested for validity, reliability, feasibility, and responsiveness in arthroplasty patients.⁹

The Oxford Knee Score (OKS) was first proposed in 1998 by Dawson et al. It contains 12 questions which combine symptoms and function, which are each scored out of five.¹¹ The OKS survey was designed specifically for the evaluation of TKA patients. It was proposed as a shorter and more specific alternative to the WOMAC

score and showed good agreement with both SF-36 and the American Knee Society (AKS) score. The OKS was also found by Dawson et al. to have high internal consistency, reproducibility, satisfactory test-retest reliability, and to be more responsive to changes following TKA than the SF-36. The OKS has subsequently been found to be reliable, feasible with minimal imposed patient-burden, and at least as responsive as the WOMAC score.¹²

Both the WOMAC score and OKS are commonly used in both clinical practice and research to evaluate the outcome of TKA. However, the functional aspects of both surveys focus on activities of daily living, without assessment of impact on higher levels of function. Early knee prostheses were considered successful if they achieved pain relief and reasonable range of movement. With the improvements of outcomes following TKA, its indications have expanded to include younger and more active patients with higher demands and all patients have increasing expectations of the result of their TKA. Previously patients were only offered a TKA when patient was more or less house bound and the arthritis was end-stage. With increasing evidence that TKA works well and with improved surgical techniques TKA is being increasingly offered to younger patients with less severe arthritis.

To be useful in clinical and research contexts for the assessment of patient satisfaction, PROMs must differentiate across the full range of patients. When observed in the context of PROMs, the “ceiling effect” is a measurement limitation which occurs when a considerable proportion of subjects score the best or maximum score. This is primarily due to the way the questions are framed and interpreted by a patient. For example, Oxford Knee Score has 12 questions primarily assessing patient's pain and function. Both are assessed through a 5 point question (5 for pain and 7 for function) and the questions can easily be answered with a maximum score, especially in the younger patients as they can easily indulge in the activities that are asked in the questionnaire (such as ability to get in and out of a car, getting up from a sitting position, go down one level of stairs etc.). Elderly patients may not be able to do these activities and at times their inability may not be primarily due to the problems in the knee itself.

In orthopaedics it is generally considered to be acceptable if less than 15% of patients achieve the maximum score.⁵ When this threshold is exceeded it becomes more difficult to differentiate between patients with good outcomes and those with excellent outcomes. The WOMAC score has been shown to demonstrate a ceiling effect in patients evaluated following both TKA and THA,¹³ and several studies have also reported a ceiling effect in the OKS for patients following TKA.¹⁴

The Lysholm Score and Tegner activity scale have been validated for use in TKA and demonstrate little or no ceiling effect. This is likely because they were originally designed for use in an active and more demanding population. However, they have questionable construct validity as the items used are surgeon-derived and may not reflect important outcomes for patients.¹⁵ In TKA patients they also showed only moderate correlation with SF-12 scores, and the Lysholm score had low reliability for some criteria.

4. Higher functional status PROMs

New PROMs have been developed in response to the increasing patient demands and expectations following TKA and are designed to discriminate better between patients with a higher level of function.

The Oxford group which developed the original OKS published a supplementary PROM for the measurement of activity and participation (OKS-APQ), designed to be used in addition to the standard OKS.¹⁶ The authors recognised the increasing numbers of younger patients undergoing TKA and their increased functional

expectations. They showed this PROM to have good correlation with AKSS, OKS and SF-36. It was found to be both reliable and valid. The OKS-APQ was developed in 99 younger patients (mean age 61.5 years), but the authors recommended its use in the assessment of all patients. Although developed recently, this questionnaire may become a default PROM for assessment of outcomes post-TKA if it is used in a variety of settings.

Roos et al. developed the self-administered Knee Injury and Osteoarthritis Outcome Score (KOOS) for the assessment of patients with meniscal and ligamentous knee injuries. All questions from the original WOMAC survey were included. The authors also added further questions about knee symptoms, and two further subsections of questions regarding sport and recreation function and knee-related quality of life. KOOS was specifically developed for younger patients with knee injury or osteoarthritis and higher levels of function. The same group validated KOOS in total knee replacement in 2003, and found it to be at least as responsive as WOMAC, in addition to have improve validity and greater sensitivity.^{17,18}

The High-Activity Arthroplasty score (HAAS) was developed and reported by Talbot et al. in 2010 and takes a purely functional approach to assessment of PROM.¹⁹ It consists of four questions which assess patient ability to walk, run and climb stairs, and also queries their general activity level. The authors found that HAAS produced a wider range of scores in patients following TKA and THA as compared with WOMAC, Knee society and Oxford score, suggesting an increased ability to differentiate. In their study of 100 patients operated for TKA, Jenny et al. found no ceiling effect as compared with AKSS (53%) and OKS (33%) despite a smaller number of questions.¹⁴ A low level of correlation of HAAS with these reference scores was found. The authors suggest this is because HAAS captures a different component of the functional result of TKA and suggest its routine use in all TKA patients as a complementary outcome measure.

The Forgotten Joint Score was validated in TKA and THA patients by Behrend et al. in their 2012 paper, where they proposed “a new aspect of patient-reported outcome: the patient's ability to forget the artificial joint in everyday life”.²⁰ The resultant 12 item survey (FJS-12) showed high internal consistency and correlated well with WOMAC. It also had a much lower ceiling effect compared with WOMAC subscales and was able to differentiate between scores even in healthy controls. Subsequent studies provided more evidence for the superiority of FJS-12 compared with WOMAC. They additionally demonstrated excellent test-retest reliability and strong correlation with OKS and KOOS, whilst also demonstrating a much lesser ceiling effect.¹³

5. Current limitations and development

OKS and WOMAC remain the most commonly used specific PROMs used both clinically and in research.²¹ For assessment of global HRQoL, these may be used in conjunction with SF-36 or a derivative of this survey. At an individual level, patients are clinically and radiologically assessed by operating surgeons. The study of these outcomes at the lower levels of the Wilson and Cleary model² is of course necessary to continued high quality outcomes. However, it is no longer sufficient. As outcomes and implant quality improve, justified confidence in TKA has permitted expansion of indications, and it is now routinely offered for much younger and more active patients. Additionally, older patients are becoming more active with greater longevity, and so also expect to return to increasingly demanding lifestyles. Earlier PROMs were designed to assess symptoms and basic activities of daily living.¹⁹ The presence of pain, stiffness and a low level of functionality are used as proxies for patient satisfaction. As a result of improving outcomes,

significant ceiling effects are now present in these outcome measures. These prevent detection of patient unhappiness, and why this occurs. Rastogi et al. investigated common patient concerns in the early post-operative period and found that many of these were not accounted for in traditional scoring systems. These included the ability to drive, quality of sleep, being dependent on others, and returning to sports and hobbies.²² Although important to the patient, it is difficult if not impossible to understand whether the ability or inability to perform these activities is solely due to the knee. Other issues important to patients include awareness of increased weight of TKA and increased awareness at extremes of temperature. These aspects are not assessed by any of the existing assessment tools and specific questionnaire(s) will need to be developed to gain a better understanding. Generic HRQoL measures also often lack the necessary specificity and responsiveness to adequately assess the impact of TKA on patient quality of life.^{9,10}

The development of more recent PROMs has focused on measures which allow improved discrimination between patients with higher levels of function, and PROMs such as KOOS, HAAS and FJS-12 demonstrate little if any ceiling effect,^{13,14,17,18} despite assessing patients with a greater range of much better outcomes. The welcome inclusion of quality of life elements within some more recent PROMs allows the assessment of the wider impact of TKA on quality of life in general, whilst also allowing specificity to eliminate confounding factors.¹⁷

Other factors independent of technical, symptomatic and functional success also affect patient satisfaction with TKA. Patients may report good levels of satisfaction despite poor clinical outcome, and vice versa.³ Patient experience of receiving care is one of the factors involved. Measurement of this has required the introduction of patient-reported experience measures (PREMs). The concept of the “Net Promoter Score” was introduced to the business world by Reichheld in 2003,²³ and has since been adapted by the UK government to be used as the “friends and family test” PREM in the National Health Service. It assesses whether patients would recommend a service or intervention to a loved one. The results of this simple PREM was studied in lower limb arthroplasty patients, and found that the factors most predictive of satisfaction were achievement of pain relief, the meeting of pre-operative expectations, and the general hospital experience.²⁴

6. Conclusion

The assessment of patient-reported outcomes allows impartial measures of the success of TKA and orthopaedic procedures in general. The information from these PROMs is combined with objective measures of technical success and clinician assessment and are vital for the further development of TKA systems. To be successful, PROMs should be developed with patient involvement to ensure content validity; in addition to impartiality, surveys must contain questions about outcomes most important to patients. These must be up to date and relevant to prevent the development of ceiling effects with time. Despite widely reported success of TKA in the treatment of end stage arthritis,²⁵ less than 10% of patients report no problems with their TKA.³ This is quite different to patients who have undergone a THA. A vast majority of patients with THA report no problems with their THA. Although exact reasons are not known for this discrepancy it is likely to be multi-factorial and include biomechanics, demands placed on the knee by the patient and ability of the spine to compensate for hip pathology.

PROMs continue to improve and better fulfil the goals laid out by Terwee et al.,⁵ but their constant revalidation and regular incorporation of better PROMs into routine practice and research is key to a better understanding of reasons for patient “unhappiness”. A holistic approach to patient services must also be employed, and

the use of PREMs allows further elucidation of healthcare factors outside the realm of PROMs which influence patient satisfaction.

One may decide to ask patients more open-ended questions rather than closed questions to get a better understanding of their dissatisfaction or concerns. However, this is not without its own issues. Open ended questions can lead to replies which are difficult to interpret and are more time consuming. They provide useful information but are more of a research tool rather than for routine clinical use.

In conclusion, existing PROMs and PREMs are an important and useful tool to impartially assess outcome of a TKA. However, they are far from perfect and further work is needed to develop questionnaires which will help clinicians understand why certain patients are not satisfied with their TKA whilst others are although there is no difference in any of the objective measures that are assessed.

Contributors

SWK performed the literature search and the wrote the manuscript draft. All other co-authors have contributed equally to editing and have seen the final manuscript and approved it.

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Similar outcomes with usage of varus valgus constrained and a rotating hinge knee: A review of 108 cases

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ABSTRACT

Objective: Constraint is defined as the effect of elements knee implant designs that provide the stability needed in the presence of a deficient soft tissue envelope. The prosthesis with the minimal acceptable constraint generates maximal functional outcome is the general dictum. Varus valgus constrained (VVC) and rotating hinge knees (RHK) are implants which comprise the constraint group with later having higher constraint. However there are no clearcut guidelines of usage of each of the above implant group and literature is sparse in comparison of outcomes of the above 2 groups. This study was done with aim to better delineate indications and compare outcomes of the VVC and RHK implants.

Methods: We evaluated 56 varus valgus constrained and 52 rotating hinge total knee arthroplasties. The indication of usage and basic demographic data was collected. Clinical and functional outcomes were calculated and compared between the implant groups.

Result: The mean final range of motion (ROM) was 104.58° in RHK group and 108.75 in the VVC group. The final mean Oxford knee score (OKS) was 31.23 in the RHK group and 32.44 in the VVC group. The final mean Knee society score (KSS) was 81.69 in RHK group and 83.79 in the VVC group. There was no statistically significant difference in the 2 groups when final mean ROM, OKS and KSS were compared. Thus the two implant groups gave similar clinical and functional outcomes. The number of revision were similar in RHK (4/52) and VVC (4/56) group.

Conclusion: Thus similar outcomes were reported in our study when both implant groups were compared. We recommend usage of RHK in revision of infected Total knee arthroplasty, in cases with any amount of flexion extension mismatch and in cases where there is doubt regarding partial or full incompetence of collaterals. The use of VVC should be restricted to Osteoarthritis (OA) with gross deformities. However long term randomised clinical trial is needed to better define longevity and complications in the 2 implant groups.

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1. Introduction

Most primary arthroplasty can be managed with unconstrained implant like Cruciate retaining (CR) or posterior substitution (PS) designs. Varus valgus constrained (VVC) (Fig. 1) and rotating hinge design (RHK) (Fig. 2) may be needed in some primary knee arthroplasties and most cases of revision surgery. Constraint is defined as the effect of elements of knee implant designs that

provide the stability needed in the presence of a deficient soft tissue envelope.¹ Increase in constraint leads increased stress at implant cement bone interface² and thus may lead to early loosening. This was the reason of failure of early uniaxial hinged knee implants and lead to introduction of rotatory freedom with later designs.³ The choice between VVC and RHK is usually taken based on competence of collateral ligaments. Inability to match flexion and extension gaps, severe flexion contracture with inability to balance the knee, large bone defects, neuropathic arthropathy, sequelae of poliomyelitis, extensor mechanism injury in need of reconstruction in unstable knees, tumour surgeries are some of the indications of usage of constrained implants.^{4,5} Many studies have been undertaken to compare Posterior substituting (PS) with

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Fig. 1. Showing VVC implant done in case of revision of primary TKA for aseptic loosening.

Cruciate retaining (CR) knees.^{6–8} However, not many studies have compared the clinical and functional outcomes in VVC and RHK designs. The study on these implants is necessary since the constrained implants are being used in higher frequency than before. Constrained implants also have a higher rate of revisions than PS or CR knees.⁹ However, the supremacy of VVC or RHK in similar situations is yet to be settled. The most important factor weighing in favour of usage of RHK over VVC is complete absence of working collateral ligament.¹⁰ The partial or complete incompetence of ligament is a subjective assessment and thus may lead to errors in judgement. Also, partially competent collateral ligament may even become totally incompetent over a period of time leading to early failure in VVC theoretically and may lead to dislocations. The lower constraint VVC implant should theoretically mimic natural knee closer than RHK. The prosthesis with minimal acceptable constraint generated maximal functional outcome is the general dictum.¹¹ Thus outcome measures should be better in VVC group. This study was carried out to compare clinical outcomes, functional outcomes and complications in VVC and RHK designs. This may form the basis of prosthesis selection especially in overlapping indications.

2. Material and methods

This was a retrospective study. Clearance was taken from institutional ethics committee. All patients who underwent Total knee arthroplasty (TKA) with a constrained implant and had a



Fig. 2. Showing RHK implant used in case of infected TKA (RHK- Rotating hinge knee TKA –total knee arthroplasty).

minimum follow-up of 1 year were included in the study. Patients were divided in to 2 groups depending on whether VVC or RHK was used. The patients were further subdivided on the basis of whether the surgery was a primary TKA or a revision TKA. Basic demographic data was collected. The indication of surgery, complications if any, and revisions if any after procedure were noted. Range of motion (ROM), Knee society score (KSS) and Oxford knee score (OKS) were recorded and groups were compared for these in the immediate preoperative period and at the latest evaluation. Fresh anterior posterior and lateral radiographs of all the knees were taken to detect and signs of loosening, subsidence or radiolucencies. Bone defects in the preoperative X rays were classified according to Anderson Orthopaedics Research Institute (AORI) classification system.¹² This was done to keep us prepared for the kind of inventory needed for reconstruction of defects. Various kinds of augments such as wedges, blocks and even cones were used to reconstruct bone defects. The amount of bone defect was not used to decide between the implant categories to be used. Thus we removed amount of bone loss as one of the factors deciding the level of constraint. After reconstructing the bone defect we assessed the stability. Our indication of doing VVC was collateral ligament insufficiency. Whenever collateral ligament was fully incompetent or there was mismatch of flexion and extension gaps and if surgery was being done in a neuropathic joint, RHK was used. Whenever there was doubt regarding partial or complete incompetence of collateral, RHK was used. One hundred and three patients with 108 TK A were found to be eligible for the study. Seven patients died due to unrelated causes, they were included in the study and the study parameters were retrieved from our records at

their last follow-up. Fifty two TKA were done in both RHK and a 56 TKA in VVC group. In the RHK group 17 patients were males and 34 were females. In the VVC group 16 were male and 36 were female. Fifty surgeries were revisions in RHK group, whereas as in VVC group 37 surgeries were revisions. The mean age of patients was 67.94 years in RHK group and 67.28 years in VVC group. The indication of doing VVC or RHK knee is show in Table 1. The mean number of surgeries done on the operated knee previously were 2.13 in RHK group 0.946 in the VVC group. The mean number of years of follow-up was 4.01 (range 1.25–14 years) in RHK group and 5.49 (range 1–15 years) in VVC group. The implants used in RHK group were LINK® Endo-Model® in 09 knees, S-ROM® NOILES™ Rotating Hinge Knee System in one patient, while rest 42 patients had Zimmer® NexGen® RH Knee. In VVC group 3 knees had LEGION◇ Revision Knee System from Smith and Nephew, rest 53 had Legacy® Constrained Condylar Knee from Zimmer. We asked the patients to grade their satisfaction with surgery in to highly satisfied, satisfied, dissatisfied and highly dissatisfied. Qualitative data were represented in the form of percentages. Quantitative data were calculated using mean ± SD. The student's t-test were done to determine the correlation between the pre-operative and post-operative KSS, OKS and ROM, between and within the groups. $p < 0.05$ was considered statistically significant. MS Office, SPSS software (v 9.4) and GraphPad softwares were used for the analysis.

2.1. Results

There were 4 knees in RHK group and 3 knees in VVC group which needed revision. These were excluded in the final evaluation of ROM, KSS and OKS. In the RHK group mean KSS and OKS in the immediate preoperative were 26.92 and 13.69 respectively, they increased to 81.69 and 32.23 respectively in the latest follow up which was statistically significant ($p < 0.05$) (Tables 2 and 3). In the VVC group mean KSS and OKS in the immediate preoperative were 29.06 and 14.63 respectively, which increased to 83.79 and 32.44 respectively in the latest follow up which was statistically significant ($p < 0.05$) (Tables 2 and 3). There was no statistically significant difference between RHK and VVC group when mean OKS and KSS at latest followup were compared (Tables 2 and 3). In RHK group, mean preoperative ROM in degrees were 60.85. It increased to 104.58 at latest followup ($p < 0.05$) (Table 4). In VVC group, mean ROM in the preoperative period was 78.85°, it increased to 108.75° in the latest follow-up which was statistically significant ($p < 0.05$) (Table 4). When ROM was compared between RHK and VVC at the latest followup, it was better in VVC group, though this was not statistically significant (Table 4). Most patients were satisfied or highly satisfied with the surgery, both in RHK (46/52) and VVC (48/56) group. We also calculated the above variables after excluding primary surgeries in both the groups. Thirty six knees in VVC group and 46 knees in RHK group were evaluated. The final mean ROM was 106.97° in VVC group and 105.00 in RHK group. The final mean

Table 1

Showing the indication of using rotating hinge knee and varus valgus constrained knee.

Indication	RHK	VVC
Infection	30	9
Aseptic loosening of TKA	10	20
Instability after TKA	4	5
Periprosthetic fracture	2	2
Nonunion fractures around knee	4	1
OA in neuropathic joints	2	0
OA with gross deformities	0	19

OA-Osteoarthritis, TKA- Total knee arthroplasty, RHK- Rotating hinge knee, VVC- Varus valgus constrained knee.

Table 2

£ showing KSS values in VVC and RHK groups, £- knees requiring revision in RHK and VVC group were excluded.

KSS	VVC			RHK			p-value#
	Mean	SD	Range	Mean	SD	Range	
Preoperative	29.06	15.01	0–69	26.92	10.87	6–55	0.4195
Post-operative	83.79	11.69	32–97	81.69	9.12	60–99	0.3218
p-value*	<0.0001			<0.0001			

*Calculated using paired t-test. #Calculated using unpaired t-test. $P < 0.05$ considered statistically significant

KSS- knee society score, RHK- Rotating hinge knee, SD–standard deviation, VVC- Varus valgus constrained knee.

Table 3

£ showing OKS values in VVC and RHK groups £- knees requiring revision in RHK and VVC group were excluded.

OKS	VVC			RHK			p-value#
	Mean	SD	Range	Mean	SD	Range	
Preoperative	14.63	4.57	5–26	13.69	3.78	4–22	0.2673
Post-operative	32.44	7.11	8–39	32.23	4.19	23–39	0.8591
p-value*	<0.0001			<0.0001			

*Calculated using paired t-test. #Calculated using unpaired t-test. $P < 0.05$ considered statistically significant

OKS-Oxford knee score, RHK- Rotating hinge knee, SD–standard deviation, VVC- Varus valgus constrained knee.

Table 4

£ showing ROM in VVC and RHK groups £- knees requiring revision in RHK and VVC group were excluded.

ROM	Constraint Knee Condylar			Hinge knee			p-value#
	Mean	SD	Range	Mean	SD	Range	
Preoperative	78.85	34.22	10–120	60.85	36.82	0–130	0.0129
Post-operative	108.75	13.75	60–120	104.58	12.02	80–130	0.1109
p-value*	<0.0001			<0.0001			

*Calculated using paired t-test. #Calculated using unpaired t-test. $P < 0.05$ considered statistically significant

RHK- Rotating hinge knee, ROM-Range of motion, SD–standard deviation, VVC- Varus valgus constrained knee.

of KSS was 81.80 in RHK group 83.09 in VVC group. The final mean OKS was 32.39 in the RHK group and 31.61 in VVC group. There was no statistically significant difference between the 2 groups in final mean ROM, KSS and OKS, even when only revision patients were considered.

2.2. Complications

There were minor complications in the form of marginal necrosis in RHK (6/52) knees and VVC(4/56) knees. The above required no further intervention. Our study had a revision rate of 7.69% in the RHK group and 6.89% in VVC group. RHK patients had 11.5% chance of having a major complication or reoperation, it was 6.89% in the VVC group. Four patients in the VVC group and 4 in RHK group required revision. In the VVC group, one patient was operated for infection of bilateral primary TKA. The infection recurred and both knees were revised to RHK by a 2 stage procedure. Two patients in the VVC group had post-operative dislocation, they were revised to RHK. (Fig. 3a and b). In 4 patients RHK failed and had to be revised. One of the patient was initially a case of periprosthetic distal femur fracture, he was operated and open reduction internal fixation with a plate was done primarily. The reconstruct failed and further revised to an intramedullary nail

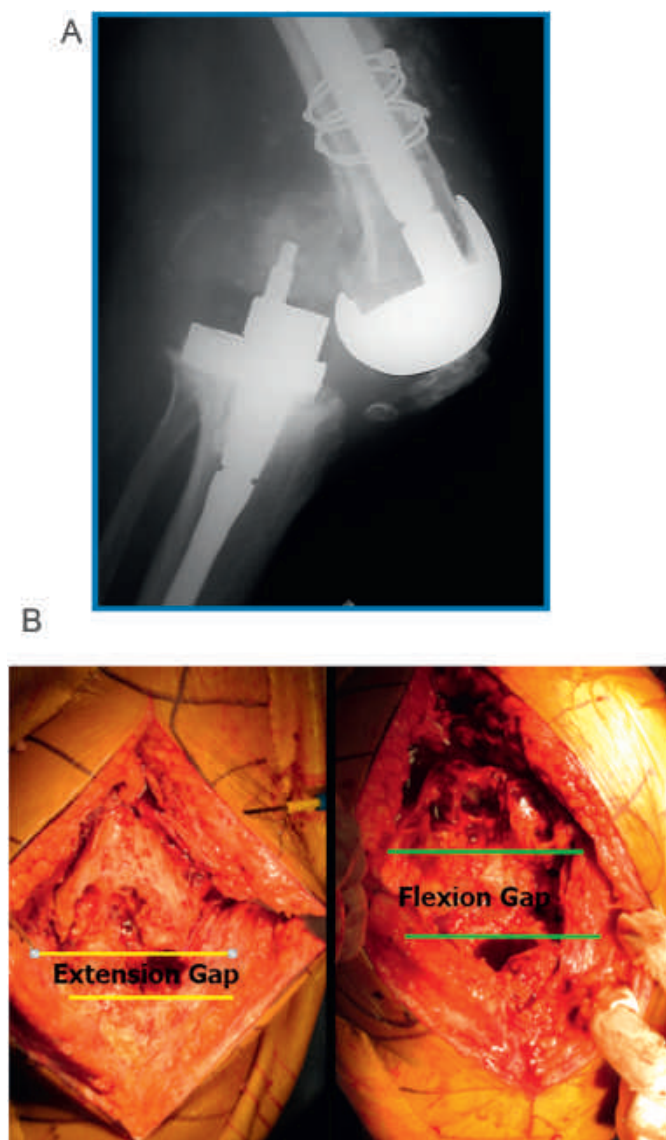


Fig. 3. A showing x ray of dislocation of a VVC implant due to mismatch in flexion and extension gap with intraoperative photo of same during revision surgery (Fig. 3b).

which too failed. The patient was revised to a RHK which failed with instability and aseptic loosening. The above patient was finally revised with megaprosthesis distal femur replacement (DFR). Second patient was case of infected TKR who was revised to RHK by a two stage procedure. The infection recurred, patient had another 2 stage revision with a DFR. Third patient was a case aseptic loosening of TKA, he was revised to RHK, and patient had a periprosthetic fracture and thus was revised with another RHK with longer stems. Fourth patient with periprosthetic fracture of femur, femoral component was revised with longer stem, femur fractured again, she was then managed conservatively with fracture uniting well. One patient in RHK group had periprosthetic fracture of tibia shaft which was managed with open reduction internal fixation with plating. Fracture united uneventfully. Another patient in the RHK group with preoperative diagnosis of infected TKA had recurrence of infection, patient is planned for stage 1 revision TKA after optimisation. There were no thromboembolic complications in both groups of patients. There were no extensor mechanism disruptions in the study. There were no signs of loosening in the form of increasing radiolucent lines, subsidence or change of

prosthesis alignment in the analysis of latest radiographs of the rest of the patients.

3. Discussion

Advanced arthritis involving majority of the 3 compartments of the knee needs TKA more often than not. It achieves high patient satisfaction rates, especially during the first year post surgery.¹³ However like all artificial devices, the TKA too have a limited life span and thus may need revision. The number of revision TKA are on the rise, with up to 600% increase by 2030 as compared to 2005.¹⁴ The revision TKA is a far more challenging procedure as compared to primary TKA. One has to take care of bone loss, poor soft tissues components due to multiple prior procedures, underlying infection if any, multiple comorbidities of the patient, and last but not the least—instability. There are many kinds of instability such as extension instability, flexion instability, midflexion instability, genu recurvatum and global instability.¹⁵ Instability in extension can be further divided in to symmetric and asymmetric instability. The asymmetrical form is much more common and is caused by failure to correct the alignment in the coronal plane, this may be contracture of ligament on concave or attenuation of ligament on convex side. In revision cases bone loss may lead to involvement of attachment of collaterals, thus a constrained implant to assist in stability on coronal plane may be needed. RHK and VVC implants vary in the degree of freedom allowed in coronal, sagittal and axial planes. RHK provided more constraint in coronal and frontal planes but probably more rotational freedom.^{16,17} There are few studies comparing VVC with RHK in terms of clinical and functional outcomes, and complication rates. In both the groups in our study, mean KSS, OKS showed improvement at last follow as compared to preoperative values. These improvements were statistically significant. These findings are similar to previous studies by Guenoun et al.¹⁸, Petrou et al.¹⁹ and Sabatini et al.²⁰ There were no statistically significant differences in final mean KSS, OKS between VVC and RHK group. This shows that clinical and functional outcomes are similar in the 2 groups. Thus the hypothesis that VVC more closely mimics natural knee and thus may lead to better clinico-functional outcomes does not hold true. This is similar to previous studies by Fuchs et al. [10], Vasso et al.²¹ and Hwang et al.²² However, studies by Hossain et al.²³ showed that VVC group has better final KSS than RHK group, it is in contrast to our findings. Our study shows lower ROM in RHK group than VVC group. This is similar to Fuchs et al.,¹⁰ Vasso et al.²¹ However the difference was not statistically significant. The revision rates were similar in RHK (4/52) and VVC (4/56) group. In VVC group flexion extension mismatch and subsequent posterior dislocation was the cause of revision in 50% cases. This complication has been described by Hagedorn et al.²⁴ Thus VVC implant does not provide immunity against dislocation in flexion extension mismatch and thus RHK should be used whenever there is any amount of flexion extension mismatch.

3.1. Limitations of the study

It was a retrospective study. The patient population was not randomised. It is mid-term follow-up study with mean follow-up of 4.01 years in RHK group and 5.31 years in VVC group. A long term follow-up is necessary to definitely ascertain the outcomes and longevity of the implant groups.

4. Conclusion

Our conclusion is that RHK should be frequently used as opposed to VVC implant especially in situations like revision for

infections, which usually need radical debridement of infected tissue including sacrificing the collateral ligaments. Also, in cases where there is doubt whether collaterals are fully or partially incompetent, or there is flexion extension mismatch, RHK should be preferred. The use of VVC should be restricted to complex primary arthroplasty with gross deformities. The RHK has similar clinical and functional outcomes as compared to VVC. Thus the principle that the prosthesis with the minimal acceptable constraint generated maximal functional outcome does not always hold true. Ours is a midterm study, complication rate and revision rates can conclusively be defined by a long term study only. Thus a randomised controlled trial with a longer follow-up is needed to ascertain the merits and demerits of usage of RHK over VVC implants in similar complex reconstructions.

Author contribution

Substantial contributions to the conception and design of the work; the acquisition, analysis, or interpretation of data for the work.

Declaration of competing interest

The authors declare that they have no conflict of interest and have received no payment in the preparation of this manuscript.

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Review article

Oxford partial knee replacement: Early follow up results in young verses elderly age group patients



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ABSTRACT

Background: Age related knee arthritis usually begins with early medial compartment changes in majority of cases. Later on, lateral and patellofemoral compartment involvement occurs. Oxford unicompartmental knee replacement is preferable in patients with isolated anteromedial knee arthritis.

Methods: The study involves retrospective review of 112 cases performed over a period of two years at a tertiary care center. It includes comparative analysis of operative and functional results of Oxford unicompartmental knee arthroplasty in young (age < 60 years) verses elderly (age > 60 years) age group patients. Preoperative radiographic assessment involves full length hip to knee radiographs taken in standing position before surgery and at one year follow up. Special views assessment was done, includes valgus and varus stress views and merchant views.

Results: Analysis shows no significant difference between the two groups for BMI, blood loss, duration of surgery and post-surgery correction in mechanical axis. Statistically significant differences ($P < 0.05$) was observed in parameters like average duration of hospital stay, rate of complications seen and duration of rehabilitation period.

Conclusion: Oxford unicompartmental knee replacement is associated with relatively less morbidity, better early rehabilitation and improvement of knee score in late period. Age not appears to be a contraindication for oxford unicompartmental knee arthroplasty. However several key outcome parameters like speed of recovery, return to work, revision rate, complications, mortality rate, and functional outcomes must be discussed with patient before surgery.

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1. Introduction

Knee arthritis is a common problem in every population and definitive treatment involves removal of damaged part and to replace with new components. The primary aim of treatment is improvement of pain, function and overall quality of life.^{1–4} Studies shows that many advances has been made in designing of new components over the time like cruciate retaining, cruciate substituting, patient specific designs, partial or unicompartmental replacement, computer navigation and robotic designs to improve the patient outcomes.⁵ Early arthritis usually begins with initial medial compartment degenerative changes. The surgical treatment of unicompartmental knee arthritis is controversial. Commonly available options includes High tibial osteotomy (HTO), Total knee

arthroplasty (TKA) and Unicompartmental knee arthroplasty (UKA).

High tibial osteotomy (HTO) reduces pain and slow down disease progression with aim to redirect the mechanical axis of lower limb in order to “offload” the medial compartment and transfer load through the relatively preserved articular cartilage in lateral compartment.⁶ Unicompartmental knee arthroplasty (UKA) involves resurfacing of single compartment, which can be either medial, lateral or patellofemoral compartment and is especially appropriate for early disease. Osteoarthritis of the knee begin with anteromedial compartment involvement in more than 80% of patients.^{7,8} Studies have shown good long term survivorship following partial knee arthroplasty as well as better knee kinematics and function, but it is seen that some surgeons still regard unicompartmental knee arthroplasty as a temporary procedure and believes in total knee replacement as a definite procedure in elderly age group.^{9–17} In young patients, total knee replacement is associated with high risk of early failure because of high demanding

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lifestyle whereas in elderly age group patients, TKA carries risk of relatively higher morbidity due to associated advance age related co-morbidities. Lot of confusion regarding UKA or TKA as the treatment of choice for eligible patients has been seen.¹⁸ many studies shows higher revision rates for UKA than for TKA particularly in younger patients.¹⁹ Higher revision rates seems to be a reason explaining why more knee surgeons do not perform both procedures. Studies shows choice between varied treatments applies to 25–47% of patients presenting with primary osteoarthritis.²⁰ Total knee replacement (TKR) is an alternative but involves replacing the normal contralateral compartment and normal cruciate ligaments. Resurfacing UKR preserves bone stock and does not violate the non-diseased parts of the knee with both favourable^{21,22} and unfavourable results.^{23,24}

The first modern unicompartmental designs, the “St. Georg” and the “Marmor Knee”, were introduced in 1969 and 1972, respectively.²⁵ Both presented a polyradial metallic femoral component and a flat tibial component made of polyethylene. Later due to wear and polyethylene deformation introduction of metal-backed tibial component was started.²⁶ Over the period, limited innovation was seen in unicompartmental knee replacement, some implants still in use has remain almost unchanged.²⁷ In the late 1980s, failures with attempts at UKR had arisen due to inadequacies in prosthetic design, poor patient selection, and surgical techniques.²⁸ In 1976, Goodfellow & O'Connor started the use of a meniscal bearing design and implanted these for bicompartamental tibiofemoral arthroplasty and after many refinements in prosthetic designs, UKR is now widely accepted as a valid procedure in the treatment of unicompartmental osteoarthritis of the knee. The presently available phase 3 components (Oxford knee) for medial compartment arthroplasty has many benefits and less disadvantages. The present study aims at midterm analysis of functional results of oxford unicompartmental knee arthroplasty in young verses elderly age group patients.

2. Patients and methods

The present study involved retrospective review and comparative analysis of results of partial knee replacement in younger verses elderly age group patients. The study was done from January 2017 to December 2018 and involves single center review of results. It involves a total of 130 knee cases (110 patients) who underwent oxford unicompartmental knee arthroplasty. All patients had primary osteoarthritis with degenerative medial compartment changes with intact lateral compartment and ACL ligament. The exclusion criteria includes cases with patellofemoral or lateral compartment arthritis needing total knee replacement, cases needing revision, cases with associated hip pathology, cases with articular bone loss requiring wedges and extension stem, inflammatory arthritis, cases with varus deformity greater than 10°, cases with flexion deformity greater than 15° and cases with ACL deficiency. The patients were divided into two groups 1) Patients with age <60 years 2) Patients with age ≥60 years. All patients were pre-informed and well explained regarding type of surgical procedure performed. The study population includes 30 males and 80 females. Side involvement includes bilateral involvement in 20 cases and unilateral involvement in 90 cases. All patients included were diagnosed with osteoarthritis knee (Kellgren-Lawrence Grade 3–4) failed to respond to conservative measures. All cases were operated by single senior orthopedic surgeon trained in joint replacement with more than two decades of clinical experience at a research tertiary care center. Parameters like age, sex, etiology, range of motion, KSS²⁶ and NKS²⁷ (New Knee Score,²⁹ Kalia and Raina Score³⁰) were assessed preoperatively. The KSS score was graded as excellent (85–100 points), good (70–84 points), fair (60–69 points) and poor

(less than 60 points).The anesthesia technique used involves regional anesthesia (Combined Spinal Epidural) in all patients. Zimmer Biomet phase 3 mobile bearing prosthesis (Oxford knee) was used in all cases. The anesthesia technique used involves regional anesthesia (Combined Spinal Epidural) in all patients undergoing partial knee replacement. Tourniquet was used in all cases. Radiographic review involves standard weight bearing knee radiographs including antero-posterior and medio-lateral (with the condyles overlying one another) views. Hip to ankle scanograms were also taken in preoperative and late postoperative (six month follow up) period. Hip-Knee-Ankle angle (HKA) or mechanical axis was calculated from hip center to center of ankle (talus) and 180° being set as target angle. Special view assessment includes valgus and varus stress views and merchant views in preoperative period.

3. Statistical analysis

The data was collected and recorded in a Microsoft Excel based software and analyzed using SPSS software version 22.0 and R.3.2.0. Clinical parameters were calculated in terms of Mean and standard deviation for quantitative variable and frequency (%) for qualitative variable. Chi square was used as test of significance. Paired *t*-test was used as test of significance for paired data before and after surgery. *P* < 0.05 was considered as statistically significant. Wilcoxon Rank-Sum Test was applied to compare the clinical parameters like KSS score, NKS score and VAS score between groups of patients. The data was collected and calculated by independent observer other than operating surgeon. Radiographic angle measurement was done using picture archiving and communication systems (PACS) by independent observer.

4. Results

The study includes a total of 110 patients (130 knee cases) divided into two groups (Table 1). The present study shows mean age of 64.4 ± 5 years, sex distribution 1:2.6 (male: female). The average duration of surgery was 53 ± 10 min and 58 ± 16 min, average correction in range of motion 10 ± 5 and 12 ± 5°, average blood loss of 90 ± 14 and 100 ± 18, mean change in VAS was 6.7 and 5.4 ± 1 points at one year follow up in young verses elderly age group patients respectively. No blood transfusion was required in any patient undergoing partial knee replacement. The average length of hospital stay was 2.3 ± 1 days for UKR subgroup in young patients which was significantly lower when compared with UKR subgroup involving elderly patients (2.9 ± 2 days). Mean correction of deformity/correction in mechanical axis was 8.2 ± 3 (average preoperative 170.6°, average postoperative 178.6°) and 10.2 ± 2° (average preoperative 171.4°, average postoperative 179 ± 4°) for young verses elderly age group patient respectively. The mechanical axis calculated was in acceptable alignment in 96.66% and 95.71% percent cases in young verses elderly subgroup respectively. The follow up was done and parameters like range of motion and hip to knee radiographs were reassessed over a period of six month and one year and documented. Two cases was loosed to follow up at one year in elderly subgroup and one case in younger subgroup. Relatively less blood loss and short duration of surgery was observed in younger age group. Rehabilitation period was significantly shorter in younger age group (*P* < 0.05). The time taken for independent walking was 19 ± 4 days in younger group verses 24 ± 6 days in elderly group. Another important parameter involves time taken to resume outdoor activities which was significantly lower (average 38 ± 6 days) in younger group verses (average 47 ± 8 days) in elderly group. The knee society score and New knee score (Kalia and Raina score) was calculated before surgery and at one year follow up (Table 2). Significant improvement was seen both in

Table 1

Patient related clinical and radiographic outcome parameters included in study. HKA- Hip Knee Ankle axis, VAS- visual analogue scale.

Parameter	UKA in Younger	UKA in Elderly	Chi square/t -test
Number of Knee cases	60	70	
Mean Age	58.4 ± 3	68.8 ± 4	P < 0.05
BMI	31.4 ± 6	30.4 ± 4	P > 0.05
Gender			
Male	12 (28.0%)	18 (24.0%)	
Female	38(72.0%)	42(76.0%)	
Blood loss (ml)	90 ± 14	100 ± 18	P > 0.05
Duration of Surgery (minutes)	53 ± 10	58 ± 16	P > 0.05
Number of Transfusions (average units)	None	None	
Length of Hospital stay (days)	2.3 ± 1	2.9 ± 2	P < 0.05
Preoperative			
Average VAS	8.5	8.9	
Average range of motion	110	105	
Average mechanical axis	170.6	171.4	
Post-operative, 6 month			
Average VAS	1.4	1.7	
Average range of motion	120	115	
Average mechanical axis	178.6	179.4	
Post-operative, 1 year			
Average VAS	1.2	1.3	
Average range of motion	125	120	
Average mechanical axis	178.6	179.4	
Improvement in VAS (mean ± SD)	6.7	5.4 ± 1	P < 0.05
Improvement in range of motion (mean ± SD)	10 ± 5	12 ± 5	P > 0.05
Improvement in mechanical axis (mean ± SD)	8.2 ± 3	10.2 ± 2	P > 0.05
Average time needed for independent walking	19 ± 4 days	24 ± 6 days	P < 0.05
Average time needed for return to work	38±6 days	47 ± 8 days	P < 0.05

Table 2Knee Scoring Distribution. KSS²⁹- knee society score, NKS³⁰- new knee score (Kalia and Raina score).

Knee Scores	UKA in Younger	UKA in Elderly	
Knee society score (KSS)			
Clinical Knee Score (Mean Score ± S.D)			
Before Surgery	30 ± 6	24 ± 8	
After Surgery (at 6 month)	88 ± 3	83 ± 4	
After Surgery (at 1 year)	92 ± 4	88 ± 6	P > 0.05
Functional Knee Score (Mean Score ± S.D)			
Before Surgery	26 ± 6	28 ± 6	
After Surgery (at 6 month)	88 ± 1	85 ± 2	
After Surgery (at 1 year)	92 ± 4	88 ± 6	P > 0.05
New Knee Score (NKS) (Mean Score ± S.D)			
Before Surgery	9 ± 1	9 ± 1	
After Surgery (at 6 month)	2 ± 1	2 ± 2	
After Surgery (at 1 year)	1 ± 1	1 ± 2	P > 0.05

clinical, functional knee score and also in New knee score at one year follow up. Younger group was associated with relatively less complications when compared with elderly group. In elderly subgroup, two cases (2.85%) presented with wound related complications, later managed with isolated dressing alone in one case and debridement with exchange of polyethylene spacer in another case followed by prolong intravenous therapy in all cases (Table 3). Medical complications including venous thromboembolism and coronary vessel disease not seen in any patient among younger group, whereas one case from elderly group developed symptomatic deep vein thrombosis and later managed using long term anticoagulant and antiplatelet therapy.

5. Discussion

UKR involves resurfacing of medial articular compartment and is helpful as it preserves bone stock and does not violate the non-affected parts of the knee but has varied response regarding functional results, both favourable^{21,22} and unfavourable results seen.^{23,24} The advantages includes improved knee kinematics and

Table 3

Complications involved in the study, Early and Late.

Complications	UKA in Younger	UKA in Elderly
Early complications		
Superficial wound infection	None	1(1.42%)
Deep wound infection	None	1(1.42%)
Neurovascular injury	None	None
Medical complications		
Deep vein thrombosis	None	1(1.42%)
Pulmonary embolism	None	None
Myocardial infarction	None	None
Cerebrovascular accident	None	None
Other complications		
Chronic stiffness	Nil	1 (1.42%)
Persistent/Chronic pain	1(1.66%)	2 (2.84%)
Aseptic loosening	None	1(1.42%)
Peri-prosthetic infection	None	None
Revision surgery	None	2 (2.84%)
Peri-prosthetic fractures	None	None

better functional outcome scores as patients were able to return to higher level of sports after surgery, also a sense of “feeling more normal” when compared with total knee replacement.^{31–35} Good clinical outcome has been proved in multiple studies in terms of parameters like pain relief, improved knee functional scores and post-surgery range of motion and many studies shows controversial results regarding long term survival of implant. UKA is favored in more active patients with single-compartment arthritis who are expecting to return to a high level of activity.³⁶ Many studies have shown good long term survivorship following Unicompartmental knee arthroplasty (UKA) as well as better knee kinematics and function.^{37–42} It is seen that many surgeons still regard Unicompartmental knee arthroplasty as a temporary procedure^{16,17} and believe that elderly patients (>60 of age) are best treated with a Total knee arthroplasty. Studies shows that, in UK around 25–47% of patients who are eligible for primary joint replacement have isolated unicompartmental osteoarthritis, and are eligible to receive either implant.^{21–23} In spite of this, the rate of implantation

of UKA in the United Kingdom remains static at around 8% of all primary knee joint arthroplasties, and shows broad variations both geographically and between the centers in the same region.²⁴ Another important fact is that only 38% clinicians who reported performing total knee arthroplasty to the UK National Joint Registry in 2017 also performed UKA.²⁴ For a special subgroup of patients involving elderly aged (more than 60 years), less data is available regarding results of unicompartmental knee arthroplasty. The present study comparing unicompartmental and total knee arthroplasty, aimed to provide evidence to support informed shared decision making in the care of elderly patients presenting with medial unicompartmental osteoarthritis of the knee.

The present study involves a total of 130 knee cases with mean age of 64.4 ± 5 years. No significant difference was seen in parameters like average duration of surgery (53 ± 10 min and 58 ± 16 min), average correction in range of motion (10 ± 5 and $12 \pm 5^\circ$) and average blood loss (90 ± 14 and 100 ± 18) in young versus elderly group respectively. Analysis of whole data shows multiple advantages associated with UKA across multiple outcome domains. Younger patients undergoing UKA had statistically significant reduced hospital stay period when compared with elderly subgroup. The average length of hospital stay was 2.3 ± 1 days in younger subgroup versus 2.9 ± 2 days in elderly group. Significant improvement in Visual analogue score was observed over a period of follow up in both groups. Fewer early complications including surgery related and medical complications were seen in younger subgroup when compared with elderly subgroup. No case presented with early post-surgery complications like superficial wound infection, deep wound infection and neurovascular injury in younger age group. Two cases developed chronic lateral compartment pain, mild in intensity over six month follow up period in elderly group but managed conservatively till one year as pain being low intensity and occasional. One case developed radiolucent shadow around tibia component resulting in persistent pain at ten month follow up later diagnosed as aseptic loosening and thus revised into total knee replacement.

Rehabilitation period was shorter in younger patients. The time taken for independent walking was 19 ± 4 days in younger subgroup versus 24 ± 6 days in elderly subgroup. However, for return to work and return to outdoor activities, a significantly quicker recovery was seen in younger subgroup.

Carr et al.⁴³ reported results of 121 medial-specific Oxford unicompartmental knee replacement surgeries in patients with a mean age of 69 years with average follow-up of 3.8 years. They reported a 99% survivorship and recommended the following selection criteria for the Oxford unicompartmental knee replacement: (1) the presence of a functioning ACL; (2) fully correctable deformity; and (3) full thickness of articular cartilage remaining in the lateral compartment. Only one knee required revision for a loose tibial component.

Liddle et al.⁴⁴ showed that surgeons who report at least 20% of their arthroplasty practice as UKA achieve lower rates of revision, but that over 80% of surgeons performing UKA in the UK who enter data to the National Joint Registry performed fewer than 10 UKA procedures per year. These results are considered to be related to the expertise and experience of the operating surgeons, producing better results, and their units having a higher threshold for revision surgery for unexplained pain and better postoperative support.

Murray et al.,⁴⁵ performed the Oxford medial unicompartmental arthroplasty ten year survival study and reported the outcome of 143 Oxford unicompartmental knee prostheses implanted for anteromedial osteoarthritis in patients with normal ACLs. The investigators reported a 10-year survivorship of 98%.

Significant improvement was seen both in clinical and functional knee score at one year follow up. Another assessment

parameter calculated was New knee score (Kalia and Raina score), significant improvement was seen in both subgroup over the follow up period.

Pandit et al.⁴⁶ in 2006 reported on phase 3 minimally invasive surgery Oxford medial unicompartmental knee replacement surgery. The series included 132 unicompartmental knee replacements, with an average follow-up of 7 years (range: 18 years). Survival rate at 7 years was 97.3%. The study concluded that the minimally invasive phase 3 Oxford unicompartmental knee replacement is a reliable and effective procedure.

Price et al.⁴⁷ in a series of Oxford Unicompartmental Knee Arthroplasty (OUKA) implanted in patients <60 years and >60 years of age, compared the two groups. They noted a 10-year survivorship of 91% in patients <60 and a 96% survivorship in patients >60. Results concluded that for patients aged >50 years, should not be considered a contraindication to the procedure.

Analysis shows both oxford unicompartmental knee replacement and total knee replacement are recommended treatment for knee arthritis, but partial knee replacement being more favourable in early onset anteromedial knee arthritis as it is associated with less perioperative morbidity, short rehabilitation period and later improvement of functional score. Clinical and functional knee score were graded as excellent (>90 points) in younger group versus good (80–90 points) in elderly group at one year follow up, thus better pain relief and functional improvement among younger population. When deciding whether to undergo knee arthroplasty surgery, several key outcome domains are important to patients, such as speed of recovery, return to work, revision, complications, mortality, and functional outcomes. If the full spectrum of outcomes is not considered, then patients cannot be considered as fully informed.

Ideally when considering between two recognized treatment options for the same condition, the decision should be shared between the patient and the clinician. Final decisions can only be made once both parties are able to understand and compare the risks and benefits of both treatment options. All wide range of outcomes, relative risks and potential benefits of each treatment option must be understood and applied to each individual patient.

The shortcomings associated with present study includes single center review of cases with relatively less number of patients, results specific to single surgeon, lack of long term follow up period and lack of external validation. The strong point associated with study is uniqueness of inclusion criteria. Minimal literature is available regarding comparative analysis of results of partial versus total knee replacement in obese subgroup of patients.

6. Conclusion

The oxford unicompartmental knee arthroplasty can be performed in elderly patients with isolated medial compartment arthritis. The procedure being less invasive is associated with minimal early and late complications, better rehabilitation in early period and significant improvement of knee score in later period when compared with total knee replacement that being associated with increased morbidity and higher number of complications. When deciding whether to undergo knee arthroplasty surgery, key outcome domains such as speed of recovery, return to work, revision rate, complications, mortality rate, and functional outcomes must be discussed with patient before procedure.

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Research paper

Bilateral HTO in same sitting: Perioperative challenge or feasible option?

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ABSTRACT

Objective: The objective of this study was to analyse the feasibility of doing a bilateral high tibial osteotomy in the same sitting for patients with isolated medial compartment osteoarthritis, its effect on Patient Related Outcome Measures at 6 months and 2 years follow up as well as the correction achieved post op.

Methods: Bilateral simultaneous HTO using Tomofix®(Depuy, Synthes, Warsaw,IN,USA) for medial compartment OA knee was done in 30 patients (60 knees), between April 2010 and August 2014, in the age group of 45–55 years (mean = 48.3 years). The patients were kept non weight bearing for 2 weeks followed by weight bearing as tolerated with crutches from 2 to 4weeks followed by full weight bearing without crutches. Patients were followed up for 2 years. Correction achieved, functional knee score, intra-operative difficulties, post-op complications, rehabilitation difficulties and patient's overall perception of the procedure were evaluated.

Results: Knee score (Insall modification) improved from mean 41.87 ± 9.7 pre-op to a mean 92.80 ± 2.75 at 2years post op and Pain score (VAS) improved from pre-op mean of 57.90 ± 6.8 to 10.03 ± 6.28 at 2 year post-op, both scores being statistically significant. The femoro-tibial angle was corrected from mean 4.1° varus to 1.15° valgus. The osteotomy healed in 5.2 months (4–7 months). There were no complications.

Conclusions: Bilateral HTO in the same sitting for selected patients is a feasible option without any added complications.

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1. Introduction

Knee osteoarthritis (OA) is a very common disorder, incidence of which increases with age and a person has a lifetime risk of about 45% for developing symptomatic knee OA^{1,2} Unicompartmental knee OA leads to knee malalignment³ causing differential load distribution that could potentially lead to radiographic and clinical OA progression.⁴ Medial unicompartmental knee OA in active patients can be treated by a valgus-producing high tibial osteotomy (HTO) which corrects the varus malalignment.⁵ The two most

commonly used surgical techniques for HTO are lateral closing wedge HTO and medial opening wedge HTO with both improving symptoms and reducing the risk of progressing to radiographic knee OA⁶ Lateral closing wedge osteotomy may result in considerable lateral overhang of the tibial plateau, producing changes in tibiocondylar offset and additionally may lead to some amount of limb shortening so was not our technique of choice. Biplanar HTO using Tomofix®(Depuy, Synthes, Warsaw,IN,USA), the technique used in this study, preserves the anterior and lateral cortex and allows for weight bearing as early as two weeks after surgery⁷

Bilateral knee arthroplasty in the same sitting is not alien to orthopaedics. Bilateral knee arthroplasty in same sitting is common, and there have been studies to prove the advantages of such a practice.^{8–14} HTO is conventionally, done one at a time, as each surgery has morbidity in terms of a prolonged period of recovery and restricted mobility associated with it. In a setting where patients travel long

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distances for tertiary care and surgery makes them less compliant to repeated visits or another surgery. A strong familial support system and nursing care makes this concept convenient. This however may be at the cost of an increased complication rate. This makes the selection of patients critical. Those who are medically fit, can tolerate longer surgery and hence anesthesia are ideal candidates. This is potentially more likely in HTO candidates rather than TKR's as the average age in this setting is less. Bilateral simultaneous high tibial osteotomy has been shown to minimise cost, reduce hospitalisation and maximise clinical benefits without any added complications.¹⁵ We, therefore, considered the idea of doing bilateral HTO at the same sitting as these contributing factors were prevalent in India.

2. Materials and methods

The study was conducted between April 2010 and August 2014.30 patients (60 knees) with bilateral medial compartment osteoarthritis of the knee were selected for simultaneous HTO using Tomofix®(Depuy, Synthes, Warsaw,IN,USA). There were 19 males (38 knees) and 11 female (22 knees) in the age group 45–55 years (mean age of 48.3 years). The selection criteria for HTO were the same as those recommended in the literature.¹⁶For this group undergoing bilateral simultaneous HTO, our additional selection criteria was a strong family/nursing support, with family members motivated to attend to the needs of an in-bed bound patient for a period of two weeks post surgery. We excluded patients with varus deformity $>10^\circ$, body mass index (BMI) > 35 , those with previous history of Deep Venous Thrombosis, and those with diabetes mellitus(to avoid any possible complications of wound healing).Prior to surgery, all patients had standard knee radiographs and a long leg hip-knee-ankle radiograph for pre-op planning.The degree of deformity pre-operatively was measured using the Femoro-Tibial angle (FTA). FTA was measured as the angle formed by the intersection of a line bisecting the femur and a line bisecting the tibia, originating 10 cm from the knee joint surfaces. Midpoint of the bases of the Tibial Spines is taken as the knee center landmark.^{17,18}

Hip knee ankle X-rays were taken at one month post operative when the patient was weight bearing without crutches. Similarly, Hip-Knee Ankle Xrays were additionally taken at 6 months and 2 years follow-up. X-rays of a representative case is shown in Fig. 1. The standard technique¹⁹ of open wedge biplanar HTO as described below.

2.1. Surgical technique

An 8 cm longitudinal incision is made medially from just below the joint line of the knee in the center of the medial tibial surface. The wound is dissected down to the bone by elevating the MCL and pes anserinus. A guide wire is passed from just above the patellar tendon insertion and in the middle of the medial surface of the tibia and is directed to the tip of the fibular head, that is confirmed on imaging. The oblique osteotomy is made beginning from just above the patellar tendon insertion to form an angle of 130° with the horizontal component of the osteotomy such that the vertical component occupies around $1/3$ of the surface of the medial aspect of the tibia. The horizontal component of the osteotomy is then made in the line of the guide wire and joining the vertical component. The lateral cortex is preserved. The osteotomy is opened up using serial osteotomes till the line of weight bearing passes through the Fujisawa's point using an alignment rod on table with imaging.The osteotomy is then fixed using a Tomofix plate and screws.Bone grafting of the defect created medially was not done²⁰

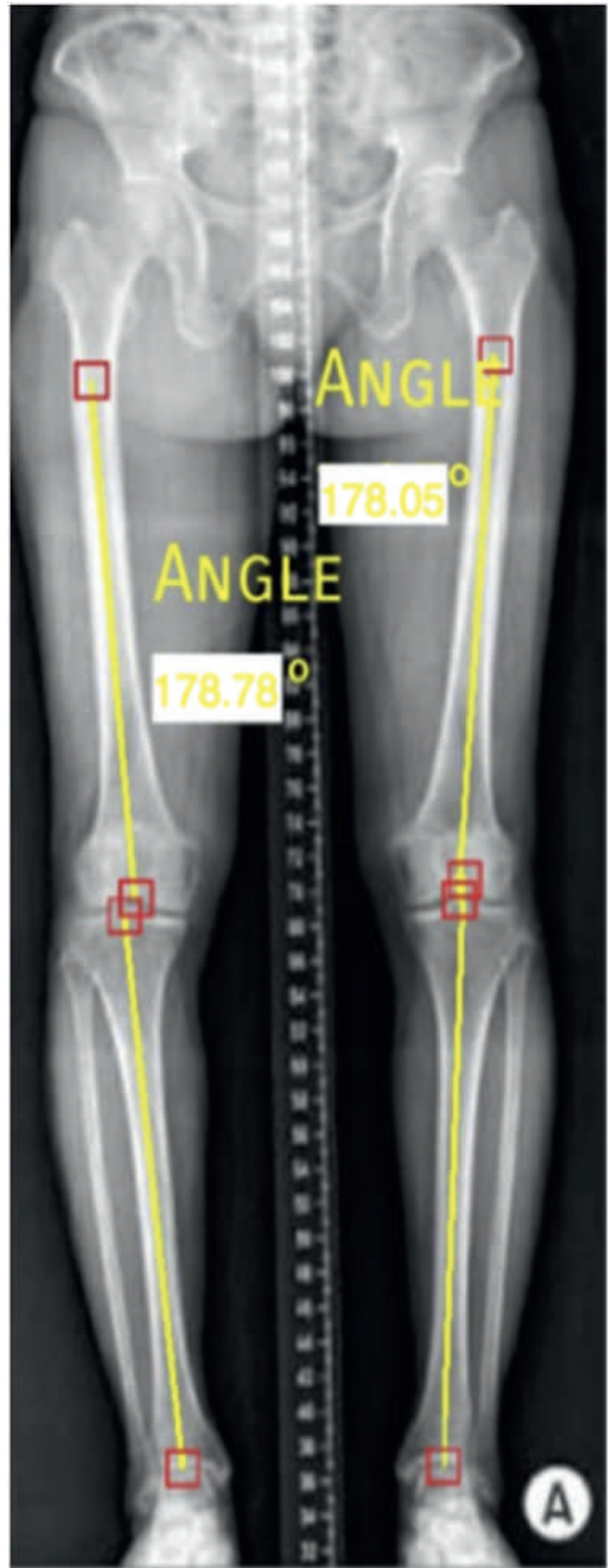


Fig. 1. Pre Op Hip Knee Ankle Xray of a representative patient.

2.2. Post-operative care

Postoperatively special care was taken to avoid Deep Venous Thrombosis by use of oral rivaroxaban 10 mg daily for 4 weeks. The patient's family was educated about positional changes in the bed to avoid bed sores. Range of motion exercises, and active and active-assisted exercises for quadriceps strengthening were started on the first post operative day. The patients were discharged on the fourth day post surgery. The patients were kept in bed for first two weeks to avoid weight-bearing stresses early on, on the osteotomy, however they were allowed to move in the bed and bend their knees as tolerated. Weight bearing as tolerated was allowed at the end of 2 weeks with the help of crutches.

2.3. Assessments (clinical and radiological)

The primary outcome measures of Knee Function Score (Insall modification), Visual Analogue Scale (VAS) and the correction achieved in femoro-tibial angle measured on standing hip-knee-ankle X-ray were recorded pre-op and at the end of 2 year (Fig. 2). Intra operative, post-operative and rehabilitation difficulties, and complications were recorded.

2.4. Statistical analyses

We used Statistical Package for the Social Sciences (SPSS) version 23 for the statistical analysis. Statistical significance was defined at $P < 0.05$. Repeated measures ANOVA test was used along with Green-house Geisser correction to detect significance of values assessed over time like VAS Score and Knee society scores. Bonferroni correction was used for Post-hoc test.

3. Results

Our Cohort had a total of 30 patients with 60 knees being assessed with the following descriptive statistics.

The median age was 48.3 years (range 45–55 years) with 19 males and 11 females.

The following variables in the study were assessed:

A: Femorotibial angle (FTA): changed from a mean pre-op varus of 4.13° (Range 3° - 7°) to a mean post-op valgus of 1.15° (Range 0° - 3°) with a mean correction of FTA being 5.31° .

There was no change in the Femoro-tibial angle at 6 months or 2 years follow-up. There were no cases of failure of fixation either.

B: The Knee Function Score (Insall Modification) improved from a mean of 41.87 ± 9.7 pre-op to 92.10 ± 3.5 at 6 months post op and 92.80 ± 2.75 at 2 years post op (Table 1).

A repeated measures ANOVA with a Greenhouse-Geisser correction determined that mean knee society score (KSS) differed statistically significantly between time points ($F(1.026, 29.757) = 784.549, P < 0.000$). Post hoc tests using the Bonferroni correction revealed that KSS values in pre op patients were significantly worse than in the same patients 6 months or at 2 years follow up (41.87 ± 9.7 vs 92.10 ± 3.5 v/s 92.80 ± 2.75 respectively) ($p = < 0.05$). Therefore, we can conclude that Knee Society scores improved significantly over time in the post op follow up period of 2 years (Table 2) (Fig. 3).

C: The Visual Analogue Score (VAS Score): for pain improved from a pre-op mean of 57.90 ± 6.8 to a mean 12.33 ± 7.1 at 6 months post op to 10.03 ± 6.28 at 2 year post-op (Table 1).

Similar to the calculations performed for the variable above (KSS), Repeated measures ANOVA with a Greenhouse-Geisser correction determined that mean VAS score differed statistically significantly between time points ($F(1.982, 57.471) = 488.60, P < 0.000$). Post hoc tests using the Bonferroni correction revealed

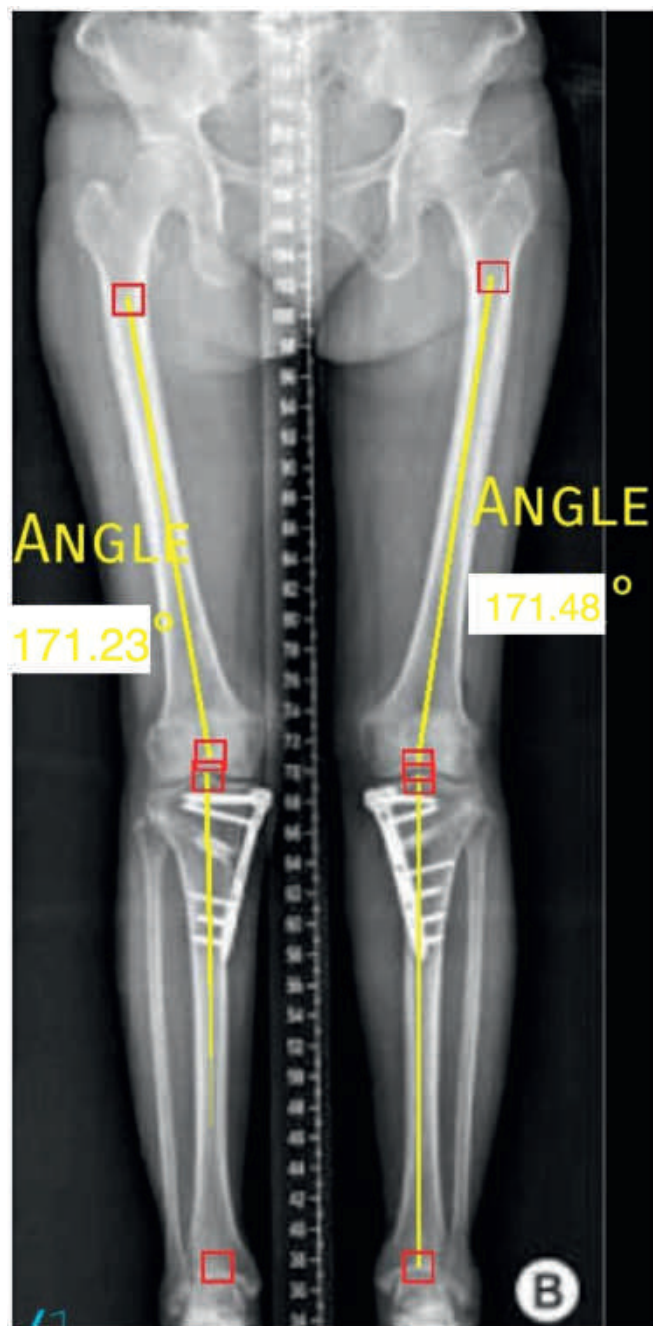


Fig. 2. Post Op Hip Knee Ankle Xray showing correction achieved with Tomofix in situ.

Table 1
Descriptive statistics pre op, 6 months post op and 2 years post op.

	Time (Dependent variable)	Mean	Std. Deviation	N
KSS ¹	1 = pre op	41.87	9.790	30
	2 = 6months	92.10	3.527	30
	3 = 2 years	92.80	2.759	30
VAS ²		57.90	6.830	30
		12.33	7.160	30
		10.03	6.283	30

1 = Knee society score.

2 = Visual Analog score.

Table 2

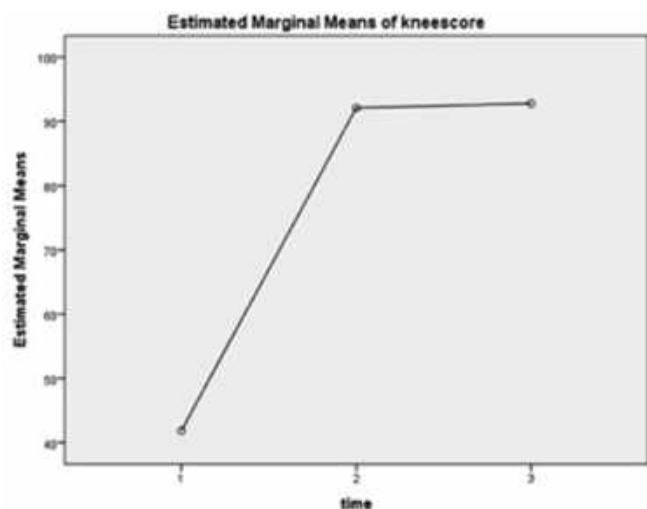
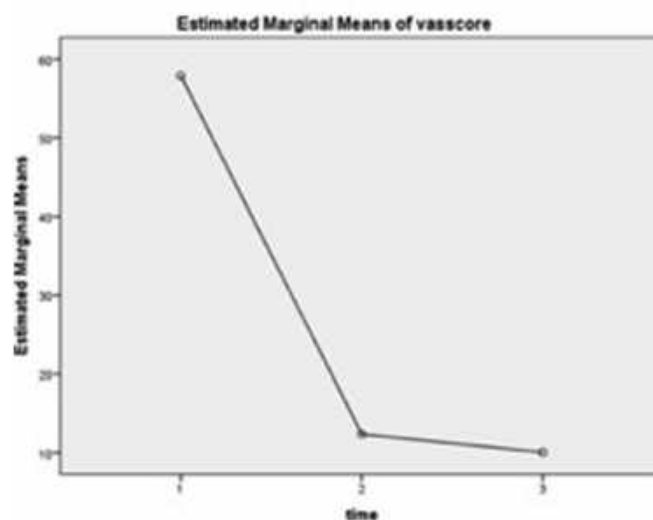
Comparison of Knee Function Score and VAS at pre op, 6 months and 2 years post op.

(I) time	(J) time	Mean Difference (I-J)	Std. Error	P ^b value	95% Confidence Interval for Difference ^b	
					Lower Bound	Upper Bound
KNEE SOCIETY SCORE.						
1	2	-50.233*	1.777	.000	-54.749	-45.718
	3	-50.933*	1.819	.000	-55.555	-46.312
2	1	50.233*	1.777	.000	45.718	54.749
	3	-.700*	.240	.021	-1.311	-.089
3	1	50.933*	1.819	.000	46.312	55.555
	2	.700*	.240	.021	.089	1.311
VAS SCORE.						
1	2	45.567*	1.690	.000	41.272	49.861
	3	47.867*	1.808	.000	43.273	52.460
2	1	-45.567*	1.690	.000	-49.861	-41.272
	3	2.300	1.680	.545	-1.969	6.569
3	1	-47.867*	1.808	.000	-52.460	-43.273
	2	-2.300	1.680	.545	-6.569	1.969

Based on estimated marginal means.

*. The mean difference is significant at the 0.05 level.

b. Adjustment for multiple comparisons: Bonferroni.

**Fig. 3.** Graph representing variation in Estimated Marginal Mean in Knee Society Score over 2 years.**Fig. 4.** Graph Representing variation in estimated Marginal Mean in VAS over 2 years.

that VAS Scores in pre op patients were significantly higher than in the same patients 6 months or at 2 years follow up (57.9 ± 6.8 vs 12.30 ± 7.1 v/s 10.03 ± 6.2 respectively) ($p = <0.05$). However the difference in VAS score wasn't significantly lower at 2 years follow up when compared with the 6 month post op score ($p = 0.545$). Therefore, we can conclude that VAS scores improved significantly over time in the post op follow up period of 2 years (Table 2) (Fig. 4).

D:Radiology: The osteotomy site had healed clinically as well as radiographically in all cases at 6 months post-operative time. There was no reported case of non-union or failure of fixation.

E: Other Observations: There were no early or late post-operative complications in any of the patients. None of the patients were converted to a TKR to date (followed up to 2 years post op).

4. Discussion

High tibial osteotomy has been successfully used in the treatment of medial compartment OA with excellent pain relief. As high tibial osteotomy, continues to enjoy a stable position in the treatment of knee OA, it suffers from a major disadvantage of doing so

one side at a time. This is so as the techniques of HTO in the past involved a prolonged period of non-weight bearing walking till the osteotomy site heals. The treatment involved a prolonged period of recuperation – the recovery from individual osteotomy and also the intervening period. The double hospitalisation and the repeated travel for two operations were also a significant negative. This becomes particularly complex in a setting where facilities for such operations are not readily available in nearby hospitals, and one may have to travel to far off places.

Bilateral simultaneous surgery has been common in orthopaedics, particularly in trauma and Arthroplasty surgery. There are publications in favour and against performing simultaneous bilateral knee arthroplasty in the same sitting.^{8,13,14} For the convenience of undergoing surgery at the same time, it is preferred by patients.¹⁴ Our main concerns with performing the HTO in a bilateral setting were maintenance of correction, early post operative rehabilitation and minimising complications associated with a long period of convalescence. Initially the popular techniques were a lateral closing wedge and medial opening wedge osteotomy. The former involved removing a wedge of bone from the lateral aspect of the upper tibia and the latter involving an osteotomy in the medial

aspect of the proximal tibia that was opened up till satisfactory alignment achieved, filled with bone graft and both techniques involved application of a plate. Over the years, the technique of HTO has undergone various changes. With recent techniques such as biplanar open wedge osteotomy using Tomofix® (Depuy, Synthes, Warsaw, IN, USA), it is possible to mobilise the knee the very next morning and also permit weight bearing immediately in post operative period.⁷ This has made the period of post-operative rehabilitation shorter, and thus the surgeons have performed the once improbable bilateral HTO in a single sitting. In one such publication, Takeuchi et al. practiced aggressive post operative protocol while doing bilateral simultaneous HTO using Tomofix® (Depuy, Synthes, Warsaw, IN, USA).¹⁷ They demonstrated post-operative outcome comparable to the surgery done one at a time. Our results seem to agree with them (Table 1). There was improvement in knee function score, significant pain relief and good correction maintained at 2 years post op. Apart from the benefit of reduction in total recuperation period, the advantage of cost saving and convenience in typical Indian setting where patients come from far off distances is great. For them it is not economically feasible to return to the far off city many times. The added advantage of early weight bearing using the biplanar osteotomy and the Tomofix® (Depuy, Synthes, Warsaw, IN, USA) plate allowed us to mobilise the patient within two weeks. There have been numerous studies done in the past evaluating simultaneous arthroplasty done in the same sitting with good results.^{8–14} Thus our hypothesis of doing bilateral simultaneous high tibial osteotomy using currently available implants is a feasible option in selected patients. Our results reflect that there were no complications in our subset of patients with improvement in Knee function scores at one year follow up and no conversions to a total knee replacement to date. The potential reasons for no medical complications were a relatively smaller and healthy subset of patients that were started on DVT prophylaxis after surgery, that was continued on discharge. The smaller population of patients and follow up of two years only could have contributed to the lack of hardware complications that are known to occur with the Tomofix.

Our study had limitations and hence affects the strength of recommendations. The smaller number of patients may be a confounding factor. Future studies with bigger number of patients may help foster the postulates of this study in regular orthopaedic practice. Patients' follow up was not possible for a longer duration because the participating cohort had to come from far flung areas. This led to the small number of follow up statistics that we have published. The manner in which the posterior slope changes after a High Tibial Osteotomy affect the outcome were not evaluated in this study and remain an area of further interest and research.

5. Conclusion

In conclusion, the authors feel that Bilateral HTO (Biplanar Osteotomy and Fixation with a Tomofix™ plate) is a feasible option for carefully selected population which allows for earlier post operative mobilisation. The technique also obviates the need for simultaneous bone grafting and thus avoids complications

associated with Auto/Allo Bone grafting. For patients who would be lost to follow up due to residence in inaccessible areas, this method of correcting the deformity and thus improving their quality of life, this may be an option to consider. However further research would be needed to recommend the same.

Declaration of competing interest

There is no conflict of interest whatsoever.

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Research paper

Arthroscopy-assisted tibial plateau fracture surgery - Minimum 2 years follow up results

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ABSTRACT

Background: Accurate anatomical reduction plays a crucial role in the surgical management of tibial plateau fractures. Arthroscopic visualization of the articular surface can allow for a precise reduction.**Objectives:** To evaluate the outcome of arthroscopy-assisted reduction and internal fixation for tibial plateau fractures, Schatzker Type III to VI.**Methods:** Thirty-five patients with tibial plateau fractures treated by arthroscopy-assisted fixation were enrolled in this prospective study. According to the Schatzker classification, the fractures types were as follows: type III (n=15); type IV (n=6); type V (n=8); type VI (n=6). The mean age was 36 years (range 24–58 years). The mean follow-up period was 38 months (range, 26–72 months). During surgery, initial arthroscopic evaluation was done, followed by provisional reduction using fluoroscopy. Subsequently, a final arthroscopic confirmation was done before definitive fixation. Bone grafting was done in all except 6 patients. Clinical and radiologic outcomes were scored by the Knee society score and Rasmussen system. **Results:** The Knee society functional score and Knee society knee score assessed at 6 months, 1 year and 2 years. Final follow up results showed good to excellent outcome in three out of four patients. With increasing severity of injury (from Schatzker types III to VI), the functional score deteriorated. The Rasmussen's Radiological Score at 24 months showed good to excellent scores in 86% individuals. The association between the condylar widening and functional score was found to be significant (p value < 0.05). The radiological and functional scoring was found to have a percentage agreement of 24%. Persistence of condylar widening had a less favorable functional outcome. Postoperative wound breakdown and infection are among major complications.**Conclusions:** Arthroscopic assisted fracture fixation for complex tibial plateau fractures with associated soft-tissue injuries is a safe and effective procedure that provides good functional outcomes.

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1. Background

The Tibial plateau is one of the critical load-bearing areas in the human body. Tibial plateau fractures are one of the most common intra-articular fractures comprising of 1% of all fractures.¹ Open reduction and internal fixation (ORIF) is the current treatment of

choice, however, the advantage of managing articular irregularities and associated meniscal or ligamentous pathology, makes arthroscopic reduction and internal fixation (ARIF), with a minimal skin incision but no capsulotomy or arthrotomy, as an emerging gold standard.² ARIF is recommended for all Schatzker³ Type III fractures, few other types namely types I, II and IV can be considered for ARIF. Arthroscopy-assisted surgery for Schatzker type V and VI fractures (skin incision and plating, with arthroscopy but no arthrotomy), can also be considered. The clinical outcomes of arthroscopically treated tibial plateau fractures are sparsely reported in the literature especially the types V and VI.⁴ We intended

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to assess the clinical and radiological outcomes of arthroscopic assisted tibial plateau fixation of types III to VI. Also we hypothesized that restoration of anatomy by accurate fracture reduction correlates directly with the functional outcome of the patient.

Objectives: 1) To evaluate the outcome of arthroscopy-assisted reduction and internal fixation for tibial plateau fractures Schatzker Type III to VI based on Knee Society Score and Rasmussen Radiological Score. 2) To correlate the radiological findings with functional outcome and to verify the hypothesis that restoration of anatomy is directly proportional to the functional outcome of the patient.

2. Materials and methods

This prospective study was carried out in a tertiary care trauma center between March 2013 and June 2014. A total of 35 patients (Schatzker type III, 15; type IV, 6; type V, 8; type VI, 6.) were enrolled based on the eligibility criteria. Inclusion criteria: Patients with proximal tibia fractures who were willing to participate in the study, age >18 years, Schatzker type III, IV, V and VI, closed fractures or Gustilo Anderson Grade I injuries. Exclusion criteria: Patients refusing to participate in the study, Schatzker Type I and II fractures, pathological fractures, neurovascular injury, open fractures Gustilo Anderson Grade II or III, associated ipsilateral or contralateral major limb injury (including fractures) affecting the treatment or rehabilitation protocol, associated upper limb fractures requiring surgery, and major systemic illness (malignancy, chronic kidney, liver disease, etc.). The study was approved by the Institutional Review Board and Ethics Committee. Informed consent was obtained from all patients. Ethical standards according to the Helsinki declaration of 1964 were conformed to.

All patients were kept on skin traction upon admission and ice pack application, limb elevation was given. A thorough history and clinical examination was done along with the relevant preoperative work-up. The radiographs obtained included Pelvis anteroposterior (AP) view and AP-lateral views of the affected knee and ipsilateral ankle joint. The fractures were classified according to the Schatzker classification.³

Time of surgery depended on soft tissue condition, all patients were taken for surgery only when skin wrinkles appeared and in open fractures after healing of the wound (four patients were Gustilo Anderson Grade I). The mean interval between injury and definitive surgery was 11 ± 5 days (range, 1–19 days). The delay was due to the fact that many patients were referred from other centers. Ceftriaxone 1 g was used as prophylactic antibiotic (administered 30 min before tourniquet inflation).

Surgical technique: All surgeries were done with patient supine, with a foot rest for knee flexion to 90° during arthroscopic assessment and a bolster was used during plate fixation. Knee was examined under anesthesia to look for ligamentous instability. The surgical approach was the same in all cases, standard two portals for arthroscopy and lateral approach for plating except for few cases where medial plating was also done. Skin incisions for fracture fixation were made initially with intact bony landmarks because arthroscopic evaluation can lead to seepage of fluid into the leg causing swelling and distort the anatomy. An arthroscopic evaluation preceded fracture reduction (Figs. 1 and 2). Initially, the inflow fluid was infused and the joint was washed thoroughly to permit evacuation of hematoma and loose bodies. During diagnostic arthroscopy concomitant intraarticular traumatic pathologies (meniscal tear, meniscal entrapment in the fracture site, loose bodies) were addressed. ACL guide was used to precisely aim at the depressed condylar fragment and elevate it. Under fluoroscopic guidance, fracture reduction and provisional fixation with K wires was done, followed by an arthroscopic confirmation of acceptable



Fig. 1. Intraoperative image of right knee showing the arthroscopic assisted tibial fracture reduction.

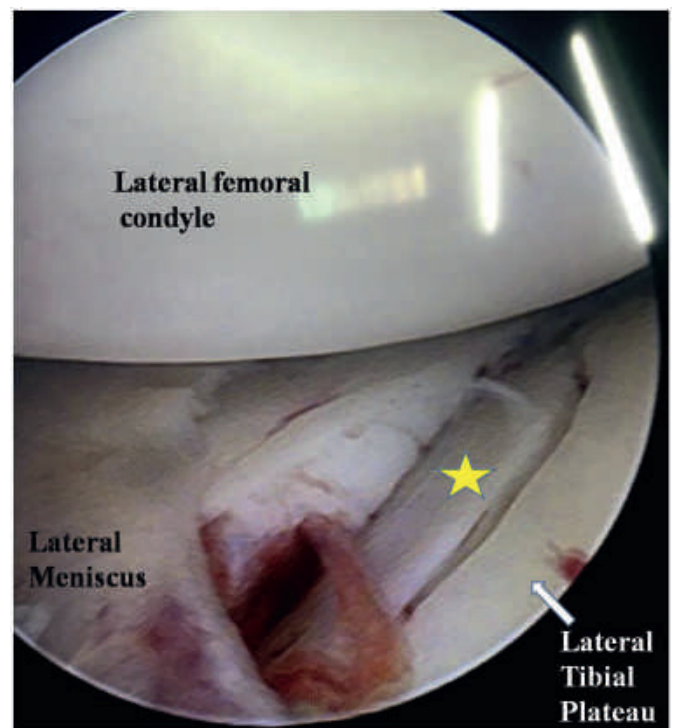


Fig. 2. Arthroscopic image denoting the fracture of lateral tibial condyle ('star' indicate the depressed fracture fragment).

reduction. After insertion of the implant, the position of bone fragments and plate were checked with an image intensifier. A drain was routinely used in all cases and removed at 48 hours.

In bed mobilization began from the 1st postoperative day. Toe-touch weight bearing was allowed only at 6 weeks or later (depending on fracture pattern and stability of fixation). Further weight bearing was advised based on the progress of fracture healing on radiographs. During follow-up patients were assessed in outpatient clinics at 6 weeks, 3 months, 6 months, one year and then annually. The functional score was evaluated as per The Knee society score⁵ and Rasmussens radiological scoring system.⁶

The sample size was calculated based on previous studies. As per a similar study conducted by Manidakis N, Dosani et al. (2010)⁷ the proportion of tibial condylar fractures having good functional outcomes were 69%. Sample size was calculated using formula $4p(100-p)/d^2$ where "p" is the proportion of subjects with good

outcome (69%) and “d” is the absolute precision (taken as 20%). For the current study, the minimum sample size for statistical significance was estimated as 21 by the above method and 35 consecutive cases who presented in the orthopaedic OPD/Emergency in the stipulated time period was included in the study. Baseline characteristics were assessed using descriptive statistics; mean and standard deviation for continuous variables and percentages for categorical variables. Univariate analysis was first carried out to determine association of exposure variables with functional outcomes using fisher exact test. P value < 0.05 was considered to be statistically significant.

3. Results

The mean age at surgery was 36 years (range 24–58 years). The mean follow-up period was 38 months (range, 26–72 months). The radiological scoring evaluation at 24 months showed that an angulation (varus or valgus) was not present or less than 10° in 92% of patients and remaining 8% had 10–20° of angular deformity. Articular depression was not present in 56%, less than 5 mm in 36% and remaining 8% had less than 10 mm articular depression. Condylar widening was not present in 64%, less than 5 mm in 32% and 4% had 6–10 mm widening. In two years, 88% of patients attained good range of movement of which 64% had flexion of 90–120° and 24% had flexion more than 120°. Majority (68%) of patients had no complications. 12% had superficial infection and 16% had wound dehiscence. 12% of patients (3 patients) had common peroneal nerve injury presented as foot drop. 2 patients had lateral meniscal injury and 1 patient had isolated medial collateral ligament injury. Knee stiffness was present in 2 patients in whom the range of movements were around 80–90°. One patient had Compartment syndrome managed by fasciotomy. Three patients who had findings of painful tense leg swelling but not consistent with that of compartment syndrome were managed conservatively.

The functional outcome deteriorated with increasing severity of the injury. In Schatzker type III 44.4% had excellent, 22.2% had good, 33.3% had fair and none had a poor score. In Schatzker type IV 33.33% had excellent, good and fair scores each. None had a poor score. In Schatzker type V 14.30% had excellent, 42.9% good, 28.6% fair and also a poor score of 14.30%. In Schatzker type VI none had an excellent score, 33.3% had good, 50.0% fair and a poor score of 16.70%.

The relationship between knee society score and condylar widening was found to be statistically significant (p value 0.04). When the condylar widening is not present we got a 37.50% excellent and 31.20% good results in knee society score. While the condylar widening increased to 5 mm, none of the patients had excellent results and 37.50% had good results, and further as the condylar widening increased to 6–10 mm, all had a poor outcome with the knee society score.

The Rasmussen’s Radiological Score at 24 months showed good to excellent scores in 86% individuals. The association between the condylar widening and functional score was found to be significant (p value < 0.05). Persistence of condylar widening had a less favorable functional outcome.

4. Discussion

The findings of this study (i.e., generally satisfactory clinical and radiological outcomes as determined by Rasmussen scores) are consistent with the findings from other studies.^{8–10} This is a prospective study of the functional outcome of tibial plateau fractures, Schatzker types III, IV, V and VI treated with internal fixation with arthroscopic assistance. The most common type of fracture was type III Schatzker (36%) followed by type V. The incision and

method of surgical fixation was decided based on the Schatzker fracture types. Bone grafting was done in cases of joint depression type of fractures and those with comminution.

The Knee society functional score and Knee society knee score assessed at 2 years showed a good to excellent outcome of 56% and 68% respectively. It was observed that as we moved from Schatzker types III to VI, the functional score deteriorated, showing the delay in functional recovery in complex fracture types.

The Rasmussen’s Radiological Score at 24 months showed a good to excellent results in eight out of ten patients. Angulation (valgus or varus) was not present or less than 10° in 92% of patients. The articular depression was not present in 56% and less than 5 mm in 36%. Condylar widening was not present in 64% and less than 5 mm in 32%. The functional outcome and radiological parameters have been compared and the association between the condylar widening and functional score was found to be significant (p value 0.04). The association between The Knee Society Score and The Rasmussen’s Radiological Scores was analyzed and there was percent agreement of 24% between them. This could be due to the short follow up period of our study which could not consider the onset of secondary osteoarthritis resulting from articular incongruity. In a comparative study, Fowble et al.¹¹ found that the proportion of patients with anatomic reduction was much higher for arthroscopic assisted fracture fixation (12 of 12; 100%) compared with open reduction and internal fixation (ORIF) (6 of 11; 55%). Our results are comparable with that of other similar studies^{9,10,12–15} which shows arthroscopic assisted surgery results in satisfactory (good or excellent) clinical outcomes in a large proportion of patients. Radiological outcomes also seem to be satisfactory in the majority of patients; although the evidence is not as strong as that for clinical outcomes.

The majority of patients had no complications but superficial wound infection and wound dehiscence was found to be the predominant complication, more in complex tibial plateau fractures. Compartment syndrome was encountered in one patient, this dreaded complication can be prevented by proper patient selection, minimizing the arthroscopic time, utilising dry arthroscopic technique and avoiding the use pressure pump. Complex fracture types had delay in wound healing, more incidence of post-operative infection and delayed union due to which late mobilization, knee stiffness and delayed functional recovery resulted.

Despite several limitations of this study like small sample size and a short follow up period, we believe that it provides useful information with regards to a good functional outcome following tibial plateau fractures treated by internal fixation. It throws light into various clinical, radiological and surgical factors and the related complications following surgical management (ARIF) of these challenging fractures. A large scale, randomized control study comparing arthroscopic assisted proximal tibia fixation with the conventional way of proximal tibia fixation is recommended.

5. Conclusions

Arthroscopic assisted fracture fixation for complex tibial plateau fractures with associated soft-tissue injuries is a safe and effective procedure that provides good functional outcomes.

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Research paper

Association among patient satisfaction, functional outcomes, and physiotherapy approaches after arthroscopic rotator cuff repair

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ABSTRACT

Introduction: Patient satisfaction is widely used for assessing medical care outcomes after arthroscopic rotator cuff repair. However, the association between patient satisfaction, functional recovery and physiotherapy approaches has not yet been studied. The purpose of the study was to investigate patient satisfaction after 2–3 years from rotator cuff repair and its association with functional outcomes and physiotherapy approaches followed after surgery.

Material and methods: A total number of 102 patients who underwent arthroscopic rotator cuff repair were interviewed 2–3 years after surgery. Overall satisfaction (Yes/No), quality of life (Euro Quality of Life 5 Dimensions - EQ-5D), subjective shoulder functioning (Subjective Shoulder Value - SSV), arm, shoulder and hand disability (Disability Arm Shoulder Hand - DASH), type of physiotherapy program and its duration were investigated by a telephone interview.

Results: Ninety-nine patients claimed to be satisfied, whereas 3 patients were unsatisfied at 32.1 months (range from 28 to 40 months) after surgery. SSV revealed a difference between satisfied and unsatisfied patients ($p = 0.005$), whereas EQ-5D and DASH scores did not show any between-group difference. One-hundred one patients followed a rehabilitation program after surgery without any association between satisfaction and physiotherapy approaches and duration.

Conclusions: Two to three years after arthroscopic rotator cuff repair almost all patients are satisfied. Satisfaction is not associated with gender, age, smoking habit, comorbidities such as diabetes, cardiovascular or respiratory disorders, tear localization, residual disability, quality of life or physiotherapy approaches followed after surgery.

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1. Introduction

Patient satisfaction is gaining greater prominence for evaluating the efficacy of medical care.¹ It incorporates congruence of healthcare services, patient's needs, desire or expectations and reflects the overall assistance experience. This indicator is a

commonly used outcome measure by healthcare services for controlling medical care outcomes and plays a fundamental role also in outcome assessment after surgical interventions.²

Arthroscopic rotator cuff repair is one of the most common orthopedic procedures in which the recovery of shoulder function, assessed by both subjective and objective clinical tools and imaging of tissue healing, represents the most important outcome.^{3,4} It is worth noting that a discrepancy between clinical outcomes and imaging results was reported, since patients may achieve successful clinical outcomes despite an incomplete healing state. Gullotta et al. studied the effectiveness of arthroscopic cuff repair by investigating the tissue healing rate through ultrasound and clinical outcomes one year following surgery.³ They found that the healing rate was 64.3% but surprisingly patient satisfaction rate was 93%.

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Similarly, pain relief and functional improvement are important outcome measures after cuff rotator repair, but their association with patient satisfaction remains unclear.⁵ In 2005 O'Holleran et al. analyzing surgical subjective and objective parameters in patients with cuff rotator repair, stated that patient satisfaction plays a central role in determining surgical outcomes and that subjective variables and function have the greatest associations with patient satisfaction.⁶ However, modern surgical techniques have evolved and patient lifestyle and expectations are also changing.^{7,8}

Furthermore, published guidelines highlight the importance of a postoperative rehabilitation program, in order to optimize functional recovery and patient satisfaction.⁹ The primary goals of postsurgical rehabilitation are to increase range of motion and minimize stiffness and muscle atrophy so as to facilitate recovery and tendon healing. Manual therapy, assisted and non-assisted exercises represent the most used postoperative rehabilitation approaches, whereas instrumental therapies are less recommended.⁹ Nevertheless, there is a lack of evidence about the most effective physiotherapy approach and its impact on patient satisfaction. Understanding satisfaction determinants after rotator cuff repair would promote the therapeutic alliance between clinicians and patients and avoid not meeting a patient's expectations.

Against this background, the association between patient satisfaction, functional recovery and physiotherapy approaches after arthroscopic rotator cuff repair has not yet been studied. The purpose of this study was to investigate patient satisfaction 2–3 years following rotator cuff repair and evaluate its association with functional outcomes and physiotherapy approaches.

2. Methods

2.1. Participants

Humanitas Research Hospital's shoulder database, which collects patient demographics and clinical data, was reviewed by the first author. Patients who underwent arthroscopic rotator cuff repair from January 2015 to February 2016 performed by the three surgeons of the Shoulder and Elbow Surgery Unit were selected for a telephone interview 2–3 years after surgery. Telephone interviews were carried out between January and April 2018. The study complied with the Declaration of Helsinki on ethical principles for medical research involving human subjects, informed consent was obtained and the study was approved by the Ethical Committee of Humanitas Clinical Institute.

2.2. Procedure

Patients with a symptomatic cuff rotator tear, diagnosed by Magnetic Resonance Imaging that underwent rotator cuff repair, were selected from the database. All patients underwent surgery more than 6 months after the diagnosis and they were classified with code ICD9 8363 (cuff rotator repair) and code ICD9 8021 (arthroscopic shoulder surgery).

After this first selection, patients undergoing rotator cuff repair with or without concomitant biceps tenotomy, biceps tenodesis, articular debridement, acromioplasty, synovectomy and bursectomy were included in the study, whereas exclusion criteria were: tendon repair with concomitant arthrolysis, rotator interval release, distal clavicle excision (Mumford), calcific tendinitis resection, removal of free intrarticular fragments and repair of glenoid labrum (SLAP). All patients were operated under regional anesthesia by the same three surgeons. The arthroscopic procedure was performed using a single row double-loaded titanium suture anchor, sometimes associated with a latero-lateral reinforcement suture.⁸

Demographic (age and gender) and clinical characteristics of

patients (smoking habit, comorbidities such as diabetes, cardiovascular and respiratory disorders and tear localization) were collected. Moreover, the telephone interview investigated: 1) satisfaction after surgery (dichotomy question: satisfied or unsatisfied) and the answer Yes or No to the question "Considering your actual results, would you repeat surgery?"; 2) quality of life (five dimensions of the EQD5 questionnaire: mobility, self-care, usual activities, pain/discomfort and anxiety/depression); 3) subjective perception of shoulder functioning (Subjective Shoulder Value - SVV); 4) disability caused by shoulder (DASH questionnaire).

Finally, patients were asked how long they had attended physiotherapy after surgery (less than 1 month, 1–3 months, 3–6 months, more than 6 months), how many treatment sessions they had attended (more or less than ten) and the main physiotherapy approach (possible answer: manual therapy, assisted or self-managed exercise, instrumental therapy application). The same operator conducted all the telephone interviews, which lasted about 30 min each, reading all questionnaires. All patients had previously encountered SSV and DASH measures during hospitalization after surgery.

2.3. Statistical analysis

Qualitative variables were described as numbers and percentages, whereas quantitative variables were described as mean and standard deviation. Satisfaction was considered as an independent variable and the Fisher test for qualitative variables and Wilcoxon test for quantitative variables were used to compare outcome measures between the two clusters of patients (satisfied and unsatisfied). Finally, the Kruskal-Wallis test was used to compare variables among the three groups of physiotherapy approaches in satisfied patients. STATA 13.0 software was used for statistical analysis and the statistical level of significance was set at $\alpha = 0,05$.

3. Results

Two hundred and two subjects were selected and 102 interviewed: 23 subjects were excluded due to the presence of exclusion criteria, 38 did not answer the telephone call and 39 were not available to be interviewed. The sample was composed of 41 men and 61 women with a mean age of 55.5 years (range from 29 to 70) and the average time elapsed after surgery was 32.7 ± 3.9 months (range from 28 to 40 months).

Table 1 shows demographic and clinical characteristics as well as the physiotherapy modalities used after surgery in satisfied and unsatisfied patients. Ninety-nine patients (60 women and 39 men) were satisfied, whereas only 3 patients (2 men and 1 woman) were unsatisfied, declaring they would not repeat surgery. Reasons for dissatisfaction were related to persistent pain, stiffness during upper limb movements limiting the range of motion and perception of considerable asymmetries in terms of strength and mobility, when compared to the unaffected limb. Smoker habit ($p = 0.484$), diabetes ($p = 0.784$), cardiovascular ($p = 1.000$) and respiratory disorders ($p = 0.806$) and tear localization ($p = 0.932$) did not differ between satisfied and unsatisfied patients. The only difference between the groups was found for SSV, with a mean difference between unsatisfied and satisfied patients of 25 out of 100 ($p = 0.005$). EQ5D and DASH scores did not show any statistically significant difference with a mean difference of 2 ($p = 0.912$) and 18.7 ($p = 0.134$) out of 100 respectively. None of the interviewed patients referred postoperative complications or re-operations. Moreover, the medical records of patients who were not contactable by telephone interview revealed that no postoperative complications or re-operations occurred.

Table 1

Satisfaction association with age, gender, comorbidities, smoking, tear localization, SSV, EQ-5D, DASH scores and different physiotherapy approaches. Categorical variables are shown as proportion and percentage, whereas continuous variables as mean and standard deviation.

	Satisfied (n = 99)	Unsatisfied (n = 3)	p-value
Age	57.7 ± 9.19	53.3 ± 5.69	0.414
Men/Women	39/60 (39.4/60.6%)	2/1 (66.7/33.3%)	0.563
Smoking (yes/no)	19/80 (19.2/80.8%)	1/2 (33.3/66.7%)	0.484
Diabetes (yes/no)	8/91 (8.1/91.9%)	0/3 (0/100%)	0.784
Cardiovascular diseases (yes/no)	33/66 (33.3/66.7%)	1/2 (33.3/66.7%)	1
Respiratory diseases	7/92 (6.9/93.1%)	0/3 (0/100%)	0.806
Tear localization			
Supraspinatus only	64 (64.6%)	2 (66.7%)	0.932
Supraspinatus + infraspinatus and/or subscapularis	31 (31.3%)	1 (33.3%)	
Infraspinatus and/or subscapularis only	4 (4.0%)	0	
SSV	85 ± 0.13	60 ± 10	0.005
EQ5D	81 ± 0.17	83 ± 0.24	0.912
DASH	9.58 ± 10.85	28.33 ± 23.15	0.134
Physiotherapy approach (n = 101)	n = 98	n = 3	0.091
Manual therapy	17 (17.3%)	0	
Exercise therapy	79 (80.6%)	2 (66.7%)	
Instrumental therapy	2 (2%)	1 (33.3%)	
Physiotherapy duration (n = 101)	n = 98	n = 3	0.12
<1 month	9 (9.2%)	1 (33.3%)	
1–3 months	63 (64.3%)	1 (33.3%)	
3–6 months	17 (17.3%)	0	
>6 months	9 (9.2%)	1 (33.3%)	

SSV: Subjective Shoulder Value, EQ-5D: Euro Quality of life 5 Dimensions, DASH: Disability Arm Shoulder Hand.

Physiotherapy programs were attended by 101 patients, only one patient, belonging to the satisfied group, did not participate. The duration of physiotherapy in the satisfied population was less than 1 month in 9.2% of the groups, 1–3 months in 64.3%, from 3 to 6 months in 17.3% and more than 6 months in 9.3% of the cohort. As for the overall number of physiotherapy sessions, 40.8% of patients had fewer than 10 treatments, whereas 59.2% participated in more. Physiotherapy sessions were focused on manual therapy in 17.3% patients, exercises in 80.7%, and instrumental therapies in 2.0% of the cohort. The comparison of the functional outcome scores among the three different physiotherapy approaches did not show any difference (Table 2). Finally, physiotherapy approaches and duration were not different between satisfied and unsatisfied patients ($p = 0.091$ and $p = 0.12$ respectively).

4. Discussion

Patient satisfaction after surgery is gaining relevance as it takes into account the hospital's ability to provide good services, reflecting a measure of healthcare quality.¹⁰ The purpose of this study was to investigate patient satisfaction and its association with functional outcomes and physiotherapy approaches 2–3 years after rotator cuff repair. This study reported that 96.6% of patients claimed to be satisfied after surgery.

Considering the results, the advancements in surgical techniques may have contributed to slightly improved patient satisfaction if Levy et al., in 2008 had already found 92% of patients were satisfied 35.8 months after surgery.⁴ This may depend on a ceiling

effect, since the satisfaction level was already high in the study of Levy. At the same time, patient satisfaction could also be less related to surgical techniques. This issue is controversial since some studies have associated patient satisfaction with quality and efficiency of surgical care, whereas other studies have reported that it is independent to surgical process.¹¹ Barnes et al. found that functional differences observed after rotator cuff repair performed with different arthroscopic techniques did not change the level of satisfaction which may be due to the fact the pain score was almost always low.¹²

In accordance with other studies, satisfaction is independent of age, probably because functional requirements decrease with aging and older patients have the same potential of functional recovery.⁶ However, unlike previous studies, we did not find that females were associated with lower functional recovery after rotator cuff repair.¹³ Though not well understood, this difference from previous studies could depend on other lifestyle factors able to influence functional recovery, such as smoking or pre-operative physical conditions (i.e. muscular strength or physical endurance) not evaluated in the current study.¹³

Recent studies have explored functional outcomes after surgical versus conservative treatment in patients with symptomatic rotator cuff tear, underlining greater benefits in favor of surgery at 1 year.¹⁴ Interestingly, these advantages have been reported to last up to 10 year after surgery.¹⁵ In particular, arthroscopic rotator cuff repair induces better improvements on perceived pain and shoulder function (Shoulder Constant Score) compared to conservative management (physical therapy and/or corticosteroid injections),

Table 2

Comparison among physiotherapy approaches in satisfied group. Data are shown as mean and standard deviation.

	Manual therapy (n = 17)	Exercise therapy (n = 79)	Instrumental therapy (n = 2)	p-value
SSV	88.33 ± 11.24	84.78 ± 12.69	60 ± 28.28	0.118
EQ-5D	79 ± 21.6	81 ± 16	90 ± 14.4	0.661
DASH	10.11 ± 12.09	9.85 ± 10.92	5.7 ± 4.52	0.934

SSV: Subjective Shoulder Value, EQ-5D: Euro Quality of life 5 Dimensions, DASH: Disability Arm Shoulder Hand.

leading to an increase in patient satisfaction.¹⁴ Therefore, despite the lack of a control group without surgery in our study, it is reasonable to speculate that the observed results would not have been reached through conservative approaches.

There were only three unsatisfied subjects, but we found a significant difference compared to the satisfied population in Subjective Shoulder Value score. Considering the subjectivity that the evaluation of satisfaction implies, it may well be related to subjective outcome measures like SSV, which quantify the perception of shoulder function, independently from the observer's opinion. A previous study described that SSV correlates with the Shoulder Constant Score after rotator cuff surgery.¹⁶ On the contrary, presented data did not show any association between satisfaction and other traditional outcome measures used as markers of functional outcomes and quality of life (DASH, EQ-5D). However, it is worth noting that the small number of unsatisfied patients did not allow for any significant differences to be reached, even if this group showed fewer functional abilities.

No association between satisfaction and physiotherapy was found. In particular, only one patient, belonging to the satisfied group, did not attend a physiotherapy program. Moreover, in satisfied patients, different rehabilitation approaches did not influence subjective opinion (SSV), functional recovery (DASH) or quality of life (EQ-5D) scores. The type of rehabilitation treatment does not seem to be a determinant of patient functional outcomes after cuff rotator repair since in interviewed patients the recovery was independent to the physiotherapy approach. A possible explanation could be that all approaches are effective in reducing stiffness and increasing muscle strength. In fact, no studies have stated the superiority of one approach over the other.⁹ Moreover, it is not possible to exclude that in the investigated population different physiotherapy approaches allowed for the achievement of functional goals with different speeds. In fact, Senbursa et al. described that patients with impingement syndrome treated with manual therapy showed greater improvements in satisfaction than the group instructed by a self-training program three months after surgery.¹⁷

This study has several limitations. The main limitation of the study was the limited number of interviewed patients (57%) compared to the number of operated subjects. In fact, although the medical records of uncontactable patients revealed no adverse events, we cannot exclude that these patients were unsatisfied with their treatment and that patients who agreed to the interview may have had a more positive point of view. Second, a control group without surgery might have reinforced our findings, and a short and/or intermediate follow-up might have provided further consideration about the efficacy of different physiotherapy regimes. Third, we have no information on what treatment patients followed before surgery, which might have contributed to better identify the responders to surgery and understand potential associations between satisfaction and clinical history. Finally, patient expectations were not investigated, whereas literature describes that it can influence satisfaction, functional outcomes and pain relief.⁷

In conclusion, presented results showed that 2–3 years after rotator cuff repair almost all patients are satisfied and the satisfaction is not associated with gender, age, smoking habit, comorbidities such as diabetes, cardiovascular or respiratory disorders, tear localization, residual disability, quality of life and physiotherapy approaches followed after surgery. The only variable which seems to be related to satisfaction is the subjective opinion of the shoulder functioning, measured using the Subjective Shoulder Value.

Author contribution

Gianluca Ruggiero: Conceptualization, Data curation, Writing. Federico Temporiti: Formal analysis, Writing, Supervision. Giulia Zanotti: Data curation, Formal analysis, Investigation, Methodology. Mario Borroni: Supervision, Methodology. Giacomo Delle Rose: Supervision, Methodology. Alessandro Castagna: Conceptualization, Supervision, Methodology. Roberto Gatti: Conceptualization, Data curation, Supervision, Writing.

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Declaration of competing interest

None.

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Case report

Greater tuberosity avulsion injury in an adolescent managed by physal sparing extraosseous stabilisation



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ABSTRACT

Rotator cuff and tuberosity avulsions in growing age group are rare injuries with concerns about delayed diagnosis and physal damages. We report in a 14-year boy with isolated greater tuberosity apophyseal separation that was initially overlooked and presented later with displacements and supraspinatus/infraspinatus weakness. The fracture geometry and proximity of physis did not favour an arthroscopic procedure. Open reduction was performed and stabilised by an extraosseous construct in the form of fibre tapes, interval closure and screw post. The proximal humeral epiphysis united by eight weeks without alteration in physis and had an excellent modified UCLA outcome score of 35 in thirteen months follow up. Knowledge on the physal anatomy, mechanism of injury and astute clinical examination of shoulder are of paramount importance to adequately manage pediatric cuff injuries. The extraosseous method is an effective alternate when the transosseous physis sparing fixation methods are limited.

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1. Introduction

Rotator cuff impairment due to tuberosity avulsions or tears in the pediatric and adolescent age group are uncommon presentations (less than 1% of rotator cuff injuries) with limited reporting in English literature.¹ This injury assumes clinical significance because of the delay in presentation or diagnosis and limited fixation methods available to avoid damage to the proximal humeral physis.^{2–4} We report this rare case of rotator cuff insufficiency in the form of greater tuberosity avulsion fracture that was managed by a novel method of extraosseous physal-sparing fixation. We also highlight the physal anatomy of the proximal humerus to avoid misdiagnosis and guide to the physal-sparing fixation methods.

2. Case report

A 14-year boy had sustained a fall on outstretched hand and complained of pain and swelling of the right shoulder and hand. There was tenderness over the proximal humerus region, and all

active and passive range of movements were limited by pain. He had associated fracture of second metacarpal of hand. He was discharged from the emergency services with arm sling and analgesics, as the plain radiograph of the shoulder was suggestive of an un-displaced greater tuberosity fracture (Fig. 1). The metacarpal fracture was also managed conservatively. Although the pain had subsided, four days later, the patient presented to the shoulder clinic with difficulty in shoulder abduction. Active abduction and external rotation were zero degrees. However the passive abduction and external rotation in adduction were 120 and 70° respectively with pain. Drop arm sign and Neer's impingement test were positive.⁵ The Jobe's test and restricted external rotation featured supraspinatus weakness and infraspinatus weakness respectively with the medical research council (MRC) grade one in each of the muscle put to test.⁵ The integrity of internal rotation (up to lumbar region) and forward flexion (170°) movements was grade four (MRC). The repeat radiographs showed a greater tuberosity apophyseal separation of right proximal humerus compared to the contralateral side (Fig. 2A–B). The computed tomography (CT) scan further confirmed an isolated greater tuberosity epiphyseal separation of more than 7mm from the intact proximal humerus physis (Fig. 2C–D).

An initial attempt to reattach the greater tuberosity along with the posterolateral rotator cuff arthroscopically was made.

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Fig. 1. Plain radiograph antero-posterior (AP) view of the right shoulder at the time of presentation in emergency. Suggestive of an undisplaced greater tuberosity fracture that was managed conservatively.

However, the large size of the fragment and the requirement of at least three suture anchors in the physis did not favour an arthroscopic technique in view of potential physeal damage. Hence, an open procedure through a delto-pectoral approach with a physeal-sparing fixation method was performed. Two 2mm fibre tapes were passed through the cuff tendinous portion in cruciate fashion and the two limbs were attached to a screw post (3.5mm cortical screw with washer) at a site 3cm distal to humeral physis, crossed over the greater tuberosity fragment (Fig. 3A–B).

Pendulum exercises were started on the third day, passive ROM at one week, assisted active movements at four weeks. At four month post fixation, the fracture united completely. He exhibited full active range of movements (180° of flexion and abduction, internal rotation up to scapula and external rotation in adduction of 80°) and strength (MRC grade five) with a CONSTANT score of 98 and an excellent modified UCLA outcome score of 35 (Fig. 4).⁶ Over the period of eighteen months, we did not observe any growth disturbances or dislocations.

3. Discussion

The incidence of rotator cuff injuries in the pediatric age group especially among the non athletic population is often limited to case reports and series (less than 1% of rotator cuff injuries).¹ Unlike the presentations in adults, subscapularis tendon/lesser tuberosity avulsion appears to be the commonly involved rotator cuff in the pediatric cohort and mostly related to overuse syndromes.^{1,2,4} Garrigues et al. suggested that a high index of suspicion of such injuries aided by clinical examination and knowledge on the physeal anatomy of proximal humerus are of paramount importance to avoid misdiagnosis.² Although a few cases of supraspinatus cuff tears have been reported, a case of isolated greater tuberosity apophyseal injury is least reported in English literature.^{4,7}

The proximal humeral head ossification takes place from three sites namely the greater tubercle, medial head and lesser tubercle which appear at varying ages between 4months to two years and the fusion process completes by 13–14 years, however remnants persists until maturity.⁹ The physis between the humeral head and shaft is multi-laminar and pyramidal in shape due to the presence of greater tuberosity over one limb and the medial head on the other. It disappears between the age of 17–19.^{9,10} In suspicion of a fracture, Opposite limb radiographs may help identifying the orientation of the physeal lines and distortions.¹⁰ As in our case, there was distortion in the lateral physeal line indicating the greater tuberosity separation.

Magnetic resonance imaging of the shoulder has been the method of choice to investigate suspected rotator cuff and tuberosity avulsions in pediatric populations.¹¹ However an arthroscopic evaluative study by Perez et al. on forty four pediatric shoulders reported inaccurate reporting on MRI and observed a degree of associated labral tears and instability with rotator cuff injuries.¹² We differed in our approach in that we undertook a CT scan in suspicion of an extension of the fracture line into the proximal humeral physis. We did not observe any associated articular or cuff pathology on arthroscopic evaluation and was a case of isolated greater tuberosity apophyseal separation with the supraspinatus and infraspinatus tendon attachments.

MRI based studies suggest an increase in incidence of partial/incomplete rotator cuff tears in the paediatric age group especially with chronic repetitive stress, however a complete tear or rehabilitation failure that require surgical interventions are infrequent.^{1,12} Arthroscopic and open techniques to restore the cuff integrity have been described in literature and regardless of the method, preservation of physis is essential (Table 1). The localised physeal scars that may arise due to inadvertent penetration by anchor threads or sutures can produce growth arrest or differential growth leading to angular or rotational deformities and cause cartilage, labral tears or instability.^{14,15} In the case described, the geometry of avulsed greater tuberosity fragment and proximity of the physis did not favour an arthroscopic fixation in view of potential damage to physis, hence fragment was reduced and stabilised with an extraosseous fixation method by means fibre tape and suture post distal to the physis. The greater tuberosity united with the proximal humeral epiphysis in three months and exhibited good functional outcomes by five months.



Fig. 2. Imaging studies at the time of presentation with shoulder abduction weakness. Plain radiograph AP view suggestive of avulsion of greater tuberosity apophysis of the right shoulder (A) when compared to the normal left shoulder (B). Proximal humeral physis was comparable on both sides. Computed tomography (CT) scan of the right shoulder with reconstruction (C) and coronal plane (D) shows isolated greater tuberosity separation of 7mm from the epiphysis and physis of proximal humerus.



A



R

B

Fig. 3. Extraosseous physal-sparing method of greater tuberosity fixation. A- Realistic diagram of the proximal humerus with muscle attachments and fixation method. 2mm



R

Fig. 4. At five months follow up-plain radiograph AP view of shoulder shows the greater tuberosity united with the proximal humeral epiphysis.

4. Conclusion

Greater tuberosity apophysis avulsion injuries are rare. Knowledge on the physis anatomy and clinical examination are the key to diagnosis. The avulsed fragment can be restored anatomically with the physis preserved using this extraosseous method when transosseous methods are limited.

fibres tapes passed in the tendinous portion of supraspinatus and infraspinatus in cruciate manner. The two limbs of fire tape crossed over the greater tuberosity apophysis (dotted line) and tied to the screw post (circle) distal to the proximal humeral physis (continuous line). B- post-operative radiograph AP view of shoulder shows the reduced greater tuberosity and suture post.

Table 1

Literature review on rotator cuff injuries in growing age group treated by physis preserving methods.

Sl.no	Study	Age/ sex	Pattern of injury	Treatment	Outcomes
1	Itoi et al. ¹³ (1993)	15/ M	Supraspinatus- partial articular surface tear	Mini open transosseous (epiphyseal) repair	one year follow up, Full ROM* at near full strength
2	Turman et al. ³ (2010)	16/ M	Complete tear of supraspinatus, infraspinatus and subscapularis.	Arthroscopic evaluation and open repair with suture anchors in the epiphysis.	One year follow up. Full ROM with equal strength.
3	Weiss et al. ⁴ (2013)	17/ M	Chronic supraspinatus tear	Arthroscopic repair.	Twelve months.
		13/ M	Acute greater tuberosity avulsion	Arthroscopic epiphyseal repair	Seven months
4	Alley et al. ⁷ (2015)	12/ M	Supraspinatus and infraspinatus- complete tear	Arthroscopic evaluation and Mini open transosseous (epiphyseal repair)	Six months follow up at full strength.
5	Lhee et al. ⁸ (2019)	14/ M	Supraspinatus partial tear with greater tuberosity apophysis undisplaced fracture	Conservative	Two months follow up, Full ROM with equal strength
6	Current study	14/ M	Greater tuberosity apophyseal separation with the supraspinatus and infraspinatus attachments.	Arthroscopic evaluation and extraosseous fixation by open method	Nine months follow up with full ROM and strength.

(*) - ROM- Range of Movements.

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Case report

Rhabdomyolysis of the long head of the triceps brachii in a female adolescent after martial arts



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ABSTRACT

We describe the case of an 11-year-old female patient who was diagnosed as having rhabdomyolysis. Furthermore, rhabdomyolysis in a localized area has not yet been well studied. The diagnosis was made on the basis of the findings from several imaging studies and laboratory data. In addition, interdepartmental consultation was performed to rule out other possible diagnoses. After the diagnosis, the patient was treated with vigorous intravenous hydration and immobilization of the affected area. Regular laboratory follow-ups were performed, and the patient could be discharged with no complication. The patient remained clinically stable at the time of discharge and returned to daily life and sporting activities without any further symptoms at the 1 month after discharge.

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1. Introduction

The term *rhabdomyolysis* refers to the disintegration of muscular tissue, which leads to a release of muscle cell components to the extracellular fluid in the body.¹ In this condition, abnormal amounts of myoglobin is released from the somatic muscle cells and reaches the kidney. This abnormally excessive load of myoglobin is filtered by the glomeruli and reaches the tubules, resulting in renal and major organ failure.^{1,2}

Rhabdomyolysis is characterized by myalgia, pain, muscle weakness, possible color change of urine (referred to as myoglobinuria), and oliguria.³ Patients with rhabdomyolysis can show various clinical presentations ranging from asymptomatic to lethal conditions such as acute renal failure or multiple-organ failure.⁴ Many causes of rhabdomyolysis have been reported, such as trauma, occlusion of muscle vessels, strenuous exercise, electrical current, and hyperthermia.¹

Rhabdomyolysis after excessive exercise has been reported worldwide. However, rhabdomyolysis occurring in a female adolescent is seldom reported.^{2,5} In this case, we present exercise-induced rhabdomyolysis localized to the lateral and medial head of

the triceps brachii in an 11-year-old female patient.

2. Case report

An 11-year-old female adolescent visited our outpatient clinic to undergo evaluation of the pain and swelling of her left arm after practicing martial arts (Tae kwon do), she had practiced martial arts for several hours mainly using her left arm. She described that she had fallen down on the floor, on her left upper arm. The pain in her left arm started just after the event, but she did not take any medical advice. On the next day, as the extensive swelling was accompanied by pain, her mother took her to the local clinic, where she was evaluated using simple radiography and physical examination. The local orthopedic surgeon suspected cellulitis of the left upper arm during her visit to the hospital. Initial physical examination revealed painful swelling of the left upper extremity, which was mainly localized between the left elbow to the left shoulder. No neurological deficit was evident, and distal circulation (radial artery pulse, ulnar artery pulse, and capillary refill time) was intact.

The patient had never suffered from similar symptoms previously and there was no family history of genetic muscle related disease. The patient had no history of suspected inflammation such as a history of acupuncture, injection, or wound in the upper arm. Furthermore, she did not show any signs of systematic inflammation, such as diarrhea or fever. Lastly, her mother denied use of any steroid and other drugs.⁶ Simple radiography of the left upper arm revealed massive soft tissue swelling (Fig. 1), and the laboratory

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Fig. 1. (A) Simple radiograph anteroposterior image of the patient's affected upper arm. Unlike image (C) and (D), the abnormal swelling of the soft tissue and the muscle is shown. (B) Simple radiograph lateral image of the patient's affected upper arm. Unlike image (C) and (D), the abnormal swelling of the soft tissue and the muscle is shown. (C) Simple radiograph AP image of the patient's unaffected upper arm. (D) Simple radiograph lateral image of the patient's unaffected upper arm.

data showed increases in creatine kinase (CK) level of 1812 U/L (normal range: 26–174 U/L) and lactate dehydrogenase (LDH) level of 314 U/L (normal range: 135–250 U/L), which are indicators of muscle breakage. The laboratory data on the indicators of systemic inflammation, such as C-reactive protein (CRP) level and white blood cell count, showed values within the normal ranges. Other laboratory data such as electrolytes and liver/renal function enzymes showed no abnormalities. Furthermore, gross hematuria was not noted and urine analysis revealed no evidence of myoglobinaemia or myoglobinuria.

After adequate tests, magnetic resonance imaging (MRI) was performed, and the results showed T2 hyperintensity and enhancement along the anterior and lateral aspects of the proximal and mid shaft of the left humerus. In addition, we observed diffuse T2-weighted high signal intensity and enhancement in the left triceps brachii, especially in the lateral and medial heads, without a definite focal mass-like lesion with abscess formation (Fig. 2). The patient was admitted to our general ward with a long-arm splint applied and treated with massive hydration (5% dextrose/sodium/potassium fluid) at the rate of 40 ml/hr. We also prescribed intravenous antibiotics (cefazidone: first-generation cephalosporin) to treat possible infection, secondary cellulitis or necrotizing fasciitis.

Furthermore, to rule out the possibility of rheumatic diseases or

infection, the pediatric and rheumatology departments were consulted. A series of laboratory (RA factor, anti-DS DNA, SS-A/Ro Ab, Sm/RNP Ab, Smith Ab, SCL 70 Ab, SS-B/La Ab, and thyroid function test) and physical examinations were performed to rule out rheumatic diseases, and all laboratory data showed no abnormalities. Over the 4-day admission period, the patient's symptoms showed daily improvement, and the laboratory data had normalized (CK level: 152 U/L) at the time of discharge. The main stay of our treatment consisted of absolute immobilization and ice therapy to the affected area. The patient did not show any clinical instability at the time of discharge and returned to daily life and sporting activities without any further symptoms at 1 month after discharge.

3. Discussion

Rhabdomyolysis caused by excessive exercise is often reported worldwide. However, exertion-induced rhabdomyolysis in female adolescents is rarely reported, and no cases have been reported in South Korea. As rhabdomyolysis usually shows diffuse symptoms with multiple muscle group involvement, our case demonstrates the occurrence of rhabdomyolysis localized to a single muscle (triceps brachii) unilaterally in an adolescent patient.

The clinical symptoms of our patient were relatively similar to



Fig. 2. (A) Magnetic resonance imaging of the long head of triceps (coronal section): Hyperintense signal on T2 weighted image (B) Magnetic resonance imaging of the long head of triceps (axial section): Hyperintense signal on T2 weighted image (C) Magnetic resonance imaging of the long head of triceps (sagittal section): Hyperintense signal on T2 weighted image.

those observed in adult patients. Two case reports by Bolgiano and Goubier showed similar clinical findings.^{7,8} All the patients from the 2 previous reports showed localized pain in the affected muscle. However, all 2 cases were from adult athletes, and they all showed symptoms of bilateral myalgia unlike in our case.

Several studies have reported various complications due to diffuse rhabdomyolysis. However, cases of localized

rhabdomyolysis have been seldom reported. Goubier⁸ stated that the reason for the low complication rate in localized rhabdomyolysis is that the small mass of the affected muscle is not sufficient to damage the other systemic functions. However, contrary to Goubier's finding,⁸ adolescents may be more vulnerable to systematic damages due to the breakdown of muscles. Therefore, thorough evaluation may be required for adolescent patients with localized

rhabdomyolysis symptoms. As Bolgiano⁷ and Goubier⁸ did not perform other laboratory tests except for muscle enzymes, other laboratory tests such as those for the rheumatic factor and thyroid function may be required to differentiate other genetic or rheumatic diseases as in our case.

Rhabdomyolysis, which is localized in a single (unilateral) muscle, is rare worldwide, especially in adolescents. Physicians should thoroughly evaluate patients by physical examination and detailed history taking. The patients may present with specific events accompanying excessive physical activities and symptoms such as myalgia and change in urine color. Blood tests, including CK, LDH, complete blood cell count, and CRP level, which are the possible indicators of muscle breakdown, must be performed initially to rule out other diagnoses such as inflammatory conditions. Some reports indicated that bone scintigraphy may be helpful in confirming the diagnosis,⁹ but as it is a time-consuming test and may not be available in local clinics, imaging studies such as MRI may be helpful to confirm the diagnosis. The obtained image may show the area affected, but imaging should not be considered the diagnostic modality of choice.¹⁰ Unlike adults, adolescents may have a greater risk of unknown genetic or rheumatic diseases, so consultation with pediatricians and rheumatologists may be helpful to differentiate other diagnoses. If the patient has no other complications such as renal insufficiency or heart failure, ice packing and absolute rest with immobilization of the affected area must be the primary treatment. Moreover, regular laboratory follow-up and adequate intravenous hydration have proved as effective as other treatment protocols.

Some studies have reported the diagnosis and treatment of rhabdomyolysis in adolescents.^{2–5,8} As this is the only reported case of rhabdomyolysis in a female adolescent, our approach to diagnosis and treatment including interdepartmental consultation and laboratory studies for autoimmune disease may be effective for difficult cases of adolescent rhabdomyolysis. In addition, rhabdomyolysis in localized areas (especially in the upper extremity) has not been well studied,⁸ and our case may provide further

information on the diagnosis and treatment of this type of rhabdomyolysis.

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This article does not contain any studies with human participants or animals performed by any of the authors.

Declaration of competing interest

The authors declare that they have no conflict of interest.

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Research paper

Comparative study between syndesmotic and suprasyndesmotic technique in syndesmotic ankle injury



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ABSTRACT

One of the most common injuries treated by orthopedic surgeons is the ankle injuries. Syndesmosis injuries account for 1%–18% of ankle sprains and much more in athletes 32%. The proper classification of syndesmosis injuries and the proper management depends mainly on the clinical and radiological assessment.

Objectives: to compare between the suprasyndesmotic and syndesmotic technique in management of syndesmotic injury regarding the functional outcome and time to weight bearing and to assess factors affecting the outcome of syndesmotic injuries management.

Methods: This prospective case series study was conducted on thirty patients attending to Kasr Alainy orthopedic surgery department with ankle fractures, they were divided into two groups each contains fifteen patients: **Group 1:** underwent and supra-syndesmotic screw fixation. **Group 2:** underwent syndesmotic screw fixation. Radiological evaluation of fixations using AP, lateral and mortise X-ray. Assessment of post-operative range of motion. Evaluation of functional outcome using **FAOS** (Foot and ankle outcome score). Patients were followed up for 24 months, with an average of 22 months.

Results: Patients scored 80–100% on the foot & ankle outcome score, with an average of 91.6 ± 5.4 ; (63.3%) had FAOS of 90% or above. Regaining weight bearing took 6–12 with an average of 8.2 ± 1.8 weeks; in (70%) wt bearing occurred within 6–8 weeks. Only one patient (3.3%) had post-operative infection, while no other patient (96.7%) had any postoperative complications. The mean FAOS score in supra-syndesmotic fixation was 92.5 and in the syndesmotic is 90 with an insignificant difference between the two groups ($P = 0.4$). The mean time to weight bearing was 8.1 and 8.3 weeks ($P = 0.84$) in supra-syndesmotic and syndesmotic fixation respectively.

Conclusion: there were no significant difference in terms of functional score and time to weight between syndesmotic and suprasyndesmotic techniques however; the functional score was significantly affected by the presence of associated injury and patient age while time to weight bearing was prolonged by the presence of associated injury and comorbidities, patient age as well as operative time.

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1. Introduction

One of the most common fractures is ankle fractures, representing 18% of all skeletal injuries per year. Most of these fractures occur in the distal tibiofibular syndesmosis. The syndesmosis is very important in stabilizing the ankle mortise and load transmission during weight bearing.¹

To get an optimal functional outcome, anatomic restoration and

stabilization of the disrupted distal tibiofibular syndesmosis is necessary.² Inadequate reduction can lead to instability and late arthrosis that lead to poor subjective and objective outcomes.¹

Syndesmotic injuries can be purely ligamentous or associated with ankle fracture and sometimes with a proximal fibular fracture (Maisonneuve, fracture).³

Most of these injury are due to sports and military activities and especially in contact sports, and more in sports that involve rigid immobilization of the ankle in a boot, such as skiing and hockey.⁴

The syndesmosis of the ankle is the interosseous membrane connecting the tibia to the fibula. However, there are three definable ligaments at the ankle:

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- Anteroinferior tibiofibular (AITF) ligament: the ligament mostly affected in syndesmotom sprains
- Posteroinferior tibiofibular (PITF) ligament: it has 3 portions from deep to superficial; the deep portion, the transverse tibiofibular ligament, and a superficial portion
- Interosseous tibiofibular ligament⁵

The distal tibiofibular syndesmosis consider a highly stable joint with limited range of motion. During the external rotation stress test using a 75 Nm force, only 2–5° of external rotation, 0–2.5 mm of medial translation and 1.0–3.1 mm of posterior displacement of the fibula occur. While during moving from plantar flexion to dorsiflexion position, only 1.25 mm of lateral translation and 2° of external rotation of the lateral malleolus occur.⁶

When the deltoid ligament is only disrupted, this will lead to medial clear space widening without affecting the stability of the syndesmosis. For complete syndesmosis instability to occur, disruption of at least two of the 3 lateral ankle ligaments (AITFL, IOL, and PITFL) and injury to the deltoid ligament are necessary.⁷

The diagnosis of syndesmotom injury is based on mechanism of injury, clinical examination, and radiological findings.

The **squeeze test** and the **external rotation** test have a high specificity but low sensitivity.^{8,9}

Syndesmotom injuries can be diagnosed radiologically if there is increase in the tibiofibular clear space, decrease in the tibiofibular overlap, and/or increased medial clear space (Fig. 5).

Stress views may be used to diagnose syndesmotom injury and indications for surgery. If there is still doubt, the intraoperative stress view (lateral translation and external rotation) has very high specificity but quite poor sensitivity.¹⁰

MRI is highly accurate in detecting the syndesmotom injury (96%), as compared with AP view in plain x-ray (63%) and mortise view in x-ray (71%).¹¹

CT scanning is more accurate than radiographs and if there is still doubt; measurement of the contralateral ankle for comparison and if there is displacement difference of 2 mm or more, injury is considered.

Arthroscopy is considered the best diagnostic tool with 100% accuracy for assessing the syndesmotom injury and widening.¹²

Syndesmotom injury classified as

Grade I: it is a mild, stable syndesmotom joint injury with normal x ray. External rotation and squeeze tests can be negative, although Gerber et al. indicated that one of these two tests should be positive.¹³

Grade II: it is a moderate degree with normal x ray and positive external rotation and squeeze tests. Scranton suggested that grade II injuries are unstable, however Wolf and Amendola indicated that they can be either stable or unstable.⁸

Grade III: it is a sever degree and the syndesmosis is clearly unstable due to complete injury to the lateral ligaments (AITFL, IOL, and PITFL) and deltoid ligament avulsion. With positive plain radiographs and all clinical tests.¹⁴

Mild and moderate (grades II and I) isolated syndesmotom sprains can be treated non surgically.¹⁵

For grade II injuries with possible dynamic instability, arthroscopy can be used for accurate assessment of the instability, and stabilization can be done in the same session.¹⁶

For sever purely ligamentous injuries, surgical treatment has better outcome than conservative treatment. Injuries associated with fracture and the syndesmosis is clearly unstable, require surgical treatment of the fracture and stabilization of the syndesmosis.⁸

Screws and suture buttons are the most common methods used. Outcomes of both are generally very good. The most important factor for good outcome is the anatomical reduction of the

syndesmosis.¹⁶

The syndesmotom screw should be angled from posterolateral to anteromedial to catch the tibia (angled 30 anteriorly) because the fibula is posterior to the tibia.¹⁷

If the screw is placed too far proximally from ankle joint, it may squeeze the fibula and widen the mortise; if it is not parallel to the ankle joint, the fibula may be pulled up; and if it is not perpendicular to the tibiofibular joint, the fibula will not lodge properly and remain laterally displaced.¹⁷

Thompson and Gesink recommended placing the screw 2 cm proximal to the tibiotalar joint. However, Sproule et al. recommended placing the screw 4 cm above to the tibiotalar joint.¹⁸

2. Methodology

Prospective randomized controlled study involved 30 patients with syndesmotom injuries of ankle joint presenting to Kasr Al-Ainy Hospital.

Suprasyndesmotom screw fixation was performed for 15 patients, while syndesmotom screw fixation was performed for the remaining 15 patients. After surgery, patients were followed up over 24 months, with an average of 22 months. The patients were assessed according to **FAOS** (Foot and ankle outcome score).

All skeletally mature patients with syndesmotom injuries are included while skeletally immature patients and revision cases are excluded.

Physical examination tests included the external rotation test and squeeze test and radiological examinations of the ankle joint included anterior–posterior, lateral and mortise views of the ankle joint. If necessary, weight bearing or stress view were done.

The two groups were compared as regard to age of patient, time to surgery, operative time, follow up period, FAOS and time to weight bearing.

An independent statistician who was unaware of the group assignments performed all the analyses. To reduce the risk of bias during interpretation, blinded results from the analyses (with study groups labeled as group A and group B) were presented to the author.

3. Surgical technique

The associated open reduction and internal fixation (ORIF) of lateral and/or medial and/or post. Malleolus were performed according to standard principles before stabilizing the syndesmosis.

Temporary reduction of syndesmosis was obtained by indirect maneuvers of medial translation and internal rotation of the talus, maintained with reduction forceps.

Stability was controlled under fluoroscopy (evaluation of the lateral tibiofibular clear space in the AP, mortise and lateral views with the ankle in dorsiflexion and in valgus stress. No formal open reduction or debridement of syndesmosis space was performed (Fig. 1).

Fixation of syndesmosis under fluoroscopic guidance, 2.5 cm drill hall was performed approximately 2 cm above and parallel to the distal tibia joint line “syndesmotom technique” or 4 cm above and parallel to distal tibia joint line or 2 cm above syndesmotom joint “suprasyndesmotom technique” (through a hole of the plate if present) from lateral to medial (Fig. 2).

Three or four cortices were drilled and a 3.5 cm cortical screw was used.

After achieving a satisfactory syndesmotom fixation, the forceps removed and stability controlled under fluoroscopy.

The patients were followed up over 24 months, with an average of 22 months (Figs. 3 and 4).



Fig. 1. Reduction under image.

4. Results

The study included 15 male and 15 female patients aged 19–60 years old, with a mean age of 34.5 ± 12.3 years. Regarding their medical history, 76.7% had no comorbidities, while the remaining percentage had either hypertension (3.3%), diabetes mellitus (6.7%) or both (13.3%). Moreover, 33.3% of the participants were smokers.

(53.3%) of syndesmotismal injuries among study participants have resulted from FTG, FFH (26.7%), or RTA (10.0%). Sixty percent of injuries affected the Lt side ankles. About 97% of patients had other associated injuries including: lateral malleolus fracture (40.0%), bimalleolar fracture (53.3%), or dislocation ankle (3.3%). Diagnosis of syndesmotismal injuries was performed either pre-operatively (70.0%) or intra-operatively (30.0%) (Table 1).

Surgical fixation of traumatic syndesmotismal injuries were performed within 1–14 days of injury, with a mean time of 4.6 ± 2.6 days. The operation has lasted for a minimum of 40 min and a



Fig. 2. A. supra-syndesmotismal technique B. syndesmotismal technique.



Fig. 3. 24 years old female, twisting injury, closed ankle fracture, supination external rotation type (A&B). Syndesmotismal screw was used (C&D). Started full weight bearing 10 weeks. Syndesmotismal screw was removal after 6 weeks (E). Scoring system according to foot ankle outcome score was 100%.



Fig. 4. 29 years old female, had full to ground, sustained a closed ankle fracture, supination external rotation type (A&B), supra-syndesmotismal screw was used (C&D), full weight bearing was allowed after full radiological and clinical union which occurred at 17 weeks. (E&F). Scoring system according to foot ankle outcome score was 100%.



Fig. 5. Syndesmosis injuries can be diagnosed radiologically if there is increase in the tibiofibular clear space, decrease in the tibiofibular overlap, and/or increased medial clear space.

Table 1
Preoperative and operative data.

Mode of Trauma	FFH	8	26.7%	
	FTG	16	53.3%	
	RTA	3	10%	
	D.T	2	6.7%	
	MBA	1	3.3%	
Side of trauma	RT	12	40%	
	LT	18	60%	
Ass. Injuries	None	1	3.3%	
	Lat mal #	12	40%	
	Bimal #	16	53.3%	
	Disloc ankle	1	3.3%	
Diagnosis of Synd. injury	Pre-operative	21	70%	
	Post-operative	9	30%	
Age (years): Mean \pm SD (min-max.)		34.5 \pm 12.3 (19–60)		
Sex (No. %)	Male	15	50%	
	Female	15	50%	
Occupation by Sex	Female	Housewife	14	93.3%
		Student	1	6.7%
	Male	Manual worker	12	80.0%
		Driver	2	13.3%
		Student	1	6.7%
Co morbidities	None	23	3.3%	
	Hypertension	1	6.7%	
	Diabetes	2	13.3%	
	Hypertension& diabetes	4	13.3%	
Smoking	No	20	66.7%	
	Yes	10	33.3%	
Days-to-Surgery: Mean \pm SD (range)		4.6 \pm 2.6 (1–14)		
Operation Time (minutes): Mean \pm SD (range)		85.0 \pm 33.7 (40–135)		
Fixation Technique	Syndesmosis	15	50%	
	Supra syndesmosis	15	50%	
Follow-up time (months): Mean \pm SD (range)		5.0 \pm 0.7 (4.0–6.0)		

maximum of 135 min with an average of 85 min (\pm 33.7). Supra-syndesmosis screw fixation was performed for 15 patients (50.0%), while Syndesmosis screw fixation was performed for the remaining 15 patients (50.0%). After surgery, patients were followed up for 24 months, with an average of 22 months.

Comparison of the two groups across the age of patient, time to surgery, operative time, follow up period, FAOS and time to weight bearing revealed that there were no statistically significant differences between both techniques, however the mean FAOS score in the suprasyndesmosis group was better than in syndesmosis group (92.5 and 90.8 respectively) and the mean time to weight bearing in suprasyndesmosis group was lesser than in syndesmosis group (8.1 and 8.3 weeks respectively) (Table 2).

The majority of patients who underwent surgical fixation of traumatic syndesmosis injuries had favorable outcomes in terms of functional outcomes, time to weight bearing, and post-operative outcomes.

Regarding the functional outcome, patients scored 80–100% on the foot & ankle outcome score, with an average of 91.6 \pm 5.4; (63.3%) of patients had FAOS of 90% or above.

Likewise, regaining weight bearing took 6–12 weeks among the study participants, with an average of 8.2 \pm 1.8 weeks, in (70%) of patients, weight bearing occurred within 6–8 weeks.

Only one patient (3.3%) had post-operative infection, while no other patients (96.7%) had any postoperative complications.

The functional score was compared according to different personal, clinical, and operative characteristics. It revealed that there were no statistically significant differences except for having associated injuries, since patients with lateral malleolar fracture had better functional outcome than patients with bimalleolar fractures or dislocated ankle and for patient's age, as younger patients had better FAOS score (i.e. significant inverse correlation) (Table 3).

However, student patients, non-smokers, non-comorbidities, pre-operative diagnosis, fixation by Supra- Syndesmosis Screw, non-postoperative complication were all associated with better FAOS score.

Comparisons of time to weight bearing across the different personal, clinical, and operative characteristics. There were also no statistically significant differences except for having associated injuries or comorbidities, patient's age as well as operation time, however, the correlation was a direct correlation (i.e. older patients took more time to gain weight bearing than younger patients, and the longer operation time the patients had, the greater time to

Table 2
Comparison between the supra-syndesmotic and syndesmotic groups.

Technique	Supra-Syndesmotic Screw	Syndesmotic Screw	P value
Age: Mean \pm SD (range)	34.33 \pm 12.2 (19–60)	34.6 \pm 12.4 (19–60)	0.95
Days-to-Surgery: Mean \pm SD (range)	3.73 \pm 2.6 (1–14)	5.53 \pm 2.8 (1–14)	0.082
Operation Time (minutes): Mean \pm SD (range)	87 \pm 35.7 (40–135)	83 \pm 33.7 (40–135)	0.72
Follow-up time (months): Mean \pm SD (range)	4.8 \pm 0.6 (4.0–6.0)	5 \pm 0.7 (4.0–6.0)	0.33
FAOS Score	92.5 \pm 5.3	90.8 \pm 5.6	0.411
Time to weight bearing (weeks)	8.1 \pm 1.7	8.3 \pm 1.9	0.841

Table 3
Distribution of Functional Outcome Score according to different personal and clinical variables (N = 30).

		FAOS Score		p-value
		Mean	Standard Deviation	
Sex	Male	91.5	5.2	0.870
	Female	91.8	5.9	
Occupation	Driver	91.5	.7	0.728
	House wife	91.2	5.6	
	Manual work	91.4	5.8	
	Student	96.0	5.7	
Smoking	No	92.5	5.5	0.223
	Yes	89.9	5.0	
comorbidities	No	92.7	5.4	0.050
	Yes	88.1	4.2	
Mode of trauma	FFH	90.6	5.7	0.696
	FTG	92.8	5.8	
	RTA	90.0	5.2	
	D.T	91.5	.7	
	MBA	86.0	.	
Side of trauma	Rt	90.6	5.1	0.397
	Lt	92.3	5.7	
Associated Injuries	None	80.0	.	0.018*
	lateral malleolus #	94.1	4.2	
	bimalleolar #	91.0	5.1	
	Dislocation Ankle	84.0	.	
Time of Diagnosis	Pre-operative	91.9	5.9	0.684
	Intra-operative	91.0	4.4	
Method/technique	Supra-Syndesmotic Screw	92.5	5.3	0.411
	Syndesmotic Screw	90.8	5.6	
Post-operative complications	None	91.9	5.3	0.157
	Infection	84.0	.	

weight bearing they would have (Tables 4 and 5).

Otherwise, non-smokers, MBA trauma, intra-operative diagnosis, fixation by syndesmotic screw, postoperative infection were all associated with longer time to weight bearing.

5. Discussion

Ankle fractures are one of the most common injuries treated by orthopedic surgeons. Syndesmosis injuries reach from 1% to 18% of ankle sprains and much more in athletes reaching 32%. The proper classification of syndesmosis injuries is quite challenging and the proper management is essentially dependent on the clinical and radiological assessment. Syndesmosis injuries included the disruption of two sets of ligaments, the Tibiofibular ligaments laterally and deltoid ligament medially.¹⁹

It has been established in the literature that syndesmotic screw fixation has long served as a suitable method for treatment of ankle fractures. For the best of our knowledge, this study is one of the few studies comparing the efficacy of supra-syndesmotic screw fixation with *trans*-syndesmotic screw fixation. We also evaluated the possible risk factors that delays and reduction of regaining the function and proper weight bearing.

The preoperative diagnosis was done for only 70% of our patients. Intraoperative stress testing under fluoroscopic guidance

was done, using a **cotton test** and/or **external rotation distraction test**.

We tried to avoid the available sources of bias in our sample, the male to female ratio was 1:1 and were mainly manual workers (n = 12) and housewives (n = 14). The mean age was 34.5 (12.3) which similar to most of the studies investigating the same question. Falling to the ground (FTG) was the most common mode of trauma with 53.3% in the second place comes falling from height (FFH) with 26.7%. These causes were the most common causes of ankle fractures as reported in Naqvi et al., 2012.²⁰

This study was conducted on thirty patients attending to Kasr Alainy orthopedic surgery department with ankle fracture. Therefore, they were divided into two groups each contains fifteen patients as follows: **Group 1:** They underwent anatomical reduction and supra-syndesmotic screw fixation. **Group 2:** They underwent anatomical reduction and syndesmotic screw fixation.

Our study is one of the few studies in literature conducted to compare between suprasyndesmotic and syndesmotic screw techniques.

Kukreti et al. suggested that suprasyndesmotic and syndesmotic screw techniques did not differ significantly regarding the clinical and radiological outcomes.²¹

McBryde et al. compared the external rotation stress tests of 3.5 mm syndesmosis screws placed 3.5 cm or 2 cm above the ankle

Table 4

Distribution of Time to weight bearing according to different personal and clinical variables (N = 30).

		Time to weight bearing (weeks)		p-value
		Mean	Standard Deviation	
Sex	Male	7.7	1.3	0.154
	Female	8.7	2.1	
Occupation	Driver	7.0	1.4	0.237
	House wife	8.9	2.0	
	Manual work	7.8	1.3	
	Student	7.0	1.4	
Smoking	No	8.4	1.9	0.391
	Yes	7.8	1.5	
Comorbidities	No	7.7	1.4	0.001*
	Yes	10.0	1.6	
Mode of trauma	FFH	8.0	1.9	0.718
	FTG	8.4	1.8	
	RTA	8.0	2.0	
	D.T	7.0	1.4	
	MBA	10.0	.	
Side of trauma	Rt	8.2	2.0	0.935
	Lt	8.2	1.7	
Associated Injuries	None	8.0	.	0.028*
	lateral malleolus #	7.3	1.3	
	bimalleolar #	8.6	1.7	
	Dislocation Ankle	12.0	.	
Time of Diagnosis	Pre-operative	7.9	1.7	0.167
	Intra-operative	8.9	1.8	
Method/technique	Supra-Syndesmotic Screw	8.1	1.8	0.841
	Syndesmotic Screw	8.3	1.8	
Post-operative complications	None	8.1	1.8	0.309
	Infection	10.0	.	

Table 5

Correlation between postoperative functional outcomes (FAOS score & Time to weight bearing) and selected personal and clinical (N = 30).

	FAOS Score		Time to weight bearing (weeks)	
	Pearson Correlation	p-value	Pearson Correlation	p-value
Age (years)	-0.476	0.008*	0.436	0.016*
Days-to- surgery	-0.039	0.837	0.092	0.630
Operation Time (minutes)	-0.169	0.371	0.456	0.011*

joint, or no screw at all. They found that the syndesmotic widening when using the screw at 2 cm was lesser than in either of the two other groups.²²

Ozgur Verim et al. conducted a biomechanical study to define the optimal level of the syndesmotic screw by evaluating the stresses in syndesmotic screws and syndesmotic widening when loading with syndesmotic screws at different levels from the ankle joint line. They found that fixation at the level of 30–40 mm above the ankle joint has advantages regarding the stress in screws in comparison with the other evaluated levels.²³

Our results showed excellent functional outcomes in both groups. However, we investigated if there was a superior efficacy in a group over the other. The mean FAOS score in supra-syndesmotic screw fixation was 92.5 and in the syndesmotic screw is 90 with an insignificant difference between the two groups (P = 0.4).

Regarding the time to weight bearing, we did not find any significant difference between the two groups with a mean time 8.1 and 8.3 weeks (P = 0.84) in supra-syndesmotic and syndesmotic fixation respectively. These results are consistent with the results of Kukreti et al. study; they did not find any significant difference in terms of clinical and radiological outcomes Tabl 10.²¹

Many suggested personal, clinical and operative factors might affect the postoperative outcomes. We proposed a list of risk factors that may have a role in postoperative functional recovery. However, the results revealed that there was no statistically significant difference except for the presence of associated injuries. Patients with

only lateral malleolar fracture achieved better functional recovery with mean FAOS score 94.1 while in bimalleolar fracture was 91 (P = 0.018).

Moreover, the presence of associated injuries significantly prolonged the time to weight bearing post-operatively. Bimalleolar fractures took mean time to weight bearing about 8.6 weeks but lateral malleolar fracture took about 7.3 weeks only (P = 0.02). The presence of comorbidity also significantly prolonged the time to weight bearing by about 2 weeks difference.

Egol et al. evaluated different possible predictors of functional outcome after ankle fracture surgery after one year of follow up. They reported that 92% of the non diabetic patients achieved more than 90% of the function, whereas only 71% of diabetic patients did so (p = 0.02).²⁴

On the other hand, Hancock et al. conducted a prospective cohort study to assess predictors of functional outcome after ankle fractures, they found that the fracture classification was a statistically significant univariate predictor with low to moderate predictive power for all outcomes 6 months after cast removal. The uni-malleolar fractures (n = 37, 59.7%) did better than the bimalleolar or trimalleolar fractures (n = 25, 40.3%) on average by 18 (95% CI, 10–26) points on the Olerud and Molander ankle scores.²⁵

6. Conclusion

Surgical fixation of traumatic syndesmotic injuries had

favorable outcomes in terms of functional outcomes, time to weight bearing, and post-operative outcomes. There were no significant difference in terms of functional score and time to weight between syndesmotic and supra-syndesmotic techniques however, the functional score was significantly affected by the presence of associated injury and patient age while time to weight bearing was prolonged by the presence of associated injury and comorbidities, patient age as well as operative time.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Corrigendum to “An in vitro study on the effects of various concentrations of low and high molecular weight hyaluronic acid on human chondrocyte cell metabolism”[J. Arthrosc. Joint Surg., 6(2) (2019) 123-127]



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The table corrections are as follows:

The tables should be replaced with the same numbering but with the new tables provided below.

The 6 figures in the previous article should be removed and replaced with the ones attached below.

The text in the Results section need only be changed.

Under the heading cell count.

The figure is cited currently as Fig. 1a and b it should be changed to Fig. 1.

Under the heading cell viability.

The figure is cited currently as Fig. 2a and b it should be changed to Fig. 2.

Under the heading CD44⁺ expression.

The figure is cited currently as Fig. 3a and b it should be changed to Fig. 3.

Below are the corrected tables intended for the article.

DOI of original article: <https://doi.org/10.1016/j.jajs.2018.11.004>.

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Table 1a Table showing concentration of HMW HA and Cell count.

	Cultural stage	Mean	sd	F	P value
Control	P1	8.7133	4.51506	0.074	0.972
0.1mg/ml HA	P1	8.0033	3.56553		
1.0mg/ml HA	P1	7.6333	4.06426		
2mg/ml HA	P1	7.2	4.07926		
Control	P2	6.28	1.22784	1.474	0.293
0.1mg/ml HA	P2	5.4433	0.59501		
1.0mg/ml HA	P2	4.95	1.12601		
2mg/ml HA	P2	4.56	1.16202		

Table 1b Table showing concentration of LMW HA and Cell count.

	Cultural stage	Mean	sd	F	P value
Control	P1	8.7133	4.51506	0.013	0.998
0.1mg/ml HA	P1	8.1667	4.10406		
1.0mg/ml HA	P1	8.4733	3.68675		
2mg/ml HA	P1	8.1333	4.15039		
Control	P2	6.28	1.22784	2.122	0.176
0.1mg/ml HA	P2	5.5867	0.41885		
1.0mg/ml HA	P2	5.1067	0.44456		
2mg/ml HA	P2	4.9433	0.39107		

Table 2a Table showing concentration of HMW HA and Cell viability.

	Cultural stage	Mean	sd	F	P value
Control	P1	96.74%	1.65%	0.284	0.836
0.1mg/ml HA	P1	96.47%	2.07%		
1.0mg/ml HA	P1	96.04%	2.40%		
2mg/ml HA	P1	95.22%	2.45%		
Control	P2	97.39%	1.04%	1.6	0.264
0.1mg/ml HA	P2	97.55%	0.23%		
1.0mg/ml HA	P2	96.78%	0.50%		
2mg/ml HA	P2	96.13%	1.33%		

Table 2b Table showing concentration of LMW HA and Cell viability.

	Cultural stage	Mean	sd	F	P value
Control	P1	96.74%	1.65%	0.069	0.975
0.1mg/ml HA	P1	96.14%	2.57%		
1.0mg/ml HA	P1	96.21%	2.74%		
2mg/ml HA	P1	95.88%	2.44%		
Control	P2	96.06%	1.68%	0.363	0.781
0.1mg/ml HA	P2	96.97%	0.78%		
1.0mg/ml HA	P2	96.35%	1.95%		
2mg/ml HA	P2	97.06%	0.70%		

Table 3a Table showing concentration of HMW HA and CD44+ expression.

	Cultural stage	Mean	sd	F	P value
Control	P1	93.79%	3.15%	4.457	<u>0.04</u>
0.1mg/ml HA	P1	89.95%	1.93%		
1.0mg/ml HA	P1	88.73%	2.04%		
2mg/ml HA	P1	85.73%	3.49%		
Control	P2	90.10%	4.71%	0.875	0.493
0.1mg/ml HA	P2	87.84%	5.66%		
1.0mg/ml HA	P2	86.99%	5.09%		
2mg/ml HA	P2	81.83%	9.36%		

Table 3b Table showing concentration of LMW HA and CD44+ expression.

	Cultural stage	Mean	sd	F	P value
Control	P1	93.79%	3.15%	3.468	0.071
0.1mg/ml HA	P1	86.71%	3.74%		
1.0mg/ml HA	P1	90.93%	1.67%		
2mg/ml HA	P1	87.43%	3.26%		
Control	P2	90.10%	4.71%	0.785	0.535
0.1mg/ml HA	P2	81.98%	11.14%		
1.0mg/ml HA	P2	88.25%	3.57%		
2mg/ml HA	P2	83.41%	8.30%		

Fig. 1

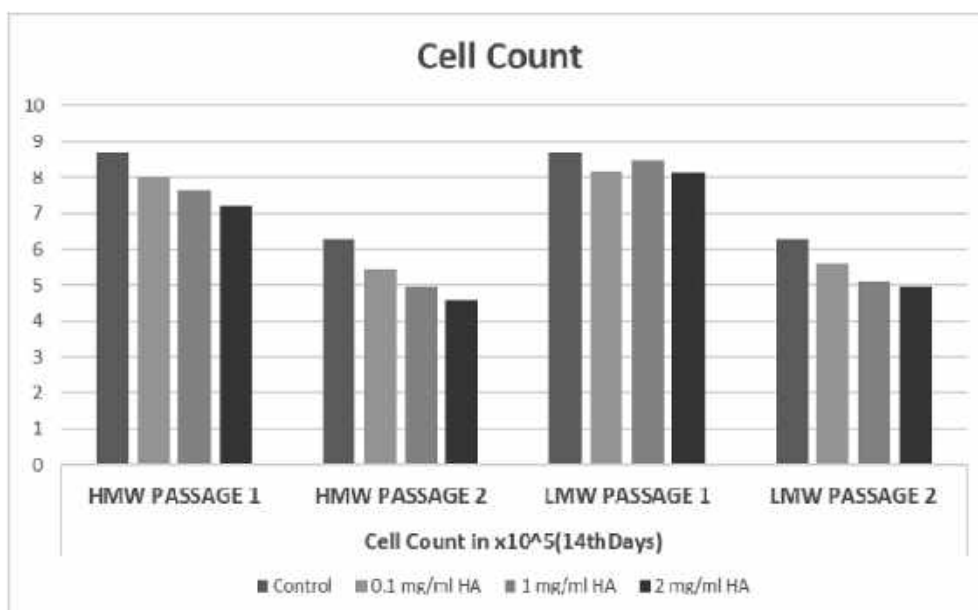


Fig. 2

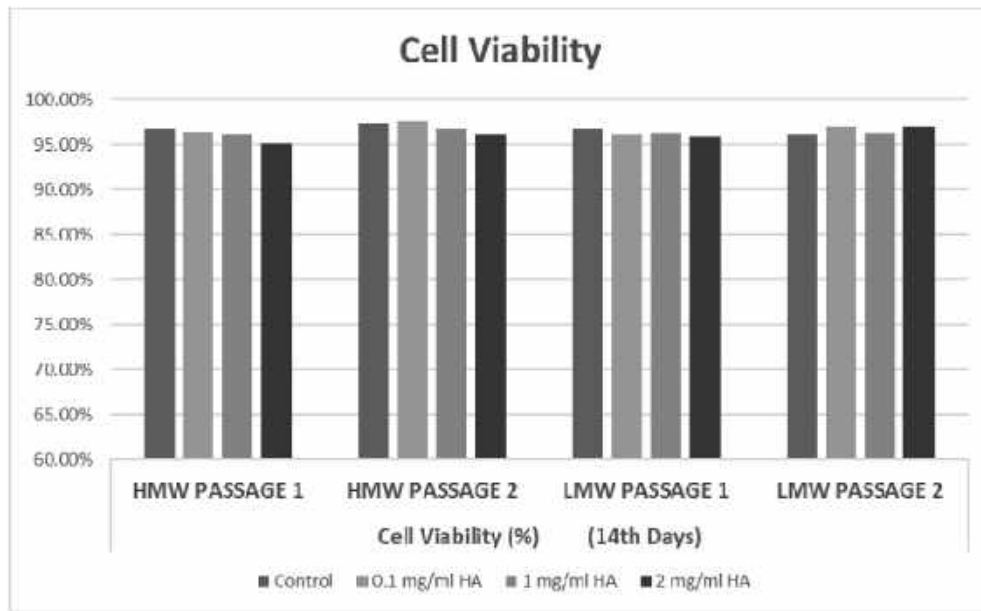


Fig. 3

