JAJS VOLUME 2 NUMBER 3 SEPTEMBER–DECEMBER 2015 PAGES 95–144 ELSEVIER

ELSEVIER

Knee & Shoulder Arthroscopy And Arthroplasty
ISKSAA

JOURNAL OF ARTHROSCOPY AND JOINT SURGERY

JAJS

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

Volume 2 Number 3 September–December 2015

ISSN: 2214-9635

Available online at www.sciencedirect.com

ScienceDirect

FREEDOM® KNEE

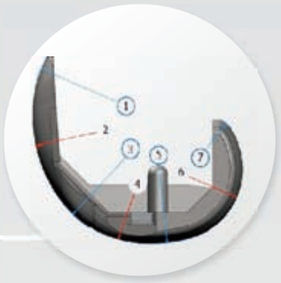
maxx medical

Meril
More to Life

INTRODUCING PATENTED TECHNOLOGIES FOR INDIANS & ASIANS

Asian & Caucasian Size

High Flexion Implants



The 7-Radius Patented Femoral design reflects natural anatomy and functional principles

LATITUD™
HIP SYSTEM | Freedom of Choice

Acetabular Cup System & Uncemented Stems

Bi-Polar Cup System & Cemented Stems

A fast growing brand in US and around the globe

Approved by : US FDA | CE European | TGA Australia SFDA
China and Singapore | DCGI,India

Pursue Life™

United States
Maxx Orthopedics Inc. 531 Plymouth Road, Suite 526, Plymouth Meeting, PA 19462, USA. W : www.maxxmed.com

India Sales & Marketing
Meril Life Sciences India Pvt. Ltd. 512, Midas, Sahar Plaza, J.B. Nagar, Andheri East, Mumbai 400 059 Maharashtra. India.
T : +91 22 4047 9797 W : www.merillife.com

ASPIFAST Tablet

(Rose Hips 250 mg + Collagen Peptide 40 mg + Sodium Hyaluronate 30 mg
Chondroitin Sulphate 200 mg + Vitamin C 150 mg + Methylsulfonylmethane 250 mg)

ARKAGEN Tablet

Cefuroxime Axetil 500mg

LESSOFU Tablet

Conjugated Linoleic Acid 900mg+Green Tea Extract 100mg+Polyphenols 95mg+Catequins 70mg
EGCG 45mcg+ ilex Paraguarienses Matt Extract 100mg+Wheat Germ Oil 5mg

Ark Lifesciences Pvt Ltd
Website : www.arklifesciences.com

XYATA LIFESCIENCES LTD.
HONG KONG
www.xyata.hk

XYATA®

XYATA LIFESCIENCES PVT. LTD.
INDIA
www.xyata.in

offers the highly specialized range

FOR OSTEOARTHRITIS MANAGEMENT

Cross Linked

BIOVISC

ORTHO SINGLE PFS

Hyaluronic Acid Inj. 3ml (90mg / 3ml)

Optimum Volume, Sustained Effect

90 High Concentration HA

Cross-Linked

High Molecular Weight

HYNEES®

PFS

Sodium Hyaluronate Inj. 2ml (10mg / ml)

For effective management of osteoarthritis

Non Avian Source

High Molecular Weight

FOR OSTEOPOROSIS MANAGEMENT

Recombinant Human Parathyroid Hormone (1-34)

ELEVOSTEO®

Teriparatide Injection (rDNA origin)

ELEVATING OSTEOGENESIS

Increases Bone Formation

Reduces Risk of Fractures

ZOLVOID®

Zoledronic Acid Infusion 5mg/100ml

The GOLD STANDARD in Osteoporosis Treatment

2013 2014 2015 Once A Year Dose

Effective and Safe

For Comprehensive Mobility Solutions

A WHO - GMP Certified Company

NATIONAL TOLL FREE HELPLINE: 1800 1111 55

An ISO : 9001 - 2008 Certified Company

ISKSAA International Society for Knowledge for Surgeons on Arthroscopy and Arthroplasty

ISKSAA (**I**nternational **S**ociety for **K**nowledge for **S**urgeons on **A**rthroscopy and **A**rthroplasty) is a society of orthopaedic surgeons from around the world to share and disseminate knowledge, support research and improve patient care in Arthroscopy and Arthroplasty. We are proud to announce that ISKSAA membership has crossed the **1100** mark (India & Overseas) making it the fastest growing Orthopaedic Association in the country in just the 3rd year of its inception. With over **175000 hits from over 129 countries** on the website **www.isksaa.com** & more and more interested people joining as members of ISKSAA, we do hope that ISKSAA will stand out as a major body to provide opportunities to our younger colleagues in training, education and fellowships.

Our Goals.....

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

ISKSAA Life Membership

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

Benefits of ISKSAA Life membership include....

- Eligibility to apply for **ISKSAA's Prestigious Fellowship Programme**. We are finalising affiliations with ESSKA , ISAKOS , BOA , BASK , Wrightington and FLINDERS MEDICAL CENTRE , IMRI AUSTRALIA to provide more **ISKSAA Fellowships** in India , UK , USA , Australia and Europe . **We awarded 14 ISKSAA Fellowships in Feb 2013, 6 ISKSAA IMRI fellowships in Feb 2014, 54 ISKSAA fellowships in September 2014, 22 ISKSAA wrightington MCh fellowships in December 2014 and 40 ISKSAA Fellowships in October 2015.**
- **Free Subscription** of ISKSAA's official, peer reviewed, online scientific journal **Journal of Arthroscopy and Joint Surgery (JAJS**) which is also available on Science Direct and is professionally managed by the international publishing house "Elsevier".
- Only as a life member, you can enjoy the benefit of **reduced Congress charges** in **ISKSAA global summit 2016 and participate in the Cadaveric workshops.**
- **Member's only section** on the website which has access to the conference proceedings and live surgeries of ISKSAA 2012 , 2013 & 2014 along with a host of other educational material .
- Important opportunity for interaction with world leaders in Arthroscopy & Arthroplasty.
- Opportunity to participate in ISKSAA courses and workshops

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

ISKSAA GLOBAL SUMMIT 2016

ISKSAA GLOBAL SUMMIT 2016 will be held from **1st – 4th September 2016 at New Delhi**. It promises to be an action packed affair with a scientific programme spread over **4 days with 7 Concurrent halls** & Delegate strength of **1200-1500** with global participation

- **50 Live Surgeries transmitted from Global Centres (Delhi , UK , Australia , Europe & USA)**
- **50** Workshops / Instructional course sessions
- **50** Overseas faculty from Australia , UK , USA , Europe , Middle East and South East Asia
- **50** Clinical Fellowships for ISKSAA members
- **50** Trade Exhibitors

Journal of Arthroscopy and Joint Surgery

An official publication of International Society for Knowledge for Surgeons on Arthroscopy and Arthroplasty

(ISSN: 2214–9635)

Volume 2, Number 3, September–December 2015

Aims and Scope

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.

Author enquiries

For enquiries relating to the submission of articles (including electronic submission where available) please visit this journal's homepage at **http://www.elsevier.com/locate/jajs**. You can track accepted articles at **http://www.elsevier.com/trackarticle** and set up e-mail alerts to inform you of when an article's status has changed. Also accessible from here is information on copyright,frequently asked questions and more.

Subscription information

The *Journal of Arthroscopy and Joint Surgery* (ISSN: **2214-9635**) is published thrice a year. The annual price for **individual subscription** based in India is **INR 3600;** and for international subscribers, the annual price is **USD 60**. For **institutional subscription** within and outside India, please contact the Publishers office at journals.india@elsevier.com.

Further information is available on this journal and other Elsevier products through Elsevier's website (http://www.elsevier.com). Subscriptions are accepted on a prepaid basis only and are entered on a calendar year basis. Issues are sent by standard mail. Priority rates are available upon request. Claims for missing issues should be made within six months of the date of dispatch.

Orders, claims, advertisement and journal enquiries: please contact

Editorial Office: Dr Pushpinder Singh Bajaj, Bajaj Specialist Clinics, B-7/5 Safdarjung Enclave, New Delhi – 110029. Tel: 41057555 / 41057556 / 41057557. Email: psbajaj@hotmail.com.

Publishing Office: Elsevier, A division of Reed Elsevier India Pvt. Ltd., 14th Floor, Building No.10B, DLF Cyber City, Phase-II, Gurgaon-122002, Haryana, India. Email: journals.india@elsevier.com

Journal of Arthroscopy and Joint Surgery

An official publication of International Society for Knowledge for Surgeons on Arthroscopy and Arthroplasty

(ISSN: 2214–9635)

Volume 2, Number 3, September–December 2015

Journal of Arthroscopy and Joint Surgery

An official publication of International Society for Knowledge for Surgeons on Arthroscopy and Arthroplasty

(ISSN: 2214–9635)

Volume 2, Number 3, September–December 2015

Published by Reed Elsevier India Pvt. Ltd.

Printed at EIH Limited-Unit Printing Press, IMT Manesar, Gurgaon

Journal of Arthroscopy and Joint Surgery

An official publication of International Society for Knowledge for Surgeons on Arthroscopy and Arthroplasty

(ISSN: 2214–9635)

Volume 2, Number 3, September–December 2015

Table of Contents

JOURNAL OF ARTHROSCOPY AND JOINT SURGERY 2 (2015) 95–98

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/jajs

Editorial

Musculoskeletal allografts – State of the art and future trends

Allograft bone was first transplanted over 125 years back by MacEwen in 1881. Bone and tissue banking has come a long way since then. Tissue banks all the world over strive to provide safe and sterile graft with minimal risk of disease transmission. The use of allografts in musculoskeletal surgery is on the rise and more than 5,00,000 musculoskeletal allografts are used annually in USA alone. Popular uses of the allograft bone have been in spinal fusions, bone cancers, fracture treatments, dental applications, and joint replacements. Using allograft tissue has the advantages of lack of donor site morbidity, decreased surgical time, smaller surgical incisions and avoidance of a second surgery to harvest autograft with attendant increased surgical time and blood loss. Disadvantages of allografts include their limited availability, high cost, fracture in case of massive structural bone allografts, and potential risk for disease transmission. Processing of the allografts can reduce the risk of disease transmission. Gamma irradiation or ethylene oxide can be employed to reduce the risk of disease transmission associated with the use of allografts. Both the techniques may also have a detrimental effect on the biomechanical as well as the biological properties of the graft.

Recent times have seen a change in the way the allografts are used. During the initial period of use, these tissues were removed from the donor and transplanted into the recipient without any manipulation. Advances were mainly confined to storage and surgical techniques. Current researchers aim to manipulate these grafts to make them more versatile.

Also, recent times have seen a lot of changes brought in by the advances in the material sciences and regenerative medicine. Allografts have been replaced by newer materials in some indications, porous metal use in revision acetabular surgery which has brought down the use of bulk allografts on the acetabular side considerably being a point in the case. However, bulk allografts on the femoral side have compared favorably with megaprostheses. Excellent to good results with good mid-term survival has been reported in the tumor surgery as well as revision hip replacements.[1,2] Moreover, the use of bulk allografts in the upper limb is also burgeoning, and the newer indications have been reported. Capanna et al.[3] reported 6 cases of scapular allograft reconstruction after total scapulectomy preserving the rotator cuff muscles. Authors reported good functional results at a mean follow-up of 5.5 years. Malignant tumors of the proximal humerus have been treated with allograft-prosthesis composite reconstruction. Black et al.[4] reported good early and intermediate results in 6 consecutive patients of malignant tumors of proximal humerus treated with allograft-prosthesis composite and followed up for a mean interval of 55 months. King et al.[5] reported proximal humerus reconstructions after resection of tumor with allograft-prosthetic composite reverse total shoulder arthroplasty. Authors reported promising functional outcomes with ostensibly less instability rates compared to hemiarthroplasty or total shoulder arthroplasty.

Morsellized bone allografts have stood their ground as biological materials to fill defects even in weight bearing situations. Even the availability of porous metal components and augments has not been able to undermine the role of morsellized allografts in filling up asperities and defects behind the implants.[6] While the role of morsellized allografts for the management of deficient bone stock, especially in contained and metaphyseal defects is undisputed, their sparse supply has been a concern. Synthetic bone graft substitutes, though readily available, vary in their resorption behavior and material properties. Bone marrow as an additive to allograft to enhance its osteogenetic potential and autologous grafts as extender have been used with moralized allografts. Recent times have seen attempts to use Bioglass BAG-S53P4 as additive to bone allograft. David et al.[7] demonstrated that allografts can be extended using bioglass without compromising the mechanical properties in vivo. An earlier study also demonstrated no negative effect of bone impaction grafting with bone and ceramic mixture.[8] Conversely, allografts can be used as extenders for autografts and have been successful in promoting and achieving a solid fusion mass in instrumented lumbar spine fusion.[9]

Manipulation of the allografts to improve their performance has also been on the agenda of the current researcher. Preclinical studies have shown that the osteoinductive capacity of allograft bone can be improved substantially by the addition of osteogenic proteins. The attempt to achieve the

same has been made in the past by adding bone marrow or autologous bone grafts to the allograft.

In other scenarios also, attempts are rife to manipulate the allografts to enhance their biological properties and specially their healing potential. Massive bone defect repairs can typically be augmented using three strategies for manipulating the allografts[10] namely, (a) by engrafting mesenchymal stem cells (MSCs) onto a graft or a biosynthetic matrix to provide a viable osteoinductive scaffold material, (b) by introducing critical factor(s), for example, bone morphogenetic proteins (BMPs), in the form of bone-derived or recombinant proteins directly onto the graft, or, (c) by targeted delivery of therapeutic genes (using viral and nonviral vectors). Awad et al.[10] developed a murine femoral model in which recombinant, adeno-associated virus (rAAV) gene was transferred to achieve revitalization of the allograft. Allografts coated with rAAV expressing osteoinductive or the angiogenic factors combined with the osteoclastogenic factor receptor were shown to have remarkable osteogenic, angiogenic, and remodeling effects in healing allografts resembling the healing response of an autograft. These innovations in gene delivery hold great promise as therapeutic approaches in challenging indications.

Hoffman and Benoit[11] have reported an emerging idea to augment allografts with a tissue engineered periosteum consisting of biodegradable poly (ethylene glycol) hydrogels as a vehicle for mesenchymal stem cells (MSC) transplantation. This bioengineered periosteum will ostensibly revitalize the allografts and heal them akin to autografts.

Cartilage transplantation and tendon allograft techniques are becoming popular with increasingly improved outcomes. There has been a rise in the sports-related and activity-related knee injuries especially among the young and active population. Chondral defects have revealed themselves in the arthroscopic studies in over 60% of these patients increasing the risk of the early onset of osteoarthritis in the injured knee. Osteochondral allograft (OCA) transplantation (OAT) is now increasingly available and has proven to be highly effective in repairing chondral defects larger than 2 cm^2 and restoring mature, hyaline cartilage with innate structure, biology, and function.

Fresh-preserved donor OCAs are commercially available through tissue banks, but the tissue must be maintained at 4 °C after retrieval until a series of microbiological and immunological tests to screen for the transmissible infections are completed. These were historically transplanted fresh, stored in Ringer's solution, within 7 days of the death of the donor.

Bugbee et al.[12] in an excellent review of their work published recently reported on the development of OCA storage protocols to enhance the longevity and the supply of suitable donor tissue, analysis of the cartilage repair and remodeling in vivo through the establishment of an appropriate animal model, refined patient selection through identification of appropriate indications, and, improvement of surgical techniques for better outcomes. The two key constituents of the osteochondral allografts are the chondrocytes and the extra cellular matrix (ECM). Fresh OCA transplantation is done with the premise that the viable chondrocytes survive storage and subsequent transplantation. They are able to maintain their metabolic activity and sustain their surrounding matrix thus providing an intact structural and functional unit to replace diseased articular tissue. Chondrocyte viability in OCA; therefore, is critical to the osteochondral graft survivorship and clinical outcome. However, when stored at 4 °C, the number of chondrocytes falls linearly with storage time. An optimal storage time of less than 28 days from procurement for OCAs has been suggested in studies because a significant decline of cellularity, crucial to maintain matrix, occurs in the fresh-preserved OCAs between days 14 and 28 in storage. The possible explanation offered is that the storage of fresh OCA at 4 °C gradually causes a mismatch between the ATP supply and demand in chondrocytes, which eventually results in necrotic cell death.[12] Chondrocyte apoptosis is also believed to be a major cause of cell depletion in the allografts. Increasing chondrocyte death in fresh-preserved OCAs might release matrix-degrading proteases, including metalloproteinases, from ruptured lysosomes of necrotic chondrocytes leading to dissolution of ECM. Ding et al.[13] have shown that, compared with patients' diseased cartilage, OCA cartilage released significantly lower amounts (10.4-fold lower) of cartilage proteoglycan degrading metalloproteinases, especially MMP-3 (matrix metalloproteinase-3) and showed much lower MMP-3/TIMP-1 (tissue inhibitor of MMP-1) ratio. According to authors, this remarkable difference in metalloproteinase levels between OCA cartilage and patients' cartilage may suggest an intrinsically low expression of cartilage-damaging metalloproteinases in OCAs from young and healthy donors, or, higher expression of these metalloproteinases in the injured knee.

Bugbee et al.[12] have gone further to show that the chondrocyte viability after storage could be improved when additional nutrients (i.e., serum) were added to the media and the superficial zone was a target for decreased viability after 14 days; also, apoptotic response could be altered by adding a TNF inhibitor to tissue culture medium (TCM) thus improving chondrocyte viability during 4 °C storage for up to 28 days; and, 37 °C storage of OCA could support long-term (≥4 weeks) chondrocyte viability, especially at the articular surface, but additional anabolic stimuli or catabolic inhibitors to maintain matrix (e.g., glycosaminoglycan – GAG) content of the cartilage of OCAs may be needed as the cells may become quiescent during storage. Authors also conclusively proved that 4 °C stored grafts have lower chondrocyte viability at the time of OCA transplantation versus fresh grafts. Moreover, 4 °C stored grafts (with reduced cellularity at the cartilage surface) were shown to be less stiff and more susceptible to tissue degeneration after transplantation and associated surface and/or bone collapse.

The research by Bugbee et al. has led to the practice of the addition of the fetal bovine serum to the TCM to preserve chondrocyte viability during screening and processing and an increased supply of fresh OCA for more widespread use.

Other contributions by Bugbee et al. to the osteochondral grafting include the introduction of a comprehensive MRI scoring system for OCA validated with histopathologic, μCT, and biomechanical reference standards in an animal (adult goat) model of in vivo OCA repair. The method has immense potential to help standardize reporting of MR findings after OCA repair with variable treatment options, ranging from

outstanding to poor repair. Authors also identified a novel use of proteoglycan-4 (PRG4) secretion as a biomarker of OCA health and performance. These developments will allow better prediction of the OCA outcomes and help devise strategies to provide more suitable tissue for transplantation, which in turn will help improve long-term repair efficacy. Furthermore, authors stressed revisiting the surgical technique in light of their findings that the impact insertion of OCA generates damaging loading impulses sufficient to cause chondrocyte death resembling apoptosis mediated by the activation of caspases, especially in the superficial zone.

Another development in the field of cartilage regeneration is the availability of an Off-the-shelf allograft cartilage implant *De Novo Natural Tissue Allograft* (Zimmer, St Louis, Missouri) which consists of minced human articular cartilage recovered from juvenile donor joints containing viable chondrocytes. Allograft cartilage pieces, molded after suspension in thrombi and fibrin can be used with fibrin glue to fit the cartilage defect bed as a graft. Successful outcome has been reported with its use[14] and the rationale provided lies in the higher proliferative capacity of the juvenile graft compared to the adult tissue.

Cryopreserved cartilage allografts, with pores to increase flexibility and enhance growth factor release, prepared with a novel tissue processing and preservation method have been used to augment marrow stimulation with improve results.[15]

Allografts are just not confined to the replacement of deficient bone and cartilage. Allografts can serve as biological substitutes that are used in the reconstruction of deficient ligaments, tendons, and menisci. Chaudhury et al.[14] have reported allograft replacement for absent native tissue to obtain stable anatomy and restoration of function. This is in contradistinction to the common notion that allografts are employed to reinforce weakened tissue.

Tendon allografts are being increasingly employed in the reconstructive procedures.[16] Fresh allograft tissue is highly immunogenic and therefore unsuitable for implantation. Processing of the allograft tissue by fresh-freezing, freeze-drying or cryo-preserving significantly reduces the immunogenicity of the tissue by killing fibroblasts within the tissue and allows their use even in immunologically incompatible hosts without provoking a significant immune response.

Most common allograft tissues used for tendon reconstruction are tendo Achilles and patellar tendon allografts. Other tissues also used include Fascia lata, rotator cuff, tibialis posterior, tibialis anterior, gracilis and semitendinosus grafts and these are also available commercially. Dermal allografts have been used for the rotator cuff reconstruction.

Secondary sterilization of the tendon allografts can be done using gamma irradiation or ethylene oxide. Both the methods lead to the compromise of the mechanical properties of the graft. The principle concerns regarding the use of ethylene oxide in tendon allografts include the concern about the persistent synovial effusion, reports of graft dissolution, and a poor clinical outcome.

The indications for the tendon allografts have been primarily in lower limb, most frequently for anterior cruciate ligament reconstruction, posterior cruciate ligament reconstruction, multi-ligament reconstruction, lateral ankle ligament for chronic ankle instability, hip abductor mechanism reconstruction, and, knee extensor mechanism reconstruction.[17] Though used less commonly in the upper limb, tendon allografts are now being considered for the management of elbow instability, triceps deficiency in patients following total elbow arthroplasty, reconstruction of the biceps tendon, and, rupture of the pectoralis major tendon. To summarize, tendon allografts are being increasingly used in reconstruction of the tendons and ligaments in a number of anatomical sites. However, major issues surrounding their procurement, processing and use must be understood and discussed with the patient including the risk of disease transmission.

Meniscal transplantation has been considered as a solution in patients with symptoms who have previously undergone meniscectomy and are known to potentially suffer from premature degenerative changes.[18] At present time there are few Level I or II studies reporting the results of meniscal transplantation. Most studies report on small study groups with limited follow-up and patient selection and description of patient factors varies greatly between the groups and data from different studies cannot be compared.

Four types of meniscal allografts are used – fresh, fresh-frozen, cryopreserved, and freeze-dried (lyophilized) graft. Out of these, cryopreserved and fresh-frozen allografts have been found to be most suitable. Matching of the allograft meniscal size with the host is absolutely crucial. Grafts are harvested and transplanted with bony plug attached separately to each horn (Medial meniscus) or both the horns (Lateral meniscus) for best results. Use of bony anchors is recommended to fix the graft. A lesser degree of degeneration in the knee prior to transplantation is associated with an improved outcome. In conclusion, the current literature suggests that meniscal allograft transplantation provides improvement of pain and function in the short and intermediate term in patients less than 40 years of age with knee pain, proven meniscal injury and a normally aligned, stable joint without severe degenerative changes. The effect of meniscal transplantation on the future joint degeneration is inconclusive.

How the technology stands to facilitate the practice of the bone banking? Wu et al.[19] in an article published this year reported improved matching accuracy and reduced allograft selection time by combining virtual bone bank and CAOS when using massive bone allografts for bone tumors. Authors scanned the massive allografts using CT scans and the data was stored in Digital Imaging and Communication in Medicine (DICOM) files. Then the images were segmented and 3D models were reconstructed and saved in Virtual Bone Bank System. Allografts were selected after a matching process based on the volume registration method. Thus, limb salvage surgery using massive allografts and 3D virtual bone bank system could be improved. The technique of 3D virtual bone banking allowed convenient management of the bank, easy and precise matching of allograft and reduced time required for allograft preparation including cutting and trimming.

The future of musculoskeletal banking remains mysterious. While expanding indications and advancing technologies promise a more widespread and easy application, other advances in technology may replace the need for allografts in certain indications. The advances in bioengineering will likely reduce the dependence on allografts in future. Synthetic

scaffolds, manufactured with new technology of additive manufacturing, or 3D printing will be instrumental in achieving a clinically successful engineered tissue construct.[20] 3D printing allows the control of scaffold size, shape, geometry, pore size and mechanical properties. Furthermore, modern medical imaging and computer assisted design could be integrated to designs scaffolds individualized to a specific defect in a patient. Refinement of nanotechnology, biocompatible materials, growth factors, gene therapies, and bioreactors will lead to improved bioengineered musculoskeletal tissues leading to reduced demand for the allograft tissue. So let us wait together and see how the future trends unfold in this exciting arena!

REFERENCES

1. Malhotra R, Kiran Kumar GN, K Digge V, Kumar V. The clinical and radiological evaluation of the use of an allograft-prosthesis composite in the treatment of proximal femoral giant cell tumours. *Bone Jt J*. 2014;96-B(8):1106–1110.
2. Malhotra R, Kancherla R, Kumar V, Soral A. Trabecular metal acetabular revision system (cup-cage construct) to address the massive acetabular defects in revision arthroplasty. *Indian J Orthop*. 2012;46(4):483–486.
3. Capanna R, Totti F, Van der Geest ICM, Muller DA. Scapular allograft reconstruction after total scapulectomy: surgical technique and function results. *J Shoulder Elbow Surg*. 2015;24:e203–e211.
4. Black AW, Szabo RM, Titelman RM, Davis CA, Atlanta GA. Treatment of malignant tumors of the proximal humerus with allograft-prosthesis composite reconstruction. *J Shoulder Elbow Surg*. 2007;16(5):525–533.
5. King JJ, Nystrom LM, Reimer NB, Gibbs CP, Scarborough MT, Wright TW. Allograft-prosthetic composite reverse total shoulder arthroplasty for reconstruction of proximal humerus tumor resections. *J Shoulder Elbow Surg*. 2015;1–10.
6. Dua A, Kiran K, Malhotra R, Bhan S. Acetabular reconstruction using fresh frozen bone allograft. *Hip Int*. 2010;20(2):143–149.
7. David F, Johannes F, Debora C-H, et al. BAG-S53P4 as an additive to bone allografts: a laboratory study using an uniaxial compression test. *J Orthop Res*. 2015;1–5.
8. Arts JJ, Gardeniers JW, Welten ML, et al. No negative effects of bone impaction grafting with bone and ceramic mixtures. *Clin Orthop Relat Res*. 2005;438:239–247.
9. Girardi FP, Cammisa Jr FP. The effect of bone graft extenders to enhance the performance of iliac crest grafts in instrumented lumbar spine fusion. *Orthopaedics*. 2003;26(5 Suppl.):S545–S550.
10. Awad HA, Zhang X, Reynolds DG, Guldberg RE, O'keefe RJ, Schwarz EM. Recent advances in gene delivery for structural bone allografts. *Tissue Eng*. 2007;13(8):1973–1985.
11. Hoffman MD, Benoit DSW. Engineering the periosteum: revitalizing allograft by mimicking autograft healing. *Clin Orthop Relat Res*. 2013;47:721–726.
12. Bugbee WD, Pallante-Kichura AL, Görtz S, Amiel D, Sah R. Osteochondral allograft transplantation in cartilage repair: graft storage paradigm, translational models, and clinical applications. *J Orthop Res*. 2015. http://dx.doi.org/10.1002/jor.23998.
13. Ding L, Zampogna B, Vasta S, De Caro F, Martin JA, Amendola A. Why do osteochondral allografts survive? Comparative analysis of cartilage biochemical properties unveils a molecular basis for durability. *Am J Sports Med*. 2015;43(10):2459–2468. http://dx.doi.org/10.1177/0363546515596407.
14. Chaudhury S, Wanivenhaus F, Fox AJ, Warren RF, Doyle M, Rodeo SA. Allograft replacement for absent native tissue. *Sports Health*. 2012;5(2):175–182.
15. Geraghty S, Kuang JQ, Yoo D, LeRoux-Williams M, Vangsness Jr CT, Danilkovitch A. A novel, cryopreserved, viable osteochondral allograft designed to augment marrow stimulation for articular cartilage repair. *J Orthop Surg Res*. 2015;10:66. http://dx.doi.org/10.1186/s13018-015-0209-5.
16. Robertson A, Nutton RW, Keating JF. Current trends in the use of tendon allografts in orthopedic surgery. *J Bone Joint Surg [Br]*. 2006;88-B:988–992.
17. Malhotra R, Garg B, Logani V, Bhan S. Management of extensor mechanism deficit as a consequence of patellar tendon loss in total knee arthroplasty: a new surgical technique. *J Arthroplasty*. 2008;23(8):1146–1151. http://dx.doi.org/10.1016/j.arth.2007.08.011 [Epub 2008 Jan 24].
18. Crook TB, Ardolino A, Williams L, Barlow IW. Meniscal allograft transplantation: a review of the current literature. *Ann R Coll Surg Engl*. 2009;91:361–365.
19. Wu Z, Fu J, Wang Z, et al. Three-dimensional virtual bone bank system for selecting massive bone allograft in orthopaedic oncology. *Int Orthop*. 2015;39(6):1151–1158.
20. Smith BD, Grande DA. The current state of scaffolds for musculoskeletal regenerative applications. *Nat Rev Rheumatol*. 2015;11:213–222.

Rajesh Malhotra*
Professor, Department of Orthopedics, All India Institute of Medical Sciences New Delhi, India

*Tel.: +91 1126589093; fax: +91 1126589093
E-mail address: rmalhotra62@hotmail.com

http://dx.doi.org/10.1016/j.jajs.2015.11.012
2214-9635/

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/jajs

Meta Analysis

Arthroscopic rotator cuff repair with and without acromioplasty for rotator cuff tear: A meta-analysis of randomized controlled trial

Sanjay Meena [a,*], *Shreesh Kumar Gangary* [b]

[a] *Department of Orthopaedics, SGT Medical College, SGT University, Gurgaon, Haryana, India*
[b] *Department of Orthopaedics, ESI Hospital, Okhla, New Delhi, India*

ARTICLE INFO

Article history:
Received 8 August 2015
Accepted 4 November 2015
Available online 7 December 2015

Keywords:
Acromioplasty
Subacromial decompression
Rotator cuff repair
Impingement syndrome
Arthroscopy

ABSTRACT

Introduction: Although acromioplasty is being widely performed with arthroscopic rotator cuff repair, it remains unknown whether it improves functional outcomes or decease retear rate. The aim of this meta-analysis is to compare the clinical outcome of arthroscopic rotator cuff repair with and without acromioplasty for the treatment of rotator cuff tear.

Methods: A search was performed in the MEDLINE, EMBASE, and Ovid databases. All randomized controlled trials that reported the outcome of arthroscopic rotator cuff repair with and without acromioplasty were included in the meta-analysis. The outcomes were American Shoulder and Elbow Surgeons (ASES) score, Constant score, UCLA score, and retear rate. We then analyzed the data using RevMan (version 5.1).

Results: The literature search identified a total of 5 studies with 447 patients that were included in the meta-analysis. There was no significant difference in the American shoulder and elbow surgeons, University of California-Los Angeles (UCLA), or constant scores between the acromioplasty and nonacromioplasty group.

Conclusion: Our meta-analysis does not demonstrate any difference in the functional outcome and retear rate of arthroscopic rotator cuff with or without acromioplasty.

Level of evidence: Level II. Therapeutic study.

1. Introduction

Rotator cuff tears are one of the most common shoulder injuries and can be a source of persistent pain, disability, and decreased range of motion (ROM) and strength.[1] Medium to large rotator cuff tears are treated with rotator cuff repair. Traditionally, acromioplasty have been routinely performed, as a part of the arthroscopic repair.[2] Acromioplasty is an effective surgical procedure in increasing the height of the subacromial space, and thus relieving the symptoms of impingement syndrome. The mechanical impingement is believed to contribute to abrasion of the supraspinatus tendon, eventually leading to its rupture.[3] Neer hypothesized that

* *Corresponding author at*: L-139, Pocket-L, Sarita Vihar, New Delhi, India. Tel.: +91 9968444612.
E-mail address: sanjaymeena@hotmail.com (S. Meena).

http://dx.doi.org/10.1016/j.jajs.2015.11.001

acromioplasty smoothens the area of contact over the supraspinatus tendon and decreases mechanical wear.[4] The effectiveness of acromioplasty, as an adjuvant procedure in rotator cuff repair, remains unknown, with some studies supporting this while others refuting any benefit.[5–7] Despite this, the incidence of acromioplasty with rotator cuff repair has significantly increased recently.[8,9]

Randomized controlled trials are considered to be the most reliable form of scientific evidence in the hierarchy of evidence because randomized controlled trials reduce spurious inferences of causality and bias. Our aim was to compare the functional outcome, revision rate of the two groups of patients treated for rotator cuff repair with and without acromioplasty by arthroscopic method. Our hypothesis was that both the groups were comparable, with no benefit of acromioplasty.

2. Methods

This meta-analysis was conducted according to the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analysis and the Cochrane Handbook for Systematic Reviews of Interventions.

2.1. *Literature search*

We searched the Cochrane Central Register of Controlled Trials (The Cochrane Library, 2013, Issue 9), PubMed (1946 to September 2013), and EMBASE (1980 to September 2013) databases. No language or publication restrictions were applied. Articles in languages other than English were translated with the help of medically knowledgeable speakers. The following keywords were used for the searches: Rotator cuff repair, cuff repair, rotator cuff, acromioplasty, and subacromial decompression. We checked the reference lists of published studies to identify additional trials. Furthermore, we searched the following journal contents in the past 3 years for randomized controlled trials: *Arthroscopy: The Journal of Arthroscopic and Related Surgery*, *The American Journal of Sports Medicine*, *The Journal of Bone and Joint Surgery*, *The Bone and Joint Journal*, *Clinical Orthopaedics and Related Research*, and the *Journal of Shoulder and Elbow Surgery*.

2.2. *Eligibility criteria*

We systematically reviewed the literature according to the following criteria: (1) a target population of rotator cuff tears requiring arthroscopic repair, (2) Level I and II randomized controlled trials evaluating surgical interventions, (3) studies comparing the outcomes of arthroscopic rotator cuff with and without acromioplasty. (4) One or more outcomes of interest postoperatively (e.g. retear rate, shoulder score, and complications).

2.3. *Selection of studies*

Two authors (SM and SK) independently scanned records retrieved by the searches to exclude irrelevant studies and to identify trials that met the eligibility criteria. They retrieved and independently reviewed full-text articles for the purpose of applying inclusion criteria. Differences in opinion between authors were resolved by discussion and consultation with the senior author (BC) (Fig. 1).

2.4. *Outcomes*

The primary outcome of interest was American shoulder and elbow surgeons (ASES score).[10] Secondary outcomes noted were Constant score,[11] University of California-Los Angeles (UCLA)score,[12] and retear rate.

2.5. *Assessment of heterogeneity and statistical methods*

We planned to consider both clinical heterogeneity (e.g. differences among patients, interventions, and outcomes) and statistical heterogeneity variation between trials in the underlying treatment effects being evaluated. To establish inconsistency in the study results, statistical heterogeneity between studies was formally tested with I^2.[13] The I^2 estimate

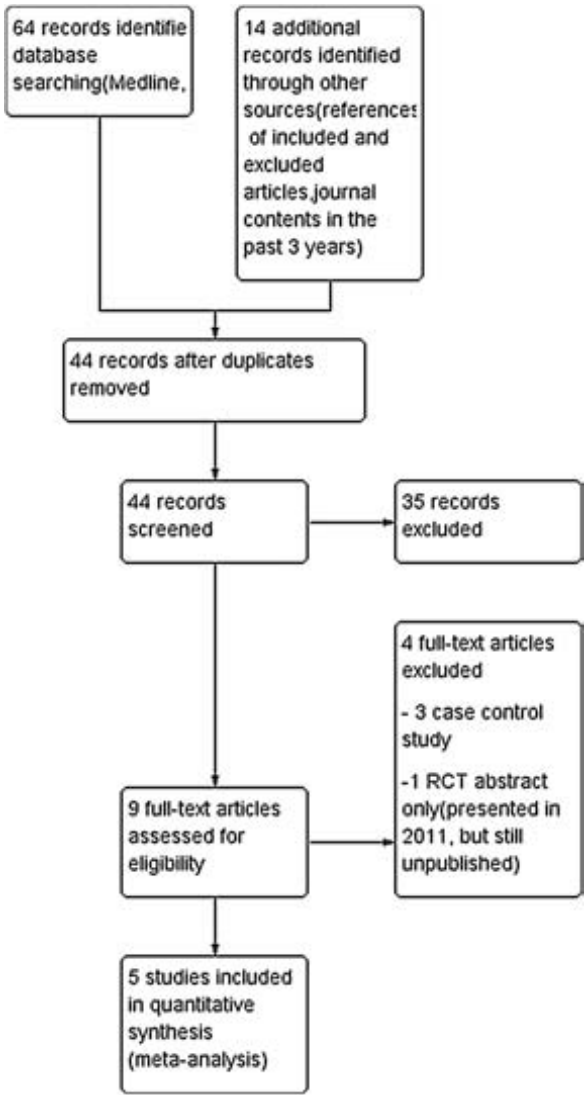


Fig. 1 – Search strategy results.

Table 1 – Study characteristics (ARCR-A: arthroscopic rotator cuff repair with acromioplasty, ARCR: arthroscopic rotator cuff repair without acromioplasty) Characteristics of included studies.

Author	Patients/age	Men (%)	Follow-up rate and length	Randomization (ARCR-A/ARCR)	Measured outcomes	Jadad score
Shin et al., 2012[18]	150 pts; mean age 56.8	44.6	120/150 (80%); 35 months	60/60	Constant, ASES, UCLA, pain VAS	2
MacDonald et al., 2011[15]	86 pts; mean age 56.8	65	68/86 (79%); 24 months	32/36	WORC, ASES	3
Abrams et al., 2014[17]	95 pts; mean age 58.8	67.3	95/114 (83%); 24 months	52/43	SST, ASES, Constant, UCLA, SF-12	3
Milano et al., 2007[16]	80 pts; mean age 60.4	54.9	71/80 (89%); 24 months	34/37	Constant, DASH, work-DASH	2
Gartsman and O'Connor, 2004[14]	93 pts; mean age 59.7	55	93/93 (100%); 15.6 months	47/46	ASES	2

examines the percentage of total variation across studies resulting from heterogeneity rather than chance. According to the Cochrane Handbook, heterogeneity is considered not important between 0% and 40%, moderate between 30% and 60%, substantial between 50% and 90%, and considerable between 75% and 100%. Therefore, an I^2 of less than 60% is accepted in this meta-analysis, and a fixed-effects model was used. Tests for significance were 2-tailed, and $P < 0.05$ was deemed to be significant.

Continuous data (ASES, UCLA, and constant score) were reported as standardized mean differences. Dichotomous data (retear) were reported as risk ratio by the use of a random or fixed-effect model. A fixed-effect model was applied when the included studies were assessed to be homogenous; a randomized effect model was applied when they are heterogeneous. The quality of studies was assessed by Jadad score.

3. Results

Hence, 5 randomized controlled trials involving 474 patients were included in this meta-analysis, with individuals ranging from 80 to 120 patients.[14–18] Of these 474 patients, 240 were randomly assigned to the group with acromioplasty and 234 patients were assigned to the group with acromioplasty. Table summarizes the characteristics of the included studies. Table 1 provides an overview of each study in this meta-analysis.

3.1. *Methodological quality*

Out of the five studies included, three were level I and two were level II. The overall methodological quality was high, and no studies were of low quality. The rate of loss to follow-up was considered to be acceptable (0% to 11%).

3.2. *ASES score*

Four studies used ASES score. The test for heterogeneity showed that there was no heterogeneity in this meta-analysis ($I^2 = 0\%$, $P = 0.39$). No significant difference was found in the fixed-effects model between the two groups (mean difference 1.92; 95%, CI, −0.85 to 4.70) (Fig. 2).

3.3. *Constant score*

Three studies used constant shoulder scores. The test for heterogeneity showed that there was no heterogeneity in this meta-analysis ($I^2 = 0\%$, $P = 0.50$). No significant difference was found in the fixed-effects model between the two groups (mean difference 3.12; 95% CI, −0.05 to 6.29, $P = 0.05$) (Fig. 3).

3.4. *University of California at Los Angeles score*

The University of California at Los Angeles (UCLA) shoulder score was reported in 2 studies. Fixed-effect analysis showed that the difference was not significant between the 2 groups (mean difference 0.70; 95% CI, −0.21 to 1.60; $P = 0.33$). No statistical heterogeneity was found in this meta-analysis ($I^2 = 0\%$; $P = 0.42$). No further analysis was possible (Fig. 4).

3.5. *Retear rate*

The retear rate was reported in two studies. Fixed-effect analysis showed no significant difference between the two groups (mean difference 0.20; 95% CI 0.04 to 1.18) (Fig. 5).

4. Discussion

Neer suggested that extrinsic impingement was the most common cause of chronic rotator cuff tear.[4] The usual

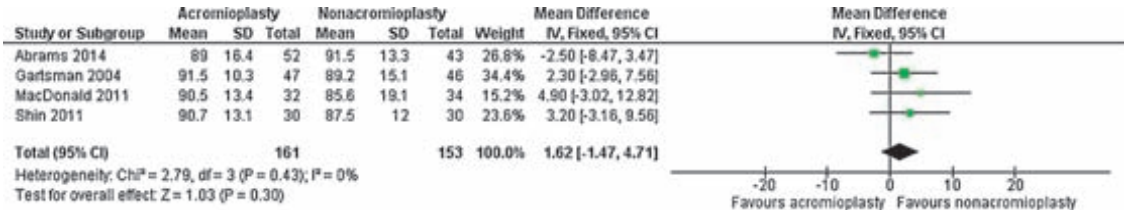


Fig. 2 – Forest plot for ASES score.

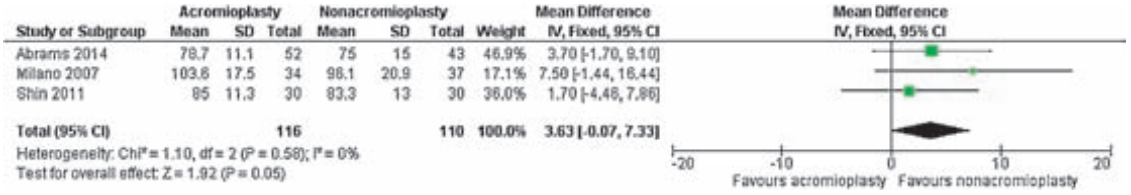


Fig. 3 – Forest plot for constant score.

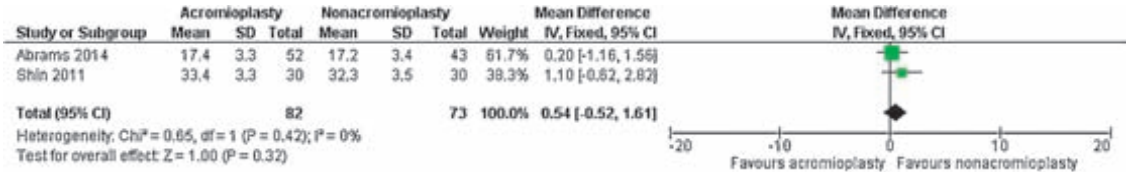


Fig. 4 – Forest plot for UCLA score.

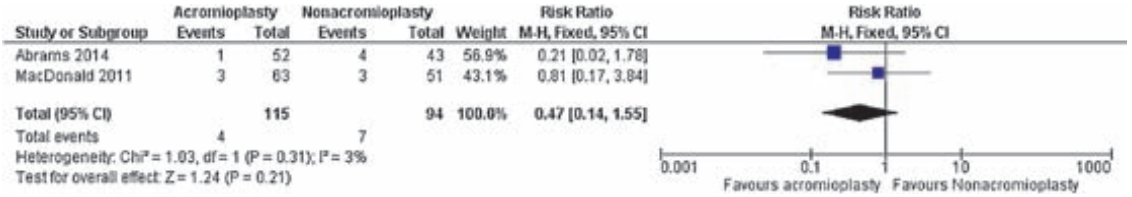


Fig. 5 – Forest plot for retear rate.

indication for acromioplasty is Neer stage II rotator cuff disease with subacromial pain or partial tear of the supraspinatus or infraspinatus tendons.[2] Subacromial decompression by acromioplasty is believed to result in relief of extrinsic, primary impingement on the rotator cuff tendons, a potential cause of extrinsic tendinopathy. However, many recent studies have shown that majority of the time rotator cuff tears are related to internal factors.[19] Some investigators have showed that the development of the acromial bony spur is a secondary degenerative change, implying that the majority of rotator cuff tears are initiated not by impingement but by an intrinsic degenerative tendinopathy. Hence, there should be no need for acromioplasty in rotator cuff repair.[20]

Several studies have shown good results after acromioplasty with rotator cuff repar.[21–23] However, recent studies have shown good clinical outcome even without acromioplasty.[24] Our meta-analysis pooled 5 randomized controlled trials showing that there were no significant differences in functional scores (ASES, UCLA, and constant scores) and retear rate for patients with rotator cuff tears from medium to large sizes. The main findings of the current study were that doing acromioplasty with rotator cuff repair does not improve functional outcomes, as measured by various shoulder scores. There is also no decrease in retear rate with acromioplasty. These results support our primary hypothesis.

Acromioplasty has been reported to have an impact on the healing rate of the tear. It leads to increase in local concentrations of growth and angiogenic factors, potentially leading to improved healing environment.[25,26] However, this is not supported by the recent literature.[27]

Only two out of the five studies included in this meta-analysis have reported retear rate. The retear rate was higher in the nonacromioplasty group but that was not significant. MacDonald et al. found a significantly higher number of patients in nonacromioplasty group requiring additional surgery. We did not evaluate the relation of the type of acromion with the outcome and retear rate. However, Shin and Macdonald et al. did not find any association between the functional outcomes and acromion type.[15,18] Henkus et al. reported that acromion morphology made no difference in the outcome of the patient. We showed that acromioplasty and rotator cuff debridement in patients with impingement syndrome and partial tears do not prevent the patient from having future tear.[28]

The disadvantages of doing acromioplasty are weakening of deltoid muscle, anterosuperior instability, and possibly formation of adhesion between exposed bone on under surface of the acromion and the underlying rotator cuff tendon, which in turn can limit smoothness, motion comfort, and range of motion.[29,30] Acromioplasty leads to increase in the cost to the patient due to the obvious increase in time and equipment costs associated with the procedure.

The American Academy of Orthopaedic Surgeons (AAOS) clinical practice guidelines for treatment of rotator cuff tears do not recommend routine acromioplasty during rotator cuff repair.[31] The academy statement is primarily based on the two randomized controlled trials available on this topic at that time. Based on our meta-analysis, we full endorse the academy statement. However, the long-term outcomes of performing or not performing acromioplasty with rotator cuff

repair are still unknown. Large, well-designed RCT with long-term follow-up is required to clarify that.

This meta-analysis has several limitations. First, the number of target patients was small. All randomized controlled trials were of small size and each was performed at a single centre. Second, the variety of different outcome measures limited our ability to combine outcome scores and make more definitive conclusions. It may also have resulted in a decrease in our ability to identify a true difference when one actually existed. We analyzed ASES, UCLA, and Constant shoulder scores, but it is noteworthy that all of these scores involve comprehensive assessments, such as pain, function, strength, and range of motion. Third, the tear size and acromion type may affect the differences between the two groups. No adequate studies reported the outcomes of subgroups. Therefore, we did not perform the subgroup analysis based on the tear size to ensure the rationality and validity of this meta-analysis.

5. Conclusions

Our meta-analysis does not any demonstrate any difference in the functional outcome and retear rate of arthroscopic rotator cuff with or without acromioplasty. Large, well-designed trials are needed to further assess the long-term outcome of performing or not performing acromioplasty.

Conflicts of interest

All authors have none to declare.

REFERENCES

1. Mitchell C, Adebajo A, Hay E, Carr A. Shoulder pain: diagnosis and management in primary care. *Br Med J*. 2005;331(7525):1124–1128.
2. Chaudhary S, Gwilym SE, Moser J, Carr AJ. Surgical options for patients with shoulder pain. *Nat Rev Rheumatol*. 2010;6 (4):217–226.
3. Ellman H. Arthroscopic sub acromial decompression: analysis of 1–3 year results. *Arthroscopy*. 1987;3(3):173–181.
4. Neer CS. Anterior acromioplasty for the chronic impingement syndrome in the shoulder: a preliminary report. *J Bone Joint Surg Am*. 1972;54(1):41–50.
5. Hawkins RJ, Misamore GW, Hobeika PE. Surgery for full thickness rotator cuff repairs. *J Bone Joint Surg Am*. 1985;67 (9):1349–1355.
6. Su WR, Budoff JE, Luo ZP. The effect of coracoacromial ligament excision and acromioplasty on superior and anterosuperior glenohumeral stability. *Arthroscopy*. 2009;25 (1):13–18.
7. Fagelman M, Sartori M, Freedman KB, Patwardhan AG, Carandang G, Marra G. Biomechanics of coracoacromial arch modification. *J Shoulder Elbow Surg*. 2007;16(1): 101–106.
8. Papadonikolakis A, McKenna M, Warme W, Martin BI, Matsen FA. Published evidence relevant to the diagnosis of impingement syndrome of the shoulder. *J Bone Joint Surg Am*. 2011;93(19):1827–1832.
9. Judge A, Murphy RJ, Maxwell R, Arden NK, Carr AJ. Temporal trends and geographical variation in the use of subacromial decompression and rotator cuff repair of the shoulder in England. *Bone Joint J*. 2014;96B(1):70–74.
10. Michener LA, McClure PW, Sennett BJ. American shoulder and elbow surgeons standardized shoulder assessment form, patient self-report section: reliability, validity, and responsiveness. *J Shoulder Elbow Surg*. 2002;11:587–594.
11. (a). Constant CR, Murley AH. A clinical method of functional assessment of the shoulder. *Clin Orthop Relat Res*. 1987;160–164;Ć(b). Amstutz HC, Sew Hoy AL, Clarke IC. UCLA anatomic total shoulder arthroplasty. *Clin Orthop Relat Res*. 1981;7–20.
12. Higgins JP, Thompson SG. Quantifying heterogeneity in a meta-analysis. *Stat Med*. 2002;21:1539–1558.
13. Amstutz HC, Sew Hoy AL, Clarke IC. UCLA anatomic total shoulder arthroplasty. *Clin Orthop Relat Res*. 1981; 7–20.
14. Gartsman GM, O'Connor DP. Arthroscopic rotator cuff repair with and without arthroscopic subacromial decompression: a prospective, randomized study of one-year outcomes. *J Shoulder Elbow Surg*. 2004;13:424–426.
15. MacDonald P, McRae S, Leiter J, Mascarenhas R, Lapner P. Arthroscopic rotator cuff repair with and without acromioplasty in the treatment of full-thickness rotator cuff tears: a multicentre, randomized controlled trial. *J Bone Joint Surg Am*. 2011;93:1953–1960.
16. Milano G, Grasso A, Salvatore M, Zarelli D, Deriu L, Fabbriciani C. Arthroscopic rotator cuff repair with and without subacromial decompression: a prospective randomized study. *Arthroscopy*. 2007;23:81–88.
17. Abrams GD, Gupta AK, Hussey KE, Tetteh ES, Karas V, Bach Jr BR, Cole BJ, Romeo AA, Verma NN. Arthroscopic repair of full-thickness rotator cuff tears with and without acromioplasty: randomized prospective trial with 2-year follow-up. *Am J Sports Med*. 2014;42(6):1296–1303.
18. Shin SJ, Oh JH, Chung SW, Song MH. The efficacy of acromioplasty in the arthroscopic repair of small- to medium-sized rotator cuff tears without acromial spur: prospective comparative study. *Arthroscopy*. 2012;28 (5):628–635.
19. Goldberg BA, Nowinski RJ, Matsen III FA. Outcome of nonoperative management of full-thickness rotator cuff tears. *Clin Orthop Relat Res*. 2001;99–107.
20. Budoff JE, Nirschl RP, Guidi EJ. Debridement of partial thickness tears of the rotator cuff without acromioplasty, long-term follow-up and review of the literature. *J Bone Joint Surg Am*. 1998;80:733–748.
21. Blevins FT, Warren RF, Cavo C, et al. Arthroscopic assisted rotator cuff repair: results using a mini-open deltoid splitting approach. *Arthroscopy*. 1996;12:50–59.
22. Gartsman GM, Khan M, Hammerman SM. Arthroscopic repair of full-thickness tears of the rotator cuff. *J Bone Joint Surg Am*. 1998;80:832–840.
23. Hawkins RJ, Misamore GW, Hobeika PE. Surgery for full thickness rotator-cuff tears. *J Bone Joint Surg Am*. 1985;67:1349–1355.
24. (a). McCallister WV, Parsons IM, Titelman RM, Matsen III FA. Open rotator cuff without acromioplasty. *J Bone Joint Surg Am*. 2005;87:1278–1283;Ć(b). Henkus HE, de Witte PB, Nelissen RG, Brand R, van Arkel ER. Bursectomy compared with acromioplasty in the management of subacromial impingement syndrome: a prospective randomised study. *J Bone Joint Surg Br*. 2009;91(4):504–510.
25. Galliera E, Randelli P, Dogliotti G, et al. Matrix metalloproteases MMP-2 and MMP-9: are they early biomarkers of bone remodelling and healing after arthroscopic acromioplasty? *Injury*. 2010;41(11):1204–1207.

26. Randelli P, Margheritini F, Cabitza P, et al. Release of growth factors after arthroscopic acromioplasty. *Knee Surg Sports Traumatol Arthrosc.* 2008;17(1):98–101.
27. Rodeo SA, Delos D, Williams RJ, Adler RS, Pearle A, Warren RF. The effect of platelet-rich fibrin matrix on rotator cuff tendon healing: a prospective, randomized clinical study. *Am J Sports Med.* 2012;40(6):1234–1241.
28. Henkus et al reported that acromion morphology made no difference in the outcome of the patient.
29. Fagelman M, Sartori M, Freedman KB, et al. Biomechanics of coracoacromial arch modification. *J Shoulder Elbow Surg.* 2007;16(1):101–106.
30. Lee TQ, Black AD, Tibone JE, et al. Release of the coracoacromial ligament can lead to glenohumeral laxity: a biomechanical study. *J Shoulder Elbow Surg.* 2001;10(1):68–72.
31. Pedowitz RA, Yamaguchi K, Ahmad CS, et al. optimizing the management of rotator cuff problems. *J Am Acad Orthop Surg.* 2011;19(6):368–379.

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/jajs

Original Article

Assessing the benefit of multidisciplinary assessment centre in a military population sustaining knee injury

David Bell, Alexander Wood *, *Stephen Wrigley, Cameron Angus*

Regional Rehabilitation Unit, Redford Barracks, Edinburgh, United Kingdom

ARTICLE INFO

Article history:
Received 10 December 2014
Accepted 10 November 2015

Keywords:
Sports injury
Arthroscopy
Knee injuries
Military
British
General practice

ABSTRACT

Objective: To evaluate the benefit of multidisciplinary assessment centres in the diagnosis of knee injury in military populations and assess the role of MRI as gold standard in the diagnosis of knee injury.

Design: Retrospective epidemiological study.

Setting: 122 servicemen attending the Multidisciplinary Injury Assessment Clinic (MIAC) at Redford Barracks, Edinburgh between January 2008 and January 2010.

Results: The most common of these injuries were to the medial meniscus (30.3%), osteochondral defects (28.7%) and anterior cruciate ligament (25.4%). 45.6% of patient sustained injury to more than one structure.23% of the 122 servicemen were deemed fully fit for military duty following treatment; 41 (34%) were classed as partially fit, with 31 (25.4%) deemed not medically fit at the end of period of assessment. The MIAC team were both more sensitive and specific at picking up all forms of structural knee injury with the exception of meniscal injuries, where the MIAC was more sensitive (0.76 vs. 0.74) but less specific (0.53 vs. 0.62). MRI was shown to have a sensitivity of between 0.68 and 0.96 when compared against arthroscopy. Its specificity was poorest for picking up osteochondral defects (0.39).

Discussion: The MIAC diagnosis of knee injuries was shown to be more effective than that of non-specalised GPs. MIAC also had a good degree of clinical accuracy when compared to MRI. MRI was shown to be an effective investigation, although not 100% sensitive and specific, and was poor at picking up osteochondral defects. It is recommended that the use of systems such as MIAC be expanded in the civilian community and be used in conjunction with MRI for maximal diagnostic efficiency.

* Corresponding author.
E-mail address: drsandywood@googlemail.com (A. Wood).

http://dx.doi.org/10.1016/j.jajs.2015.11.005

1. Introduction

Young active populations are at risk of knee injures owing to the stress they place on their joints during physical activity.[1,2] The most common injuries are those involving the anterior cruciate ligament, medial meniscus and medial collateral ligament.[3] The prognosis and recovery rates post-knee injury depend largely on the mechanism and nature of injury. Large epidemiological studies in Scandinavia have indicated that knee injury was the most common cause of disability following injuries in a variety of sports,[4] with many athletes struggling to return to pre-injury fitness.

Magnetic resonance imaging (MRI) is routinely used as the modality of choice for imaging of the knee, owing to its ability to identify soft tissue injuries[5] and is widely considered as a practical 'gold standard' test when used in associated with clinical assessment.[5] It is generally regarded as the investigation of choice in both civilian and military populations, particularly in patients with equivocal findings and risk of substantial injury.[6–9] The National Institute of Clinical Excellence (NICE) provide a knee assessment protocol that dictates when referral to emergency services and orthopaedic surgeon is recommended. In reality, these guidelines are often not fully adhered to. This is partly due to clinical symptoms often presenting equivocally and the subsequent burden on emergency departments this would place if all high index of suspicion injuries were referred on. In addition, waiting lists for orthopaedic referrals are often lengthy, preventing rapid assessment and diagnosis. Anecdotal evidence suggests that knee injuries in the UK are largely dealt with in the primary care setting with the majority of the remainder first presenting to the emergency department; there is no current epidemiological data highlighting what percentage of patients present to which services. Recent research indicated a mean delay from presentation to diagnosis of 22 months in patients with anterior cruciate ligament rupture presenting to sports injury clinics.[10] In addition, this same study found fewer than 10% of patients with anterior cruciate ligament rupture were given this diagnosis by referring doctors, with 30% having no formal diagnosis even after review with an orthopaedic consultant. Clearly any system that could improve these statistics by providing quick and efficient assessment and diagnosis would benefit both the patient and reduce strain on NHS services.

Military personnel are at risk of sustaining knee injuries due to the physical nature of their employment. As fitness is considered an integral aspect to military service, disability as a result of knee injury would have consequences for the individual's professional life in addition to affecting day-to day functioning and participation in sporting activities. Loss of full function could result in alteration of duties or discharge from medical service in severe cases.

As a result of this, the military operate a system whereby patients are streamlined to ensure there is minimum delay between initial presentation and diagnosis. Most patients initially present to their medical officer (MO) or general practitioner. Patients will either be treated at this level, or if it is felt warranted, referred on to Regional Rehabilitation Units (RRU). These units provide assessment, diagnosis and treatment via their Multidisciplinary Injury Assessment Clinic (MIAC).[11] These clinics are situated at 15 military bases across England, Scotland and Wales. The team working at these centres typically consists of an MO or general practitioner, physiotherapists and remedial instructors. These health professionals have specific sports medicine training for diagnosis and rehabilitation of sporting injuries. Each MIAC aims to see each patient within 20 days of referral to the clinic. The clinics have intensive physiotherapy programmes available as well as on site medical officers.[11] Each MIAC also has 'rapid access' to MRI scans, with a timeline of 10 days between referral and scan targeted. This service aims to minimize the waiting time between initial presentation and diagnosis, which, as research has shown, is one of the most significant[12] aspects for patients, both physically and psychosocially. If significant injury is suspected through clinical examination and MRI, the patient is booked in for arthroscopy. Arthroscopy can be both diagnostic and therapeutic. Although it too is neither fully sensitive nor specific as a stand alone diagnostic tool, it is often recognised as the gold standard test for diagnosis of internal derangement of the knee.[13]

We present the impact of a Multidisciplinary Injury Assessment Clinic in the diagnosis and subsequent treatment pathway of individuals presenting with knee injury in a military population. We provide valuable information on the outcomes of knee injuries in servicemen, which will help guide people treating servicemen and athletes around the world.

2. Methods

2.1. *Population sampling*

The sample group was military servicemen who presented to the Redford Barrack Multidisciplinary Injuries Assessment Centre (MIAC) to have MRI for knee pathology between January 2008 and January 2010 inclusive. In total this was a population of 182 servicemen from the Royal Navy, Royal Marines, British Army and Royal Air Force. Those who were seen but injury felt not sufficient enough to undergo further investigation with MRI were not included in the sample, unless later re-attending and undergoing investigation at that point.

Records of MIAC attendance to the Redford Barracks in Edinburgh were used to identify individuals who presented with injury severe enough to warrant MRI during the above time frame. Information was taken from initial GP referral letter, MIAC records, MRI scan reports and surgical notes.

Of the 182 patients, 60 of these patients were not included in the final data set. 50 of these were due to these patients having inadequate or absent initial referring GP letter, therefore data could not be assessed for these patients. The remaining 10 patients had incomplete MIAC notes or inadequate documentation of MRI results. This left 122 patients within the sample population.

2.2. *Evaluation of clinical assessment*

The mechanism of injury and suspected clinical diagnoses and by the initial referring GP, MIAC team, MRI and arthroscopy (if performed) were recorded. Due to the number of structural injuries that it is possible to sustain with knee trauma, only a

select number of the most commonly occurring knee injuries were assessed. These were; meniscal injuries; anterior and posterior cruciate ligament injuries; collateral ligamentous injuries and osteochondral defects, which research has indicated clinicians are poor at diagnosing and detecting. For the GP referral and MIAC team, MRI was used as the gold standard against which the GP and MIAC team were compared. In order to assess the clinical accuracy of using MRI, those patients who underwent arthroscopy had their MRI results tests against their end arthroscopy findings.

Pathology was classified as a recognised rupture or tear, or injury to the ligament significant enough to cause notable inflammation of the surrounding tissues. In those individuals who sustained injury to more than one structure in the knee, this was recorded in both the incidence of each injury sustained and also in Figs. 2–4 in the results section showing the spread of multiple pathologies. For example, in an individual damaging both his lateral meniscus and anterior cruciate ligament, this would count as 2 individual injuries to calculate mechanism per individual pathology sustained, and would show as the intersection between lateral meniscus and ACL on the Venn diagram in Fig. 3.

These data were then used to calculate the sensitivity, specificity, positive predictive value and negative predictive value for each method of diagnosis (Table 1).

2.3. *Treatment and end outcome assessment*

Records were reviewed for information regarding treatment outcome for those individuals with substantial pathology. Treatment options were split into four main categories: arthroplasty (functioning as both diagnostic and therapeutic procedure); ACL/PCL surgical repair; menisectomy; and chondroplasty and microfracture for osteochondral defects. Owing to the nature of the MIAC system as outlined above, none of these surgeries was substantially delayed from presenting date to affect end outcome data. The online applet Euler3[9] was used for production of the Venn diagram relating to demographics of surgical intervention.

End outcome in all patients presenting was assessed by use of the military physical status system. All military divisions in

Table 1 – Prevalence of knee injury, mechanism of injury and end outcome in military personnel following treatment.

Characteristic	RAF	Navy	Army	Marine	Total
Diagnosis					
Meniscal	16 (13.1)	15 (12.3)	14 (11.5)	1 (0.8)	46 (37.7)
Medial	10 (8.2)	14 (11.5)	12 (9.8)	1 (0.8)	37 (30.3)
Lateral	9 (7.4)	1 (0.8)	3 (2.5)	0 (0)	13 (10.7)
ACL	14 (11.5)	8 (6.6)	8 (6.6)	1 (0.8)	31 (25.4)
PCL	2 (1.6)	3 (2.5)	2 (1.6)	1 (0.8)	8 (6.6)
OCD	13 (10.7)	9 (7.4)	11 (9.0)	2 (1.6)	35 (28.7)
MCL	2 (1.6)	3 (2.6)	0 (0)	1 (0.8)	6 (4.9)
LCL	0 (0)	0 (0)	1 (0.8)	0 (0)	1 (0.8)
Other[a]	3 (2.5)	2 (1.6)	4 (3.3)	0 (0)	9 (7.4)
End outcome					
Fully Fit	13 (10.7)	8 (6.6)	6 (4.9)	1 (0.8)	28 (23.0)
Partially Fit	13 (10.7)	11 (9.0)	11 (.0)	6 (4.9)	41 (33.6)
Unfit	12[d] (9.8)	7[e] (5.7)	10 (8.2)	2 (1.6)	31 (25.4)
Not documented	7 (5.7)	3 (2.6)	11 (9.0)	1 (0.8)	22 (18.0)
Mechanism					
Sporting	24 (19.7)	14 (11.5)	22 (18.0)	5 (4.1)	65 (53.3)
Football	13 (10.7)	10 (8.2)	7 (5.7)	2 (1.6)	32 (26.2)
Running	2 (1.6)	1 (0.8)	7 (5.7)	0 (0)	10 (8.2)
Rugby	3 (2.5)	1 (0.8)	4 (3.3)	1 (0.8)	9 (7.4)
Other[b]	6 (4.9)	2 (1.6)	4 (3.3)	2 (1.6)	14 (11.5)
Low Impact	8 (6.6)	6 (4.9)	6 (4.9)	2 (1.6)	22 (18.0)
Walking	2 (1.6)	0 (0)	3 (2.5)	1 (0.8)	6 (4.9)
Low impact fall	2 (1.6)	3 (2.5)	1 (0.8)	1 (0.8)	7 (5.7)
Other[c]	4 (3.3)	3 (2.5)	2 (1.6)	0 (0)	9 (7.4)
Military related	6 (4.9)	2 (1.6)	6 (4.9)	1 (0.8)	15 (12.3)
On exercise	3 (2.5)	0 (0)	5 (4.1)	0 (0)	8 (6.6)
Physical training	3 (2.5)	2 (1.6)	1 (0.8)	1 (0.8)	7 (5.7)
Unknown	6 (4.9)	6 (4.9)	3 (2.5)	1 (0.8)	16 (13.1)
Total					122

Data reported as *n* (%).
ACL = anterior cruciate ligament; PCL = posterior cruciate ligament; CD = osteochondral defect; MCL = medial collateral ligament; LCL = lateral collateral ligament.
[a]Others included substantial tendinosis, joint degeneration and chondromalacia patellae.
[b]Cricket, golf, cycling, hockey, kite surfing, skiing, squash, volleyball, martials arts.
[c]Load carrying, chronic damage, road traffic accident, fire fighting duty.
[d]Exited military.
[e]For medical reasons unrelated to knee injury.

the UK use the PULHHEEMS system to assess capacity to work. As part of this classifications system, overall physical capacity (P) is assessed. This 'P' grade is adjusted depending on the roles of the individual, the activities required within this role and their ability to be fit with the amendment of duties.[15] The P grades are as follows:

- P2: Medically fit for unrestricted service worldwide.
- P3: Medically fit for duty with minor employment limitations.
- P4: Medically fit for duty within the limitations of pregnancy.
- P7: Medically fit for duty with major employment limitations.
- P8: Medically unfit for service.

Records were read between May and June of 2010—this allowed a period of six months between the last patients presenting and their assessment of their clinical progress and end outcome. This time period left enough time for all patients to undergo satisfactory investigations and for the vast majority of patients to have reached a level of fitness which one can assume to be nearer their baseline level of fitness, regardless of whether or not they went on to have surgery. It is recognised that not all patients will reach their maximal fitness level in this time period. Information was gathered for all patients in general, for each individual injury and also for those who underwent some form of surgical intervention. The high number of multiple injuries and frequency of patients undergoing more than one surgical procedure made it difficult to individualise the end outcome assessments for patients. For example, many patients with meniscal injuries who went on to have menisectomy also underwent ACL repair. As a result, data was accrued for those who underwent any form of surgical procedure.

From this information, the overall benefit of the MIAC vs. conventional GP diagnostics was assessed.

3. Results

3.1. *Demographics*

A total of 182 servicemen were seen by the MIAC clinic and had MRI between January 2008 and 2010, with 122 being included in the final population sample Of these, 36.8% (45) were RAF servicemen, 31.1% (38) were army, 23.7% (29) were naval servicemen and 8.2%[10] were royal marines. 95% (116) of the population were male. 75.4% (92 of the 122) of the referrals on from MIAC were by physiotherapists working in the centre, with 23% being doctors and the remainder unknown.

3.2. *Incidence of knee injury on MRI*

79 of the 122 (64.7%) servicemen had evidence of significant pathology relating to cruciate ligaments, collateral ligaments, menisci and osteochondral defects on MRI. Of these, 24 (30.3%) were army servicemen, 4 (5.0%) were marines, 23 (29.1%) were naval and 28 (35.4%) were RAF. In this limited female population, it was not possible to discern any significant gender differences in injury sustained ($p = 0.57$).

Table 2 outlines the raw data for individuals with positive pathology on MRI regarding diagnosis, end outcome and mechanism of injury for each military sub population. Total percentage figures for diagnosis equate to greater than 100% due to the incidence of multiple separate pathologies occurring in one individual (see Fig. 3).

Table 2 – Mechanism of injury according to pathologies sustained on MRI.

	Mechanism of Injury				
	High Impact	*Low Impact*	*Military Duty*	*Unknown*	*Total*
Lat men	11 (84.6)	1 (7.7)	1 (7.7)	0	13
Med men	18 (48.6)	5 (13.6)	5 (13.5)	9 (24.3)	37
ACL	25 (83.3)	2 (6.7)	1 (3.3)	2 (6.7)	30
PCL	6 (75)	2 (25)	0	0	8
OCD	22 (62.9)	4 (11.4)	2 (5.7)	7 (20)	35
MCL	5 (83.3)	1 (16.7)	0	0	6
LCL	0	1 (100)	0	0	1

Data reported as *n* (% of injury total).
Lat = lateral; med = medial; men = meniscal; ACL = anterior cruciate ligament; PCL = posterior cruciate ligament; OCD = osteochondral defect; MCL = medial collateral ligament; LCL = lateral collateral ligament.

The most common pathologies are outlined in Fig. 1. The highest incidence of injury was related to the medial meniscus (30.3%), osteochondral defects (28.7%) and anterior cruciate ligament (25.4%). 36 of the 79 (45.6%) sustained injury to more than one structure. Of these, 58.3% (21) sustained 2 injuries, with 38.9%[14] sustaining 3 and 1 injuring three structures. The anterior cruciate ligament (24 of the 36) and medial meniscus (23 of the 36) were the two structures most commonly injured in those with multiple pathologies.

3.3. *Incidence of knee injury on arthroscopy*

A total of 55 servicemen (45% of the original sample) underwent arthroscopy following MRI. Of these, 49 (89%) had evidence of positive pathology on arthroscopy. The incidence of each pathology separately is shown in the graph below.

A total of 23 (41.8% of the 55 undergoing arthroscopy) patients were found to have on isolated pathology on arthroscopy, 12 (21.8%) had two separate pathologies, 12

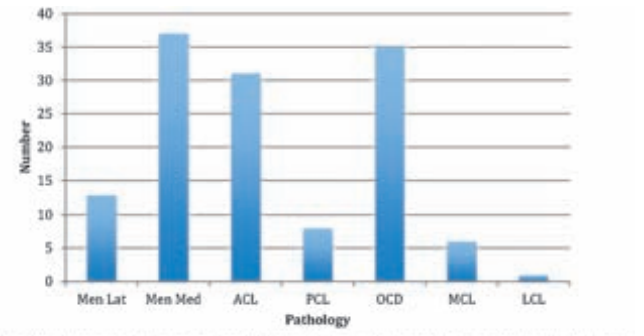


Fig. 1 – Bar graph demonstrating incidence of knee injury according to pathology as detected on MRI scan.

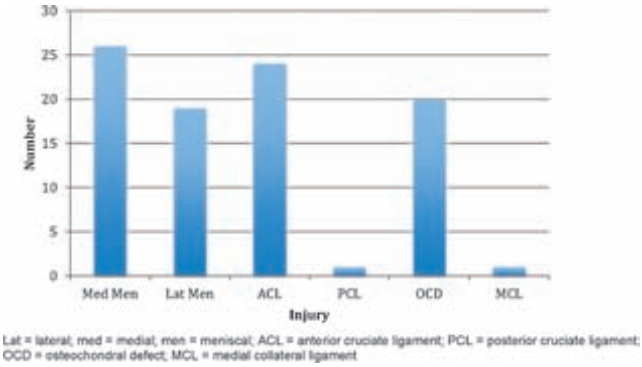


Fig. 2 – Bar graph demonstrating incidence of knee injury according to pathology as detected on arthroscopy.

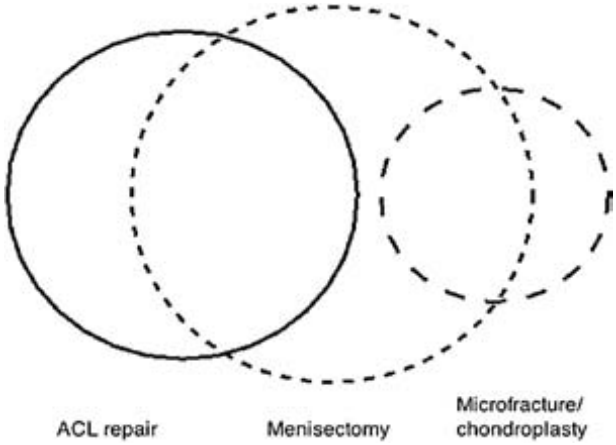


Fig. 4 – Venn diagram demonstrating the incidence of ACL repair, menisectomy and microfracture/chondroplasty.

patients (21.8%) had 3 separate pathologies, and a further 2 (3.6%) had 4 pathologies.

3.4. *Mechanism of Injury*

103 (86.9%) had a documented mechanism of injury recorded. Of these, 65 (53.3%) were performed during high impact sporting activity, with the remainder reporting low-level activity or chronic pain with no acute mechanism of injury. Of these, 15 (12.3%) were sustained whilst on exercise or military duty. Table 2 demonstrates the mechanism of injury sustained in each of those individuals who had confirmed pathology on MRI scan.

The mechanisms of injury for each specific injury type were sustained largely through high impact activities (as defined above), with the exception being that of the one lateral collateral ligament injury, which occurred through a low impact fall (see Fig. 3). Both medial meniscal injuries and osteochondral injuries had relatively fewer high impact injuries (48.6% and 62.9%, respectively), with all other injuries comprising 75% or greater high impact injury. These categories also had a substantially higher percentage of unknown mechanisms of injury (24.3% and 20%, respectively) p value = 0.098 (Fig. 5).

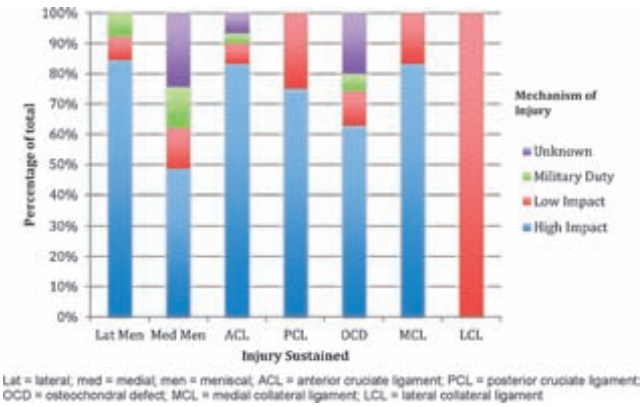


Fig. 3 – Stacked bar graph demonstrating mechanism of injury according to confirmed injury on MRI.

3.5. *Treatment*

A total of 49 patients (40.2% of the initial 122 in the sample population) underwent treatment other than simple arthroscopic measures. Of these, 12 (9.8%) underwent microfracture or chondroplasty for ostoechondral defects, 26 (21.3%) underwent ACL repair and 33 (27%) underwent menisectomy. The Venn diagram below shows the incidence overlap for each of these treatments.

3.6. *End outcome assessment*

28, or 23% of the 122 servicemen in the initial sample population were deemed fully fit for military duty following treatment; one of these was on the condition of fulfilling administrative duties only. 41 (34%) were classed as partially fit. Of the 31 (25.4%) deemed not medically fit, one was due to unrelated medical problems. One of the servicemen left the military between and attending and data correlation-the reasons for this departure were unknown.

Of the 79 servicemen with positive findings on MRI, 26 (32%) were fit for service at the end of the study period, 20 (26%) were partially fit and 18 (22%) were unfit, with 15 servicemen having no end point fitness assessment recorded. Of the servicemen with no pathology found on MRI, 1 (4%) was fully fit at the end of the study period, 15 (65%) were partially fit, 5 (22%) were unfit and 2 (9%) had no end outcome data. With the exclusion of those individuals with no outcome data, there was significant difference between those patients with no findings on MRI and with positive findings on MRI ($p = 0.0017$).

Table 3 highlights the end outcome for each individual injury on MRI finding. The surgery column for each includes individuals who underwent any form of surgery, accounting for those individuals with multiple pathologies. There was no statistical signficance between the injury sub groups and end outcome ($p = 0.79$). As can be seen, there was a decrease in the percentage of patients who were assessed as fully fit across all injury types when undergoing surgery compared to the injury population as a whole. With the exception of the PCL injured

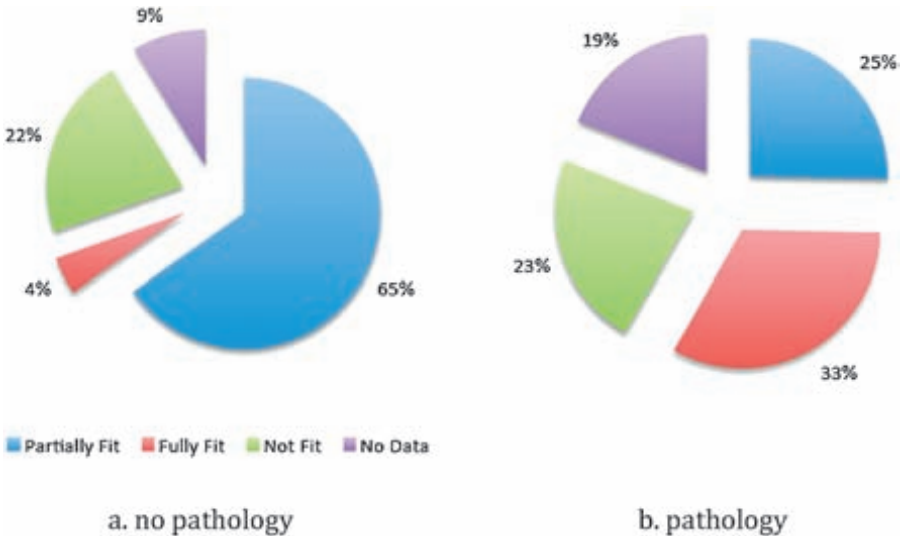


Fig. 5 – Pie chart showing the end outcome for servicemen attending MIAC with and without knee pathology on MRI.

Table 3 – End outcome data according to injury found on MRI.

	Meniscal		ACL		PCL		OCD		MCL	
	All	Surgery	All	Surgery	All	Surgery	All	Surgery	All	Surgery
Fully fit	17 (37.0)	11 (26.8)	9 (29.0)	7 (25.0)	2 (25.0)	0 (0)	11 (31.4)	8 (30.8)	2 (33.3)	0 (0)
Partially fit	10 (21.7)	10 (24.4)	7 (22.6)	8 (28.6)	2 (25.0)	0 (0)	8 (22.9)	8 (30.8)	0 (0)	0 (0)
Not Fit	11 (23.9)	12 (29.3)	12 (38.7)	9 (32.1)	2 (25.0)	2 (100)	7 (20.0)	7 (26.9)	3 (50.0)	3 (100)
No Data	8 (17.4)	8 (19.5)	3 (9.7)	4 (14.3)	2 (25.0)	0 (0)	9 (25.7)	3 (11.5)	1 (16.7)	0 (0)
Total	46	41	31	28	8	2	35	26	6	3

population ($p = 0.014$), there was no statistical significance between the population for each injury and those operated on ($p = 0.17$, 0.21, 0.0014, 0.006, 0.0833).

3.7. *Assessment of clinical evaluation*

Using the data collected from the findings of the GPs, the MIAC and MRI, the sensitivity, specificity, positive predictive value and negative predictive value were calculated to assess the ability of both GPs and MIAC in picking up pathology. This was calculated using MRI as a gold standard.

Table 4 outlines the findings for each individual pathology for both the GP and MIAC assessments.

As can be seen, the MIAC was consistently more sensitive than GP diagnosis in ascertaining pathology, and had a higher level of specificity and positive predictive value in all but the meniscal subpopulation. Significance was unable to be calculated owing to population sizes. The small population

Table 4 – End outcome assessment of GP diagnosis vs MIAC diagnosis in diagnosing knee pathology.

	N	Sensitivity	Specificity	Positive predictive value	Negative predictive value
Meniscal	46				
GP		0.74	0.62	0.54	0.80
MIAC		0.76	0.53	0.50	0.79
ACL	31				
GP		0.45	0.85	0.50	0.82
MIAC		0.55	0.86	0.57	0.85
PCL	8				
GP		0.13	0.94	0.13	0.94
MIAC		0.28	0.96	0.38	0.96
MCL	6				
GP		0.33	0.83	0.09	0.96
MIAC		1	0.90	0.33	1
LCL	1				
GP		0	0.98	0	0.99
MIAC		1	0.99	0.5	1

Table 5 – End outcome assessment of MRI in diagnosis of knee pathology using arthroscopy as gold standard.

	N	Sensitivity	Specificity	Positive predictive value	Negative predictive value
Medial men	26	0.96	0.71	0.77	0.94
Lateral men	19	0.53	0.93	0.83	0.76
ACL	24	0.88	0.88	0.88	0.88
PCL	1	1	0.96	0.33	1
OCD	20	0.39	0.68	0.41	0.66

sizes for PCL, MCL and LCL make data analysis difficult to interpret, but the MIAC scored higher in all functions in these groups, although both groups had a low positive predicative value for these injuries. The meniscal and ACL groups, the two most commonly occurring injuries, were relatively similarly matched in terms of diagnosis by both GP and MIAC. Recognition of osteochondral defects was unable to be ascertained as the GP did not list this as a primary diagnosis and so analysis could not be performed (Table 5).

3.8. *Assessment of MRI vs. arthroscopy*

As demonstrated above, 55 patients underwent arthroscopy during the study period. Documented below are the data analysing the performance of MRI in diagnosing knee pathology, using arthroscopy as a gold standard for those selected individuals who underwent arthroscopy.

As demonstrated, MRI had a specificity >0.65 for all pathologies, with the lowest being for osteochondral defects at 0.68 and the highest for lateral meniscal injuries at 0.93. Sensitivity figures varied to a greater extent between 0.39 for osteochondral defects to 0.96 for medial meniscal injuries. Positive predictive value also varied from 0.33 for PCL injuries to 0.88 for ACL. Negative predictive value was more consistently high, between 0.66 for OCD and 1 for PCL injuries. Figures cannot be accurately assessed for PCL injuries, as there was only one documented injury on arthroscopy.

4. Discussion

Individuals presenting with knee injury to MIAC were demographically representative of those within the general military population. 64.8% of individuals who present displayed positive findings on MRI. The highest incidence of injury occurred with meniscal injury, ACL injury and osteochondral defects, with a substantial percentage (45.6%) of individuals sustaining damage to more than one internal structure. These findings were consistent with previous research into the epidemiology of knee injury in active populations.[3,4] The majority of injuries (65.5%) were sustained through high impact sporting injuries or on military duty, with the remainder being low impact injury or unknown mechanisms. These fit with the higher incidence of knee injuries in athletes and active populations[3,4] and suggest a higher suspicion of index should be used for those undertaking such activities, although the not insubstantial proportion of low impact injuries (18%) raise the importance of clinical findings in diagnosing such injuries.

There was significant difference in end outcome between patients with and without pathology on MRI: of those without pathology, a significantly higher percentage were partially fit at the end of the study period, with significantly smaller percentage (4% vs. 33% in those with pathology) being documented as fit for active duty. There was no significant difference in those patients who underwent operative treatment and those without. These findings are in keeping with anecdotal evidence from the MIAC: those without pathology are less likely to have serious injury but may not benefit from targeted physiotherapy and operative treatment.

The MIAC was more sensitive than GP diagnosis in all but the meniscal subgroup (where the difference in sensitivity was just 0.02), suggesting it has a function in picking up knee injury in military populations. The two groups were well matched in terms of specificity, again with the exception of meniscal injuries where GP diagnosis was more specific. This may be that GPs more frequently see meniscal injuries and so are more comfortable making this as a diagnosis compared to pathologies with lower incidence such as collateral ligament damage and PCL injury. Significance could not be ascertained in this population owing to population size, which limits the statistical strength of these findings. These findings suggest that MIAC may play even more of a beneficial role in a civilian environment, where GPs may see a lower percentage of knee injuries when compared to their military counterparts. We would propose these centres to be related closely to general practice, with individuals specially trained in the diagnosis and management of musculoskeletal injuries, working in conjunction with both general practitioners and secondary care when appropriate. The drawback to this would be that the data above shows that MIAC has a specificity equal to that of GPs for most injuries, and a lower specificity for meniscal injuries. This lower specificity could lead to a higher percentage of negative MRIs being carried out.

Data analyzing the sensitivity and specificity of MRI vs. arthroscopy showed that, in general, MRI had both a strong positive and negative predictive value (>0.75) for all pathologies with the exception of osteochondral defects. Sensitivity and specificity were substantially lower (0.39 and 0.68, respectively) for these. Although it is recognised that there are limitations in using MRI as a gold standard with regards to knee injury,[6] our findings support the use of MRI as a diagnostic examination in conjunction with clinical examination.

In those individuals that then underwent arthroscopy ± surgery, the data showed that MRI still functioned well, with the exception of those patient with osteochondral defects: if symptoms are ongoing despite negative MRI findings or osteochondral defects are suspected, it may be beneficial for the patient to undergo arthroscopy to exclude osteochondral defects.

There were two main limitations to the study. The first relates to the time between the final patients attending MIAC

and data collection, with a period of 6 months being allocated. Although the vast majority of patients had run through the MIAC process by this point, 3 patients had not been formally discharged from the MIAC service. It is also possible that some patients were still undergoing self-directed physiotherapy or physiotherapy through their GP. This could be improved on by performing follow-on analyses assessing whether end outcome varied substantially 1–2 years after initial diagnosis (although the incidence of non-related injury would also increase in this time).

The second limitation relates to the size of the population. In total 2 years of data were collected, with 122 servicemen being included in the initial population size. However, due to the number of separate pathologies these individuals presented with, the number in each sub-group was not substantial enough to perform statistical analysis, and thus significance could not be calculated. As the role of MIAC service has remained largely unchanged since the initial data collection, this could be remedied by performing a further data collection in order to provide numbers sufficient for statistical analysis.

5. Conclusion

These findings suggest that the MIAC plays an important role in the diagnosis and management of knee injuries in the military. By providing a cohesive combined multidisciplinary service, the majority of patients were deemed fully or partially fit once discharged. Further research should be carried out over a longer time period to allow for more complete statistical analysis and also with a longer follow up period. This data indicates that there could be a substantial role for the MIAC in a civilian population. This data also indicates that for the majority of individuals MRI remains an effective gold standard. The exception to this in the case of osteochondral defects, which are underdiagnosed by both clinical examination and MRI. When suspected, arthroscopy with the potential for operative treatment should be carried out. We therefore recommend the introduction of a model comparable to the MIAC in civilian populations.

Conflicts of interest

All authors have none to declare.

REFERENCES

1. Nicholl JP, Coleman P, Williams BT. *Injuries in Sport and Exercise: Main Report*. London: Sports Council; 1993.
2. NHS Clinical Knowledge Summaries-Knee pain-assessment, National Institute for Health and Care Excellence. 2013. Accessed online via http://cks.nice.org.uk/knee-pain-assessment#!scenariorecommendation:1, Modified 14/1/2014 Accessed 20.01.13.
3. Majewski M, Susanne H, Klaus S. Epidemiology of athletic knee injures: a 10-year study. *Knee*. 2006;13(June (3)):184–188.
4. Kujala UM, Taimela S, Antti-poika I, Orava S, Tuominen R, Myllynen P. Acute injuries in soccer, ice hockey, volleyball, basketball, judo and karate: an analysis of national registry data. *BMJ*. 1995;311:1465–1468.
5. Stoller DW. *Magnetic Resonance Imaging in Orthopedics and Sports Medicine*. 3rd ed Philadelphia, PA: Lippincott Williams and Wilkins; 2006.
6. Crawford R, Walley G, Bridgman S, Maffuli N. Magnetic resonance imaging versus arthroscopy in the diagnosis of knee pathology, concentrating on meniscal lesions and ACL tears: a systematic review. *Br Med Bull*. 2007;84:5–23.
7. Munshi M, avidson M, MacDonald PB. The efficacy of magnetic resonance imaging in acute knee injuries. *Clin J Sport Med*. 2000;10(January (1)):34–39. Jan.
8. Patel NK, Bucknill A, Ahearne D, Denning J, Desai K, Watson M. Early magnetic resonance imaging in acute knee injury: a cost analysis. *Knee Surg Sports Traumatol Arthrosoc*. 2012;20 (June (6)):1152–1158.
9. Rodgers R, Flower J Stapleton G, Howse J. Euler3 Applet. Accessed online via http://www.eulerdiagrams.com/Euler3.html, Last modified 17/10/2014 Accessed 19.01.14.
10. Bollen SR, Scott BW. Anterior cruciate ligament rupture: a quiet epidemic? *Injury*. 1996;27:407–409.
11. Primary Care-Regional Rehabilitation Units. Accessed online via http://www.nff.org.uk/medical/primary_care/rehab_02.htm, Reviewed 16.08.13, Accessed 10.01.14.
12. Robling MR, Pill RM, Hood K, Butler CC. Time to talk? Patient experiences of waiting for clinical management of knee injuries. *Qual Saf Health Care*. 2009;18(April (2)):141–146.
13. Venu KM, Bonnici AV, Marchbank NDP, Chipperfield A, et al. Clinical examination MRI or arthroscopy: which is the gold standard in the diagnosis of significant internal derangement in the knee? *Bone Joint Surg Br*. 2003;85-B(Supp II (167)):10.
14. Hawass NED. Comparing the sensitivities and specificities of two diagnostic procedures performed on the same group of patients. *Br J Radiol*. 1997;70:360–366.
15. Ministry of Defence JSP 346. *PULHHEEMS a joint service system of medical classification*. Surgeon General's Policy Letters, 2000–2003.

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/jajs

Original Article

Double bundle medial patello-femoral ligament reconstruction for recurrent patellar dislocation – A modified technique and documentation of importance of arthroscopy

S.R. Sundararajan [a,*], K.P. Srikanth [b], S. Rajasekaran [c]

[a] Consultant Orthopaedic and Arthroscopic Surgeon, Ganga Hospital, Coimbatore, India
[b] Senior Registrar in Orthopaedics, Ganga Hospital, Coimbatore, India
[c] Chief of Orthopaedics and Spine Surgery, Ganga Hospital, Coimbatore, India

ARTICLE INFO

Article history:
Received 21 January 2015
Accepted 28 September 2015
Available online 11 November 2015

Keywords:
Patellar instability
Recurrent dislocation patella
MPFL reconstruction
Semitendinosus graft
Knee arthroscopy

ABSTRACT

Aim: Evaluation of outcome of double bundle MPFL reconstruction for recurrent patellar dislocation using semitendinosus tendon autograft passed through vertical tunnel in patella and to document the scope of arthroscopic assistance during the procedure.

Methods: The prospective case series study included 22 patients (17 females and 5 males) with recurrent lateral patellar dislocation. The average age was 29 years (15–55 years) and all underwent arthroscopy-assisted MPFL reconstruction using semitendinosus tendon autograft passed through vertical tunnel in patella.

Results: At an average follow-up of 30 months (17–43 months), none had apprehension or re-dislocation of patella postoperatively. Intraoperative arthroscopy was useful in the confirmation of patella tracking; removal of loose body (9 cases), performing chondroplasty (11 cases), simultaneous management of associated intra-articular pathology (4 cases) and careful tunnel placement for tendon graft. Radiologically, the congruence angle improved from pre-operative average of 13.41° (−9° to +53°) to 2.59° (−10° to +14°) and the lateral patellar tilt angle improved from 11.95° (2° to 21°) to 4.18° (0° to 9°) post-operatively. Functionally, the Kujala score improved from pre-operative average of 49.59 (42–76) to 92.18 (86–96), the Lysholm score from 62.13 (56–70) to 94.31 (90–100) and the Tegner activity scale from 2.31 (2–3) to 3.31 (3–4) post-operatively.

Conclusion: Double bundle MPFL reconstruction for recurrent patellar dislocation using looped semitendinosus tendon autograft passed through vertical tunnel in patella produces promising radiological and functional results. The study highlights the value of arthroscopic assistance during the procedure to improve the outcome.

* *Corresponding author at*: Consultant Orthopaedic and Arthroscopic Surgeon, Ganga Hospital, #313, Mettupalayam Road, Coimbatore 641043, Tamil Nadu, India. Tel.: +91 0422 2485000/9843256545; fax: +91 422 2451444.
E-mail address: sundarbone70@hotmail.com (S.R. Sundararajan).
http://dx.doi.org/10.1016/j.jajs.2015.09.001

1. Introduction

Patellar instability is a painful disabling condition of the knee often characterised by repeated lateral subluxation or dislocation of the patella. Although many surgeries have been described, reconstruction of the medial patello-femoral ligament (MPFL) aims at correcting the primary pathology. Literature published by various authors has supported good outcome with MPFL reconstruction.[1–3] Kang et al.[4] explained functional double bundle configuration of MPFL paving the way for double bundle reconstruction. Initially, this was performed using 'Y' configuration of the graft with two transverse tunnels made in the patella for graft fixation.[5,6] Wang et al.[7] retrospectively reported good outcome with this type of double bundle reconstruction compared with single bundle reconstruction. Unfortunately, double bundle MPFL reconstruction performed with two transverse tunnels in patella places patella at high risk for fractures post-operatively.[8] We conducted a prospective case series study to radiologically and functionally evaluate the results of double bundle MPFL reconstruction for recurrent patellar dislocation using looped semitendinosus autograft passed through a vertical tunnel in patella and to document the scope of arthroscopic assistance during the procedure.

2. Materials and methods

A prospective case series study was done including 22 patients with recurrent lateral patellar dislocation operated between May 2010 and October 2012. The patients requiring combined osteotomy procedures (having TT–TG $>$ 20 mm, severe trochlear dysplasia and patella alta with Insall-Salvati ratio $>$ 1.4) were excluded from the study.[9] Approval for the study was obtained from the Institutional Review Board.

The study included 17 females and 5 males. The average age was 29 years (range 15–55 years). The premorbid Tegner activity scale in our patients was on an average 3.45 (range 3–5), since most of our patients were females, who were restricted to light labour activities only. Aetiology of primary episode was spontaneous in 5 patients and post-traumatic in 17 cases (accidental fall during daily activities in 9 cases, twisting injury of knee in 5 cases, fall from two wheelers in 2 cases and fall of weight over the knee in 1 case). Left knee was more commonly affected (left:right = 13:9). Generalised ligamentous hyperlaxity was noticed in 8 patients (including all the 5 cases with insidious onset). Patients commonly presented with anterior knee pain aggravated by climbing stairs or uphill, repeated episodes of patellar subluxation or dislocation with swelling and locking of the knee, feeling of giving way sensation of the knee during vigorous activities. The duration of symptoms ranged from 3 months to 31 years (average 60.22 months). The number of episodes of patellar dislocations among them ranged from 2 to 20 times (average 6 episodes).

Clinically all the patients had positive apprehension sign on attempted lateral displacement of patella. Retropatellar tenderness was present in 12 patients. Range of movement in the knee was painless and normal in 18 patients, and 4 patients had restriction of terminal 10° to 20° of movements. In the 4 patients with terminal movement restriction, two patients had synovial hypertrophy, one patient had associated ACL ganglion cyst, and the other had associated medial meniscal tear. The Q angle was measured with patient supine and knee flexed to 30°, wherein patella is centralised over trochlea. It was found to be on an average of 13.68° (range 8° to 18°) in our cases.

Radiological evaluation was done with lateral view and Merchant axial view taken with knee flexed to 30°. Insall-Salvati ratio (Patella tendon length/Patella height) was measured in the lateral radiograph, which was found to be an average of 1.13 (range 0.9–1.38) in our cases. In the Merchant axial radiograph, the sulcus angle, congruence angle and the patella inclination angle (lateral patellar tilt angle) were measured as per standard guidelines[10] (Fig. 1a). The sulcus angle was on an average 141.77° (range 136° to 150°). The congruence angle was on an average 13.41° (range −9° to +53° negative and positive variable denote medial or lateral subluxation of patella, respectively). The normal congruence angle being −6°(±11°), there were 18 outliers pre-operatively.

Magnetic resonance imaging of the knee was done in all the patients that revealed thinning of MPFL in 17 patients and complete tear in 5 patients. Cartilage defect over patella was noticed in 11 cases, and loose body within the knee joint was picked up in 4 cases. Trochlea dysplasia with shallow groove (Dejour type A) was seen in 4 cases. Patello-femoral arthritis was present pre-operatively in 6 cases. The tibial tuberosity and trochlear groove (TT–TG) distance was measured in axial sections which were on an average 14.12 mm (range 10–17 mm).

All the patients underwent arthroscopy-assisted double bundle MPFL reconstruction using looped semitendinosus autograft passed through vertical tunnel in patella and fixed to femoral condyle using interference Bioscrew. Surgery was performed by single surgeon (first author) in all the cases.

3. Surgical technique

Surgical procedure was performed under regional spinal anaesthesia and tourniquet control. All the patients underwent intraoperative arthroscopy of the knee joint and looked for patella subluxation/tilt with excess medial parapatellar opening, patella maltracking, intraarticular loose bodies and chondral injuries (Fig. 2). Any associated knee pathology including patellofemoral arthritis was also documented (Table 1).

Through a 3 cm incision extending vertically below the tibial tuberosity, semitendinosus tendon graft was harvested and prepared. Another vertical incision was made midway between medial border of patella and medial epicondyle. A tunnel was made in the medial third of patella parallel to its supero-medial border using a 4 mm cannulated drill over a guide wire placed under fluoroscopy assistance. The position of the tunnel was carefully planned so as to avoid any rim fracture of patella or penetration into the knee joint, which was confirmed arthroscopically. The margins of entry and exit holes were smoothened by nibbling the margin so as to prevent any graft impingement. The tendon graft was then passed through the tunnel in patella creating a double bundle configuration (Fig. 3a). The ends of the tendon graft were then passed deep to medial retinaculum (between 2nd and 3rd

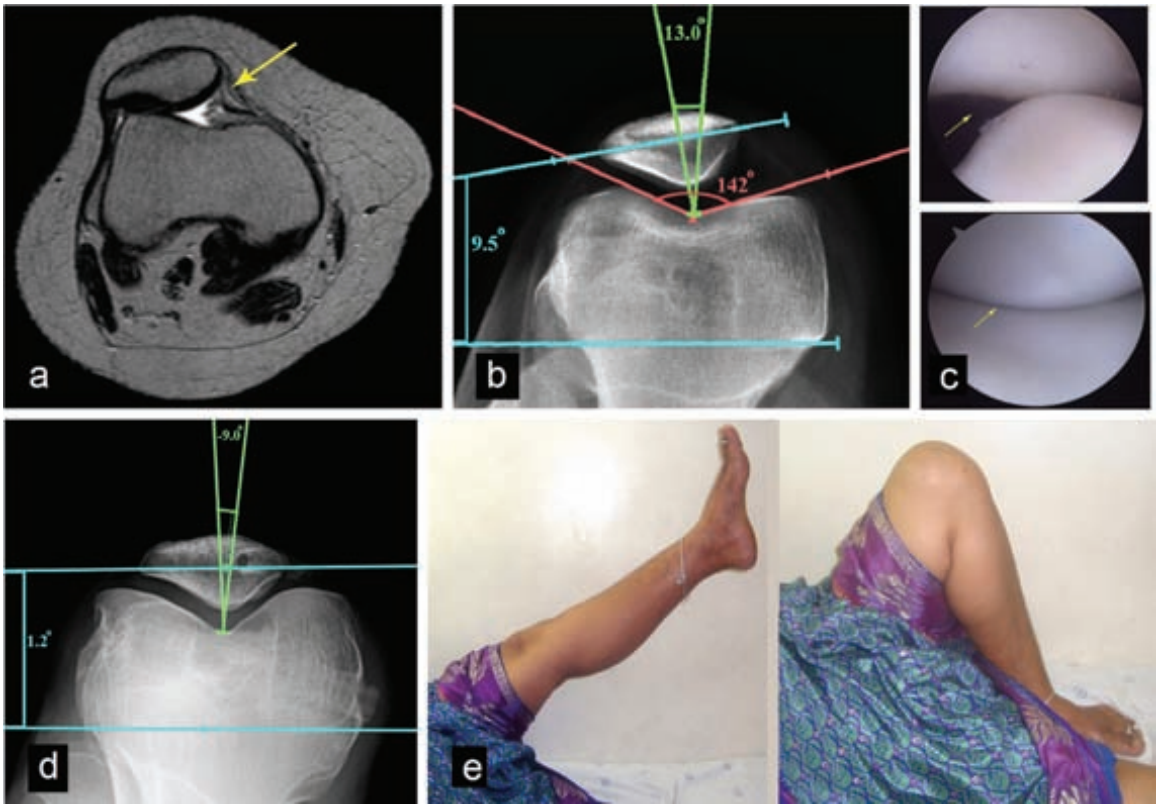


Fig. 1 – (a–e): Case example of a 38-year-old female with recurrent dislocation of patella. (a) Pre-operative MRI shows MPFL tear. (b) Pre-operative radiograph shows lateral subluxation with tilting of patella. (c) Intraoperative arthroscopy confirms abnormal patellar tracking which is restored to normal after MPFL reconstruction. (d) Post-operative radiograph shows restoration of normal patellar alignment. (e) Post-operative regain in full range of movements in the knee.

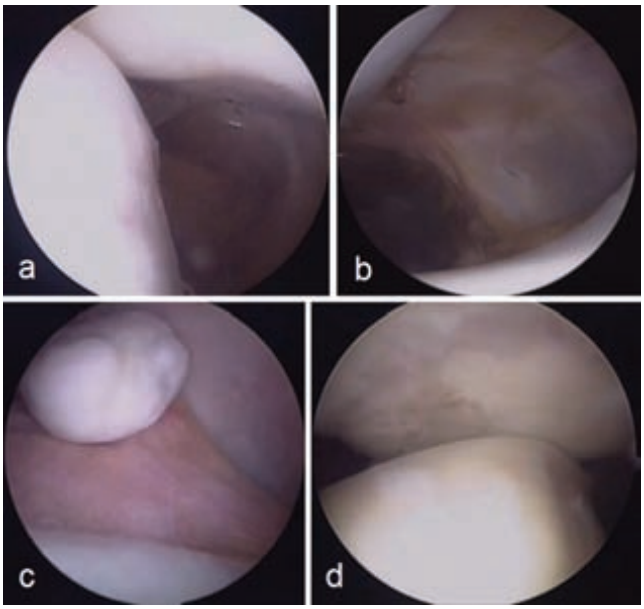


Fig. 2 – (a–d) Intraoperative abnormal arthroscopic findings. (a) Lateral subluxation of patella. (b) Patellar tilt with abnormal opening in the medial parapatellar space. (c) Loose body within the knee joint as a result of osteochondral injury. (d) Chondral damage in patella due to recurrent dislocation.

fascial layers of Warren) towards the medial epicondyle, and the ends were sutured together. A guide pin was placed horizontally parallel to the joint line at the isometric point of attachment of MPFL between medial epicondyle and adductor tubercle. Its position was confirmed by intraoperative fluoroscopy (1 mm anterior to the posterior cortex extension line, 2.5 mm distal to the posterior origin of the medial femoral condyle on a lateral radiograph with both posterior condyles projected in the same plane).[11] Arthroscopic evaluation also noted any violation of intercondylar notch by the guide pin. After confirming the position, a femoral tunnel of 7–8 mm diameter (corresponding to the size of combined and sutured tendon ends) was drilled over the guide wire, and tendon ends were passed through the tunnel mediolaterally using beath pin. The graft length and tension required were confirmed by arthroscopic visualisation of patellar position, tilt and tracking. After its confirmation, the graft was fixed at the aperture of the femoral tunnel using bio-absorbable interference screw of (2 mm larger than the tunnel size) with knee in 45° of flexion (Fig. 3b). Finally after fixation, the patella tracking was reconfirmed and documented arthroscopically (Fig. 1b).

Post-operatively, knee was splinted in knee immobiliser until wound healing. Isometric quadriceps exercises were started immediately and patient was mobilised full weight bearing on first post-operative day. Passive knee mobilisation was started after 10th day and active assisted knee mobilisation

Table 1 – Intra-articular pathological findings noted in scout arthroscopy of the knee joint.

Sl. no	Pathological findings	Number of cases (Total = 22)
1	Patella subluxation	15
2	Patella tilt with medial opening	7
3	Intra-articular loose body	9 (4 were not picked up in MRI)
4	Cartilage defects	11
5	Medial meniscal tear	1
6	Synovial hypertrophy	2
7	ACL ganglion cyst	1

was allowed after 6 weeks aiming for full range of movements within 12 weeks. Quadriceps strengthening exercises were started post-operatively after 3 months. Activities like running and squatting were permitted only after 6 months. Radiological re-assessment of congruence angle and patellar tilt was done by Merchant axial view (Fig. 1c). Functional assessment was done using Kujala score, Lysholm knee score and Tegner activity scale. Statistical analysis of results was done using Minitab-10.

4. Results

With an average follow-up of 30 months (range 17–43 months), none of our patients had apprehension or recurrence of dislocation of the patella post-operatively and all resumed their premorbid Tegner activity level.

Intraoperative findings noted in scout arthroscopy of the knee joint are summarised in Table 1. In addition, arthroscopy was also useful in removal of loose bodies within knee, evaluation for joint penetration of patellar and femoral bone tunnels, assessing the tension in graft required before fixation and confirmation of patella tracking. None of our patients required lateral retinacular release.

Post-operative radiological assessment was done after 6 months since surgery, and the functional assessment were done at their last follow-up. Radiologically, the congruence angle improved from pre-operative average of 13.41° (range −9° to +53°) to 2.59° (range −10° to +14°). There were only 6 outliers beyond the normal range post-operatively. The lateral patellar tilt angle improved from 11.95° (range 2° to 21°) to 4.18° (range 0° to 9°) (Table 2). Functionally, the Kujala score improved from pre-operative average of 49.59 (range 42–76) to 92.18 (range 86–96); the Lysholm score improved from an average of 62.13 (range 56–70) to 94.31 (range 90–100), and the Tegner activity scale improved from an average of 2.31 (range 2–3) pre-operatively to 3.31 (range 3–4) post-operatively at the final follow-up. Pre-operative and post-operative radiological alignment and functional scores were analysed statistically by paired *t*-test and were found to be significant at $p < 0.001$ (Table 2).

Active and passive movements of the knee were regained to full range in 19 (86.4%) patients within 3 months. Three patients had terminal restriction of the knee movements. One among them had associated deep vein thrombosis post-operatively and her movements improved with physiotherapy and the other two patients regained full movements after manipulation of the knee under anaesthesia and arthrolysis, respectively. Anterior knee pain was persistent in 3 cases (13.6%), for all of whom had documented patello-femoral joint arthritis pre-operatively. However, the pain was mild to moderate and tolerable without any functional limitation.

Table 2 – Radiological and functional results.

	Pre-operative mean	Post-operative mean	95% CI for mean difference	*p*-Value
Congruence angle	13.41	2.59	−6.62, −15.01	<0.001
Lateral patellar tilt angle	11.95	4.18	−6.05, −9.48	<0.001
Functional outcome				
Kujala score	49.59	92.18	46.24, 38.94	<0.001
Lysholm score	62.14	94.32	34.89, 29.47	<0.001
Tegner activity scale	2.31	3.31	1.13, 0.86	<0.001

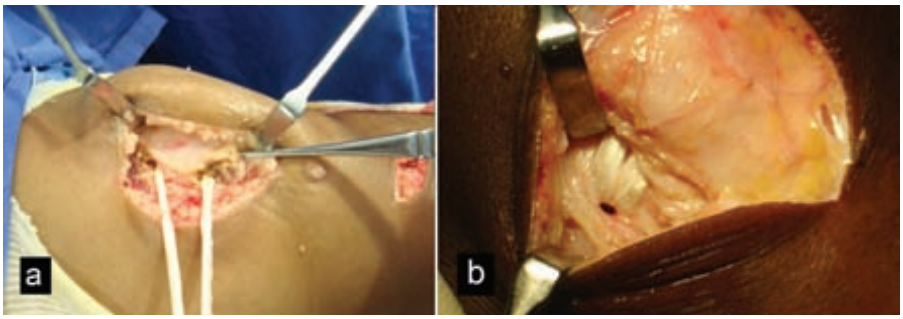


Fig. 3 – Surgical technique. (a) Semitendinosus tendon graft looped through the patellar tunnel. (b) Tendon graft passed through the femoral tunnel and fixed using bioscrew.

One patient had numbness over the medial aspect of the leg and symptoms improved gradually within 6 months. None of our patients had surgical site wound healing problem or patellar fracture post-operatively.

5. Discussion

The main factors contributing for patellar stability are articular geometry, muscular action and passive soft tissue restraints.[12] MPFL is a static stabiliser that acts as a checker in preventing lateral patellar dislocation and contributes to 40–80% of total medial restraining force.[3,13,14] Further, from full extension to approximately 20°–30° of knee flexion, patella has no bony guidance; forcing the MPFL complex to bear the load of restraint against the literalising vector of the quadriceps muscle.[15] Anatomically, MPFL is a 10–30 mm wide condensation of medial patellar retinaculum extending from proximal 2/3 of medial border of patella to adductor tubercle of femur.[16] Functionally, it has two bundles: a superior-oblique bundle, which is a dynamic restraint and an inferior straight bundle which is a static restraint.[4]

Surgical methods for recurrent patellar dislocation such as proximal realignment procedures, distal realignment procedures, lateral release and medial plication all intend to realign the extensor mechanism; however they do not tackle the primary pathology – 'medial soft tissue laxity'.[14] In majority of cases with patella instability, MPFL is disrupted and hence several authors have recommended MPFL reconstruction for high success rate (83–93%).[1,17] Non-operative treatment for first time patellar dislocation has a re-dislocation rate of 14–44%.[18] MPFL repair in recurrent dislocation has high failure rate camp with 28% recurrence of dislocation.[19]

Numerous reconstruction techniques have been described to restore medial restraint of patella; including various tendon sources (gracilis, semitendinosus, partial patellar tendon, allograft, synthetic tendon) and various fixation methods (transverse or vertical patella drill holes, single/double bundle reconstruction, anatomic/isometric point fixation, sutures, anchors, interference screws).[16]

Double bundled MPFL reconstruction is more anatomical, as it reproduces cyclical tightening and slackening pattern with movements and has functional advantage with rotational stability of patella when compared to single bundle reconstruction.[7,12] Double bundle MPFL reconstruction with single vertical tunnel does not require fixation of graft to the patella and also avoids the risk of patella fracture seen when reconstruction is performed with two transverse tunnels are placed in patella.[8]

Additional procedures such as medialisation of tibial tuberosity, distal transfer of tibial tuberosity or trochleoplasty were not performed in our cases. Mild trochlear dysplasia does not compromise the outcome of MPFL reconstruction as reported by Steiner et al.[20] and is confirmed in our study with 4 cases of Dejour Type A trochlear dysplasia.

In our study, patellar instability was seen commonly in females (77%) similar to that found in other studies. The onset was commonly post-traumatic (77%) suggesting high rate of recurrence after previous dislocation since MPFL has poor capacity to heal resulting in increased laxity and patellar instability.

Position of femoral fixation is crucial and requires radiological confirmation.[21] Another important aspect of tendon reconstruction is adequate tension of the graft – any small alteration in length and position of fixation significantly affects the outcome.[5] A lax MPFL reconstruction produces persistent instability and an over tight MPFL produces extension lag (when tight in extension) or loss of flexion (when tight in flexion).[22] In our study, we fixed the tendon graft to the femur with knee in 45° of flexion to avoid any chondral overload during knee flexion. Fernandez et al.[13] and Yoo et al.[23] have suggested fixation of the graft with knee in 30° of flexion.

Radiological improvement after double bundle MPFL reconstruction has been studied by Han et al.[12] with dual transverse tunnel in patella and reported improvement of congruence angle from 12.2° to −2.4° and lateral patellar tilt from 11.4° to 8.4°. Our series with reconstruction using vertical patellar tunnel showed better improvement of patellar tilt from 11.95° to 4.18° and also the average congruence angle in our cases improved from 13.41° to 2.59° post-operatively.

Functional improvement seen in our cases was better compared to other series of single bundle reconstruction[2,14,17] and comparable to other series of double bundle reconstruction.[8,24,25] In a similar retrospective study done by Matthews and Schranz,[16] either gracilis or semitendinosus graft was used and the post-operative Kujala score was 87 with 20% knee stiffness due to less aggressive mobilisation in initial cases with poor femoral fixation as revealed by the author. Compared to it, our study used only semitendinosus graft for better strength along with stable fixation for aggressive mobilisation yielding good results with average post-operative Kujala score of 92.18 with 13.6% knee stiffness.

Osteochondral fractures with loose body within the knee joint were present in 41% of cases; of which, only 22.7% were picked up by MRI suggesting need for routine intraoperative arthroscopic evaluation. Intraoperative arthroscopy of the knee has been performed in few studies during MPFL reconstruction.[2,8,12,17,19] We stress the importance of routine arthroscopic assistance in these cases for it helps in – diagnostic evaluation for associated injuries and patellofemoral cartilage integrity; confirmation of diagnosis as shown by medial parapatellar opening, patellar tilt, subluxation and maltracking; removal of intra-articular osteochondral loose bodies; management of any associated knee pathology (like meniscal tears, synovial hypertrophy, ACL ganglion cyst as seen in our cases). It also helps in performing chondroplasty, microfracture or lateral retinacular release in selected cases; evaluation for joint penetration caused by tunnels placed in patella and femoral condyle; confirmation of isometric fixation and to assess the adequate tensioning of the tendon graft before fixation and to finally confirm patellar tracking.

A limitation of our study is mid-term follow-up in small series of selective patients. Further randomised controlled trials are needed to establish the differences in outcome with various techniques of MPFL reconstruction.

6. Conclusion

Double bundle MPFL reconstruction for recurrent patellar dislocation using looped semitendinosus tendon autograft

passed through vertical tunnel in patella produces promising radiological and functional results. The study highlights the value of arthroscopic assistance during the procedure to improve the outcome.

Conflicts of interest

All authors have none to declare.

REFERENCES

1. Smith TO, Walker J, Russell N. Outcomes of medial patellofemoral ligament reconstruction for patellar instability: a systematic review. *Knee Surg Sports Traumatol Arthrosc*. 2007;15(11):1301–1314.
2. Howells NR, Barnett AJ, Ahearn N, Ansari A, Eldridge JD. Medial patellofemoral ligament reconstruction: a prospective outcome assessment of a large single centre series. *J Bone Joint Surg Br*. 2012;94(9):1202–1208.
3. Mikashima Y, Kimura M, Kobayashi Y, Asagumo H, Tomatsu T. Medial patellofemoral ligament reconstruction for recurrent patellar instability. *Acta Orthop Belg*. 2004;70:545–550.
4. Kang HJ, Wang F, Chen BC, Su YL, Zhang ZC, Yan CB. Functional bundles of the medial patellofemoral ligament. *Knee Surg Sports Traumatol Arthrosc*. 2010;18(11):1511–1516.
5. Carmont MR, Maffulli N. Medial patellofemoral ligament reconstruction: a new technique. *BMC Musculoskelet Disord*. 2007;8:22.
6. Kang H, Cao J, Yu D, Zheng Z, Wang F. Comparison of 2 different techniques for anatomic reconstruction of the medial patellofemoral ligament: a prospective randomized study. *Am J Sports Med*. 2013;41(5):1013–1021.
7. Wang CH, Ma LF, Zhou JW, et al. Double-bundle anatomical versus single-bundle isometric medial patellofemoral ligament reconstruction for patellar dislocation. *Int Orthop*. 2013;37(4):617–624.
8. Singhal R, Rogers S, Charalambous CP. Double-bundle medial patellofemoral ligament reconstruction with hamstring tendon autograft and mediolateral patellar tunnel fixation: a meta-analysis of outcomes and complications. *Bone Joint J*. 2013;95-B(7):900–905.
9. Arendt EA. MPFL reconstruction for PF instability. The soft (tissue) approach. *Orthop Traumatol Surg Res*. 2009;95(8 suppl 1):S97–S100.
10. Wilson T. The measurement of patellar alignment in patellofemoral pain syndrome: are we confusing assumptions with evidence? *J Orthop Sports Phys Ther*. 2007;37(6):330–341.
11. Schöttle PB, Schmeling A, Rosenstiel N, Weiler A. Radiographic landmarks for femoral tunnel placement in medial patellofemoral ligament reconstruction. *Am J Sports Med*. 2007;35(5):801–804.
12. Han H, Xia Y, Yun X, Wu M. Anatomical transverse patella double tunnel reconstruction of medial patellofemoral ligament with a hamstring tendon autograft for recurrent patellar dislocation. *Arch Orthop Trauma Surg*. 2011;131:343–351.
13. Fernandez E, Sala D, Castejon M. Reconstruction of the medial patellofemoral ligament for patellar instability using a semitendinosus autograft. *Acta Orthop Belg*. 2005;71:303–308.
14. Schottle PB, Fucentese SF, Romero J. Clinical and radiological outcome of medial patellofemoral ligament reconstruction with a semitendinosus autograft for patella instability. *Knee Surg Sports Traumatol Arthrosc*. 2005;13:516–521.
15. Philippot R, Boyer B, Testa R, Farizon F, Moyen B. The role of the medial ligamentous structures on patellar tracking during knee flexion. *Knee Surg Sports Traumatol Arthrosc*. 2012;20(2):331–336.
16. Matthews JJ, Schranz P. Reconstruction of the medial patellofemoral ligament using a longitudinal patellar tunnel technique. *Int Orthopaed*. 2010;34:1321–1325.
17. Rashid MA, Niekerk L. Management of patellofemoral instability with MPFL reconstruction. *J Bone Joint Surg Br*. 2012;94-B(supp XXI):84.
18. Bitar AC, Demange MK, D'Elia CO, Camanho GL. Traumatic patellar dislocation: nonoperative treatment compared with MPFL reconstruction using patellar tendon. *Am J Sports Med*. 2012;40:114.
19. Camp CL, Krych AJ, Dahm DL, Levy BA, Stuart MJ. Medial patellofemoral ligament repair for recurrent patellar dislocation. *Am J Sports Med*. 2010;38(11):2248–2254.
20. Steiner TM, Torga-Spak R, Teitge RA. Medial patellofemoral ligament reconstruction in patients with lateral patellar instability and trochlear dysplasia. *Am J Sports Med*. 2006;34(8):1254–1261.
21. Servien E, Fritsch B, Lustig S, et al. In vivo positioning analysis of medial patellofemoral ligament reconstruction. *Am J Sports Med*. 2011;39(1):134–139.
22. Thaunat M, Erasmus PJ. Management of overtight medial patellofemoral ligament Reconstruction. *Knee Surg Sports Traumatol Arthrosc*. 2009;17:480–483.
23. Yoo YS, Chang HG, Seo YJ, et al. Changes in the length of the medial patellofemoral ligament: an in vivo analysis using 3-dimensional computed tomography. *Am J Sports Med*. 2012;40(9):2142–2148.
24. Schöttle PB, Hensler D, Imhoff AB. Anatomical double-bundle MPFL reconstruction with an aperture fixation. *Knee Surg Sports Traumatol Arthrosc*. 2010;18(2):147–151.
25. Toritsuka Y, Amano H, Mae T, et al. Dual tunnel medial patellofemoral ligament reconstruction for patients with patellar dislocation using a semitendinosus tendon autograft. *Knee*. 2011;18(4):214–219.

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/jajs

Original Article

Efficacy of the "local anaesthetic injection technique" in anterior cruciate ligament reconstructions of professional soccer players☆

Haluk H. Oztekin [a,*], *Hakan Boya* [b], *Bulent Zeren* [c]

[a] *Beykent University, School of Health Sciences, Department of Nursery, Beylikduzu, Buyukcekmece, Istanbul, Turkey*
[b] *Baskent University, Department of Orthopaedics, Ankara, Turkey*
[c] *Private Clinic for Sports Trauma and Orthopaedics, 1738 Sokak, No: 10, Karsiyaka, Izmir, Turkey*

ARTICLE INFO

Article history:
Received 23 January 2015
Accepted 10 November 2015
Available online 5 December 2015

Keywords:
Tourniquet complications
Injection technique
Bloodless operation field
Local anaesthetic
Anterior cruciate ligament surgery

ABSTRACT

Background: There are very little data in orthopaedic literature about ACL reconstruction, without use of tourniquets. One of the alternatives to pneumatic tourniquets in ACL surgery is the "injection technique" described by Furia and Zambetti. Between 1994 and 2000, we preferred to apply this local anaesthetic technique in ACL reconstruction operations lasting more than 2 h in 576 professional athletes.

Hypothesis: This technique gives more time to the senior surgeon for training resident surgeons and almost same bloodless field as visible as tourniquet usage in ACL senior surgery.

Study design: Level of evidence: IV (case series, prospective study of previously collected data).

Methods: In 576 cases, injections of "Solution 1" (lidocaine and epinephrine, for skin and subcutaneous injection) and "Solution 2" (bupivicaine and epinephrine, for intra-articular injection) were administered without inflating the preapplied pneumatic tourniquet. After performing a diagnostic arthroscopy or a surgical arthroscopic procedure, we reconstructed the ACL with a BTB autograft through a mini anterior arthrotomy incision. All major or minor complications due to the injections were carefully recorded.

Results: The mean operation time was 165 min in patients without co-existing cartilage or meniscal pathology and 205 min in patients with co-existing pathologies. No cardiovascular complications were recorded. The bloodless field was obscured in only seven patients (1.2%). Partial wound edge cyanosis was noted in 18 patients (3%) near the graft harvesting incisions, making the overall complication rate of this "injection technique" 4.3%.

Conclusion: This technique gave superior visibility as tourniquet usage in 98.8% cases and also gave more time to the surgeon for resident education. So the surgeon did not have to worry about tourniquet times.

☆ This work has been presented in a different title in 11th ESSKA Meeting, May 5–8, 2004, Athens, Greece.

* *Corresponding author at*: 1359 Sokak No: 2/54, 35520 Alsancak, Izmir Turkey. Tel.: +90 232 463 33 15; fax: +90 232 464 73 77; mobile: +90 532 312 24 04.

E-mail addresses: hhoztekin@isbank.net.tr, halukh1@yahoo.com (H.H. Oztekin).

http://dx.doi.org/10.1016/j.jajs.2015.11.006

1. Introduction

Tourniquet usage to obtain a bloodless operating field in the lower extremities may result in serious complications.[1–8] Ultrastructural changes are seen in myofibrils after 2 h[5] (Table 1), and are associated with postoperative swelling (with or without compression neurapraxia), quadriceps weakness, electromyographical findings[4] and tourniquet paralysis.[1] Potential complications of tourniquet use also include wound haematoma with the potential for infection, tissue necrosis, vascular damage[2] and compartment syndrome, all of which increase the risk for local and systemic infections. Because of these potential and real complications after prolonged tourniquet use, surgical techniques without using tourniquet are of interest to knee surgeons.

Besides the widely used approach of using epinephrine to achieve a bloodless field in anterior cruciate ligament (ACL) reconstructions, very few published data were found in the literature. The most detailed study is the ''local anaesthetic injection technique'', introduced by Furia and Zambetti[10] in 1992.

Hoping that their method would eliminate the complications associated with tourniquets during prolonged reconstructive surgery of the ACL, we began using this technique routinely in 1994, but with slightly more dilute anaesthetic solutions.

One of the most important advantages of this technique is that the senior surgeon has no need to constantly worry about possible complications from prolonged tourniquet times.

2. Patients and methods

2.1. *Patient demographics*

Professional soccer players ($n = 576$; 93% male) presenting to our orthopaedic clinic between 1994 and 2000 with indications for ACL reconstruction participated in the study. The right to left knee ratio was 2:1. The ''injection technique'' of Furia and Zambetti[10] (with the modification mentioned below) was used in a routine fashion in all eligible patients.

2.2. *Injection technique*

Following spinal and epidural anaesthesia, 30–35 mL of a mixture of 30 mL bupivacaine, 6 cc of diluted adrenalin solution (9 cc saline solution + 0.5 mg/mL adrenalin), 7.5 mL lidocaine and 22.5 cc saline solution, so-called ''Solution 2'' was injected into the joint (maximum dose 65 cc) approximately 15–20 min prior to the arthroscopic incision. Then, 10–15 mL of a mixture of 10 cc 2% lidocaine, 4 cc of diluted adrenalin solution (9 cc saline solution + 0.50 mg/mL adrenalin), 12.5 cc saline solution, so-called ''Solution 1'' was injected into the skin and subcutaneous tissues (maximum dose 25 cc) in the areas of the arthroscopic and graft harvesting incisions. The joint was irrigated 15–20 min after the injections were completed. The solutions were prepared according to the technique recommended by Furia and Zambetti, but we made the anaesthetic solutions slightly more dilute by 10%.

Table 1 – Major tourniquet complications.

1. Muscular and vascular (Gardner[2])
2. Tourniquet paralysis (Dobner[1])
3. Weakness in quadriceps muscle and anomaly in EMG findings (Kienerman[4])
4. Ultrastructural changes occurring in the myofibrils, especially after 2 h (Patterson[5])
5. Deep venous thrombosis (Dong et al.[10])

The solutions were administered according to the weight of each patient, so that the toxic dosage was not excessive, as Furia described.[9] The total dosage of ''Solution 1'' did not exceed 25 cc, whereas the amount injected into the joint did not exceed 65 cc. Initially, half of those amounts were used as the starting dosage. If intra-articular haemorrhage were to occur during the operation, an additional bolus (approximately 20 cc) of ''Solution 2'' was injected into the joint, in an attempt to create a bloodless field again. The anaesthesia team was careful to watch for cardiac and allergic complications before, during and after the injections. Although never inflated, a tourniquet was applied in all patients.

2.3. *Surgical procedure*

All of the ACL reconstructions were performed by the same surgeon under combination pinal/epidural anaesthesia. Prior to the operation, on the same day as the surgery, patients received 1 g of sodium cephazoline intravenously. No arthroscopic pump was used during the operations. The intra-articular pressure of the irrigation fluid was maintained at 300 mmHg by a blood pressure cuff manometer. The Bone-Tendon-Bone (BTB) graft technique was used in all patients, through a mini-open arthrotomy via the fat pad. Following diagnostic arthroscopy, meniscal or the cartilage surgery, ACL reconstructions were done with a BTB autograft in a routine fashion. Both intra- and extra-articular exposure visibilities were carefully monitored. Patients were discharged from the hospital within 48 h after the vacuum drains and catheters were removed. Post-operative analgesia for the duration of the hospitalization was achieved via epidural medications. On the third day after the operation, 3 g/day of oral paracetamol was prescribed to each patient for pain relief.

3. Results

The ''injection technique'' of Furia and Zambetti (with more dilute anaesthetic solutions) was routinely used on 576 patients (mean age: 27 years, range 17–42 years) undergoing ACL surgery between 1994 and 2000. Among these patients, 152 had only an ACL repair procedure performed. Rest of the patients required additional surgeries, including 203 for lateral meniscal pathology, 134 had medial meniscal pathology and 87 knees had meniscal and/or cartilage pathology necessitating partial meniscectomy and/or micro-fracture.

The mean operation time was 165 min in those without co-existing cartilage or meniscal pathology and 205 min in those with co-existing pathologies. No cardiovascular changes or allergic reaction was observed during or after the operation, and all procedures were completed without inflating the

tourniquet. We encountered no ''red-out''s during arthroscopies lasting up to 2 h. During graft harvesting, seven patients (1.2%) had excessive bleeding. In those cases, bleeding from the tibial graft harvesting site obscured the operation site. In these patients, a bolus local dose injection of ''Solution 2'' (approximately 20 cc) easily resulted in a bloodless field again. We observed partial wound edge cyanosis in only 18 patients (3%), resulting in an overall complication rate of 4.3%. The mean amount of drainage collected in the vacuum drain was 35 mL (range 25–100 mL).

4. Discussion

The complications of pneumatic tourniquets used in ACL reconstruction operations which last more than 120 min have been detailed in the literature.[1–9] Furia and Zambetti[10] found no significant difference in postoperative complications, length of hospital stay, operative time and quality of visual fields when comparing tourniquet use with epinephrine injections into the knee joint. They also found that the epinephrine injection group required less postoperative pain medication. In our case series, we have observed that the surgeon and his team could fully concentrate on the operation without any concern or anxiety due to the notorious tourniquet time limit. Furia[10] questioned the feasibility of ACL reconstruction while educating orthopaedic residents within the 2-hour tourniquet time constraint. However, with our technique, we were able to adequately train residents while performing the procedures in a more relaxed time frame. For this reason, our mean operation time was quite long. We did not encounter excessive bleeding that Furia[10] described in his group of seven patients on which he used the injection technique, to which he had to then apply a tourniquet in addition to control the haemorrhage. In the seven patients with excessive bleeding that obscured the surgical field in our study, reinjecting ''Solution 1'' into the bleeding area resulted in a bloodless field again. Thus, our re-bleeding rate was lower than Furia reported (1.2% vs.14%) despite using almost the same solutions. Their original ''injection technique'' consisted of subcutaneous injections of 20 mL of 1% lidocaine with 1:100,000 epinephrine into the operative sites (Solution 1), while a 60 mL 1:1 mixture of 0.5% bupivacaine and 0.5% lidocaine with 1:200,000 epinephrine (Solution 2) was used for the intra-articular injection. Our moderately diluted solutions may not be more effective than Furia's – our low rebleeding rate may also be a consequence of the hypotensive effect of combined spinal-epidural anaesthesia.

The other reason for the low rebleeding rate may have been our use of multiple injections of the anaesthetic solutions, without exceeding the upper limits of recommended doses. In order to maintain the desired pressure in the joint, simply squeezing the irrigation fluid bags with a blood pressure cuff at 300 mmHg was satisfactory. This pressure also counters any tendency for bleeding in the knee joint; in fact, with this pressure, the injection technique may not even be necessary in a very short arthroscopic procedure. No vasospasm or major complications were observed in our cases. Only 18 patients experienced minor wound problems due to the partial vasospasm and excessive skin traction nearby the wound edges, all of which resolved spontaneously within one week. Furia and Zambetti did not mention such complications in their patients.[10]

Adequate haemostasis is likely achieved by hypotensive epidural anaesthesia rather than the solutions' effect. But it is also true that pressure from the arthroscopic irrigation fluid resulting in joint distension can prevent bleeding. Thus, it is possible to use neither tourniquet nor epinephrine during ACL reconstruction without significant problems with bleeding and intra-operative visualization. However, the superior visibility we obtained during both the extra-articular and intra-articular steps of the procedure caused us to make this method routine in our practice.

In an ACL reconstruction, using either an arthroscopic or mini open technique following a meniscal or cartilage surgery, the mean operation time usually lasts more than 2–3 h, rendering the use of a tourniquet unwise due to potential quadriceps ultrastructural changes and loss of gross motor function. Also, more than 2 h of tourniquet use is associated with higher incidence of DVT.[9] We agree with Furia and Zambetti, that an injection technique instead of tourniquets may be used reliably in ACL reconstructions. This gives the surgeon more time for patient education, as he/she does not have to worry about tourniquet times.

Conflicts of interest

All authors have none to declare.

REFERENCES

1. Dobner JJ, Nitz AJ. Postmenisectomy tourniquet palsy and functional sequel. *Am J Sports Med*. 1982;10:211–214.
2. Gardner VO, Caiozzo VJ, Long ST, Stoffel J, McMaster WC, Prietto CA. Contractile properties of slow and fast muscle following tourniquet ischemia. *Am J Sports Med*. 1984;12:417–423.
3. Gersoff WK, Ruwe P, Joki P, Panjabi M. The effect of tourniquet pressure on muscle function. *Am J Sports Med*. 1989;17:123–127.
4. Kienerman L. The tourniquet in surgery. *J Bone Joint Surg B*. 1962;44:937–943.
5. Patterson S, Kienerman L. The effect of pneumatic tourniquets on the ultrastructure of skeletal muscle. *J Bone Joint Surg B*. 1979;61:178–183.
6. Rorabeck CH, Kennedy JC. Tourniquet-induced nerve ischemia complicating knee ligament surgery. *Am J Sports Med*. 1980;8:98–102.
7. Rudge P. Tourniquet paralysis with prolonged conduction block: an electrophysiological study. *J Bone Joint Surg B*. 1974;56:716–720.
8. Shaw WEF. Observations on the effects of tourniquet ischemia. *J Bone Joint Surg Am*. 1971;53:1343–1346.
9. Dong JT, Wang X, Men XQ, Wang XF, Zheng XZ, Gao SJ. Incidence of deep venous thrombosis in Chinese patients undergoing arthroscopic knee surgery for cruciate ligament reconstruction. *Knee Surg Sports Traumatol Artrosc*. 2014 [Epub ahead of print].
10. Furia JP, Zambetti Jr GJ. An injection technique to create a bloodless field in arthroscopically-assisted anterior cruciate ligament reconstruction. *Am J Sports Med*. 1992;20:406–409.

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/jajs

Original Article

Clinical and radiological outcomes of arthroscopic subacromial decompression for stage-II impingement of shoulder

Rahul Khare *, *Vishal Srivastava*, *Hitesh Lal*

Department of Orthopaedics, Dr. Ram Manohar Lohia Hospital, New Delhi 110001, India

ARTICLE INFO

Article history:
Received 27 August 2015
Accepted 4 November 2015

Keywords:
Shoulder
Impingemnt
Arthroscopic
Subacromial
Decompression

ABSTRACT

Background: Shoulder impingement is described as a mechanical impingement of the rotator cuff tendon beneath the antero inferior portion of the acromion, especially when the shoulder is placed in the forward-flexed and internally rotated position. It is a common cause of recurrent shoulder pain and disability.

Aim: The aim of the present study was to study the clinical and radiological outcomes of arthroscopic sub acromial decompression for stage II impingement of the shoulder.

Methods: All adults with type 2 impingement of the shoulder having positive impingement signs and unimproved pain after a course of conservative treatment of at least 3 months were included in the study. Glenohumeral arthroscopy was performed under general anaesthesia in lateral position followed by subacromial decompression. Postoperatively a sling was given initially for support but to prevent adhesions, passive mobilization of the shoulder was initiated as early as possible. Active exercises were started at 2 weeks' time and cuff strengthening exercises at 6 weeks' time.

Patients were followed up at 3 weeks, 6 weeks, 9 weeks, 3 months and 6 months. Post-operative assessment was performed using the UCLA shoulder rating scale and radiological assessment of acromiohumeral distance was made.

Results and conclusion: Those patients who had failed conservative treatment were benefited by the procedure. The pain decreased, functional capacity of the shoulder increased, range of motion increased, strength of forward flexion increased and almost 90% patient reported that their symptoms had improved and were feeling better and satisfied. The cost of the treatment was low because no implants were used. Duration of procedure was short. Post-operative return to activities was quick. Number of days absent from work was less as patients returned to normal activities soon and were discharged either next day or a day after surgery. Pre, intra and post-operative complications were nil in our study and are also otherwise rare.

* Corresponding author.
E-mail addresses: drrahulkhare@gmail.com (R. Khare), think.vishal@yahoo.com (V. Srivastava), drhiteshlall@gmail.com (H. Lal).
http://dx.doi.org/10.1016/j.jajs.2015.11.004

1. Introduction

Shoulder impingement is described as a mechanical impingement of the rotator cuff tendon beneath the antero inferior portion of the acromion, especially when the shoulder is placed in the forward-flexed and internally rotated position.

It is a common cause of recurrent shoulder pain and disability.

Although rotator cuff tears are more common in the older population, impingement and rotator cuff disease are frequently seen in the repetitive overhead athlete. The increased forces and repetitive overhead motions can cause attritional changes in the distal part of the rotator cuff tendon, which is at risk due to poor blood supply.

Curved or hooked shape of the acromion, osteophytes under the acromioclavicular joint, subacromial bursitis, thickened coracoacromial ligament, degenerative or a traumatic cuff failure and calcific rotator cuff tendinitis are some of the reasons for impingement of the shoulder.

Neer[1] has described the following 3 stages in the spectrum of rotator cuff impingement:

- Stage 1, commonly affecting patients younger than 25 years, is depicted by acute inflammation, edema, and hemorrhage in the rotator cuff. This stage usually is reversible with nonoperative treatment.
- Stage 2 usually affects patients aged 25–40 years, resulting as a continuum of stage 1. The rotator cuff tendon progresses to fibrosis and tendonitis, which commonly does not respond to conservative treatment and requires operative intervention in the form of open/arthroscopic sub acromial decompression.
- Stage 3 commonly affects patients older than 40 years. As this condition progresses, it may lead to mechanical disruption of the rotator cuff tendon and to changes in the coracoacromial arch with osteophytosis along the anterior acromion. Surgical anterior acromioplasty and rotator cuff repair is commonly required.

The aim of the present study was to study the clinical and radiological outcomes of arthroscopic sub acromial decompression for stage II impingement of the shoulder.

2. Material and methods

This prospective study was conducted between November 2011 and February 2013 in the Department of Orthopaedics, PGIMER, Dr. Ram Manohar Lohia Hospital. A total of 20 patients were enrolled in the study.

All consenting adults with type 2 impingement of the shoulder having positive impingement signs and unimproved pain after a course of conservative treatment of at least 3 months were included in the study.

Patients with completely torn rotator cuff diagnosed by ultrasound and patients with glenohumeral instabilities as detected by clinical examination were excluded from the study.

2.1. *Surgical technique*

Under general anaesthesia, the patient was placed in a lateral decubitus position with the back even with the edge of the table and the affected side up. The patient's torso was rolled back by about 30°. The affected shoulder was abducted 45° and 15° anteverted. A skin traction of between 4 and 6 kg was applied to the affected limb (Fig. 1).

After painting and draping a posterior portal was made in the soft spot between infraspinatus and teres minor muscles, 1–2 cm inferior and 1 cm medial to the posterolateral corner of acromion. Posterior portal was used to inspect the glenohumeral joint before subacromial decompression. Findings of the glenohumeral joint were recorded especially synovitis, rotator cuff tears and signs of instability (Fig. 2).

To enter the sub acromial space it was necessary to decrease the abduction of the shoulder to about 15°. Through the same skin incision, the arthroscope was withdrawn from the glenohumeral joint and blunt obturator was inserted into the sheath. The sheath with obturator was taken out from the glenohumeral joint, angled superiorly and advanced towards the acromion to enter the sub acromial space. The sheath with blunt obturator was swept from medial to lateral to lyse adhesions and create room in the subacromial space. A soft-tissue resector blade or a radio frequency probe was used to remove adhesions and to expose the anatomical landmarks of the undersurface of the acromion.

A needle was inserted to mark the position of the acromion and its junction with the coracoacromial ligament (Fig. 3). The coracoacromial ligament was then carefully divided in layers with a radiofrequency probe. Before the acromioplasty was performed portions of coracoacromial ligament that attach to the acromial undersurface were released. The under surface of the acromion was examined for bone spurs. The under surface of the acromion was resected with a motorized bur. About 6–9 mm of resection was considered sufficient. The under surface was smoothened with a rasp. The residual stump of coracoacromial ligament was then resected with a basket forceps.

Postoperatively a sling was given initially for support but to prevent adhesions, passive mobilization of the shoulder was initiated as early as possible. Active exercises were started at 2 weeks' time and cuff strengthening exercises at 6 weeks' time.

Fig. 1 – Positioning of the patient.

Fig. 2 – Marking of landmarks and checking the stability.

Patients were followed up at 3 weeks, 6 weeks, 9 weeks, 3 months and 6 months. Post-operative assessment was performed using the UCLA shoulder rating scale and radiological assessment of acromio humeral distance was made.

3. Ethics

The procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional) and with the Helsinki Declaration of 1975, as revised in 2000 when reporting on human studies. Institutional Ethics Committee permission was taken before undertaking the study.

4. Results

In case of Type II impingement of shoulder of the 20 patients with Type II impingement of shoulder 13 were males and 7 were females and age of the patients ranged from 18 to 68 years with mean age of 39 years.

Of total of 20, 11 had their right shoulder affected and 9 had their left shoulder affected.

Fig. 3 – Entering the sub acromial space.

Most of the patients in the study had duration of symptoms less than 6 months. Average duration of symptoms was 12.95 months.

UCLA pain score showed total increase from pre op period was 3.25 with the highest value being 10. The score increased by about 0.80 in 3 weeks to reach 4.65. Maximum increase was seen in 6 weeks to 9 weeks period i.e., of 0.90. The post 6 months mean pain score was 7.10.

The UCLA function score mean pre op score was 4.65. The mean score at 6 months was 8.20. Total increase in score from pre op period was 3.55.

The active forward flexion mean pre op score was 2.45 and the mean score at 6 months was 4.25. Total increase in score from pre op period was 1.80.

The strength of forward flexion by manual muscle testing showed total increase in score from pre op period was 0.60.

All the patients except 2 experienced satisfaction and betterment on one or more fronts right from 3rd week which continued up to the end of 6 months.

UCLA score observation showed a total increase in score of 13.65 from pre op.

Out of 20 patients in the study only 4 patients had type I acromion, while patients with type II and III were 8 each. Type II and Type III acromion were associated with more symptoms and low UCLA score. Post operatively all type III were converted into either type I or II and all type II into type I. Post operatively none of the patients had Type III acromion.

The mean pre op acromiohumeral distance was 8 mm while the mean post op acromiohumeral distance was 10.62. The mean resection was 2.62 mm.

Out of 20 patients 30% of our patients had partial cuff tear and 70% had no tear. It was observed that presence of partial cuff tear had no bearing on the post-operative UCLA score.

The mean degree of abduction in pre-operative status was 86.75° (Table 3). After 6 months of arthroscopic subacromial decompression the mean degree of abduction increased to 139.75° (Fig. 4).

5. Discussion

In this study we included 20 patients with Stage II impingement of shoulder and performed arthroscopic subacromial decompression and all the patients were assessed on various parameters.

In our study the age of the patients ranged from 18 to 68 years with mean age of 39 years. Most of the patients (i.e., 12) were in the age group of 26–50 years. The mean age was about 50 years in a study conducted by Tangtrakulwanich and Kapkird.[2] In a study conducted by Ahmed et al.[3] a total of 80 patients who underwent ASD for impingement syndrome between 2003 and 2006 were analysed. Mean age was 57.1 years.

Of the 20 patients with Type II impingement of shoulder, 11 had their right shoulder affected and 9 had their left shoulder affected, with the right to left ratio at around 1.22:1. The dominant shoulder was involved in 39 out of 65 patients (60%) in a study conducted by Ellman and Kay[4] which is almost

Fig. 4 – Pre operative flexion, pre operative abduction, post operative flexion, post operative abduction.

similar to our study where 55% of affected shoulders were dominant.

Most of the patients in the study had duration of symptoms less than 6 months. Average duration of symptoms was 12.95 months. Duration of symptoms ranged from 4 months to 60 months. The mean duration of symptoms was 32 months (3–225) in a study conducted by Massoud et al.[5]

Of the 20 patients with Type II impingement of shoulder, 11 had their right shoulder affected and 9 had their left shoulder affected, with the right to left ratio at around 1.22:1. The dominant shoulder was involved in 39 out of 65 patients (60%) in a study conducted by Ellman and Kay[4] which is almost similar to our study where 55% of affected shoulders were dominant.

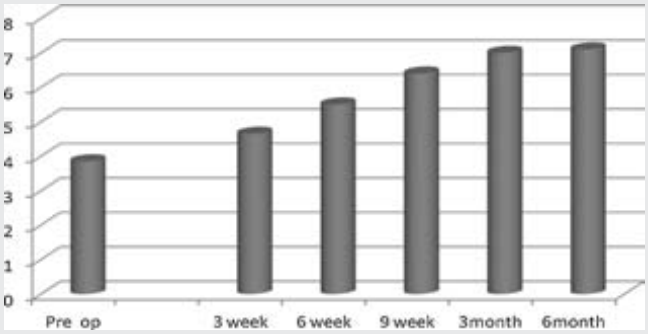
There was a statistically significant ($p = 0.02$) increase in pain score from pre-operative status 3.85 to 6 months post-operative time (Table 1). The mean follow up pain score for the UCLA scale was 8.0 in a study conducted by Lim et al.[6]

Total increase in score from pre op period was 3.55. There was a statistically significant ($p = 0.0006$) increase in function score from pre-operative status to 6 months post-operative time. The mean follow up pain score for the UCLA scale was 8.0 in a study conducted by Lim et al.[6] The average 'function' score in the study conducted by Ellman and Kay[4] on the UCLA scale pre-operatively was 5.1 (Table 2).

85% of our patients had poor UCLA score with only 15% having fair score at the beginning of the study. At 9 weeks 10% patient scored excellent with the percentage of patients with poor score decreasing from 85% to 5%. The maximum number

Table 1 – Pain score observation.

Duration	Pre op	3 week	6 week	9 week	3 month	6 month
Mean score	3.85	4.65	5.50	6.40	7.00	7.10



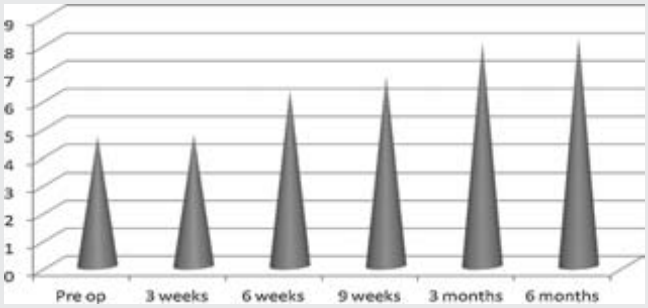
UCLA PAIN SCORE:
Present always & unbearable; strong medication frequently 1.
Present always but bearable; strong medications occasionally 2.
None or little at rest, present during light activities; salicylates frequently 4.
Present during heavy or particular activities only; salicylates occasionally 6.
Occasional and slight 8.
None 10.

of patients scored fair at 3, 6 and 9 weeks on UCLA score. At the end of the 6 months period 20% patients scored excellent, 35% scored good, 40% had fair score and 5% remained at poor score. In a study conducted by Ellman[7] 94% had excellent or good results by the UCLA Shoulder Scale, while in a study conducted by Ellman and Kay[4] out of 65 patients 32 had excellent result, 4 patients had fair results and 3 poor (Table 4).

None of 20 patients enrolled in our study had any complications in pre-operative period like drug allergy or hypersensitivity. Intra operative anaesthesia or surgery related complications were also not seen. Post-operative period of all patients was uneventful. In a study conducted by Ellman and Kay[8] it was found that there have been very few complications associated with the procedure. Early in the series, three patients had complained of transient dysaesthesia in the distribution of the superficial branch of the radial nerve on the dorsum of the thumb. One patient experienced leaking from both the anterolateral and posterior portals but this ceased in one week with local

Table 2 – Function score observation.

Duration	Pre op	3 weeks	6 weeks	9 weeks	3 months	6 months
Mean score	4.65	4.70	6.30	6.80	8.00	8.20



UCLA FUNCTION SCORE:
Unable to use limb 1.
Only light activities possible 2.
Able to do light housework or most activities of daily living 4.
Most housework, shopping, driving able to do hair and to dress and undress 6.
Slight restriction only; able to work above shoulder level 8.
Normal activities 10.

Table 3 – Results by the UCLA Shoulder Scale.

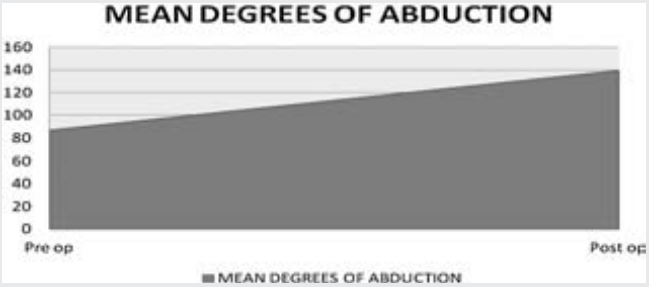
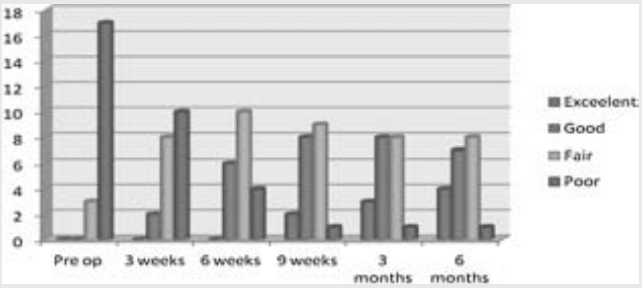


Table 4



wound care and antibiotic ointment. Another patient developed a local haematoma at the site of the anterior portal which resolved spontaneously.

6. Conclusions

Patients who had failed conservative treatment were benefited by the procedure. The pain decreased, functional capacity of the shoulder increased, range of motion increased, strength of forward flexion increased and almost 90% patient reported that their symptoms had improved and were feeling better and satisfied. Post-operative return to activities was quick. Number of days absent from work was less as patients returned to normal activities soon and were discharged either next day or a day after surgery. Pre, intra and post-operative complications were nil in our study and are also otherwise rare.

Conflicts of interest

All authors have none to declare.

REFERENCES

1. Neer CS. Anterior acromioplasty for the chronic impingement syndrome in the shoulder. *J Bone Joint Surg Am*. 1977;54:41–50.
2. Tangtrakulwanich os, Kapkird uh. Analyses of possible risk factors for subacromial impingement syndrome. *World J Orthop*. 2012;3(January (1)):5–9.
3. Eid Ahmed Smd, Dwyer Amitabh Jia, Chambler Andrew Fde. Mid-term results of arthroscopic subacromial decompression in patients with or without partial thickness rotator cuff tears. *Int J Shoulder Surg*. 2012;6(3):86–89.
4. Ellman ra, Kay Stephen Peh. Arthroscopic subacromial decompression for chronic impingement two- to five-year results. *J Bone Joint Surg Br*. 1991;73-B:395–398.
5. Massoud SN, Levy O, Copeland SA. Subacromial decompression treatment for small- and medium-sized tears of the rotator cuff. *J Bone Joint Surg Br*. 2002;84-B:955–960.
6. Lim KK, Chang HC, Tan JL, Chan BK. Arthrscopic subacromial decompression for stage-II impingement. *J Orthopaedic Surg*. (2):2007;(2):197–200.
7. Ellman H. Arthroscopic subacromial decompression: analysis of one- to three-year results. *Arthroscopy*. 1987;3(3):173–181.
8. Ellman ra, Kay Stephen Peh. Arthroscopic subacromial decompression for chronic impingement two- to five-year results. *J Bone Joint Surg Br*. 1991;73-B:395–398.

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/jajs

Original Article

Radiographic analysis of the axial alignment of the lower extremity in Indian adult males

Lalit Maini [a], *Shailendra Singh* [b,*], *Narendra Singh Kushwaha* [c], *Abhishek Saini* [d], *Surabhi Rohilla* [e], *Hemant Sharma* [f], *Vineet Sharma* [g]

[a] *Professor, Maulana Azad Medical College & Lok Nayak Hospital, New Delhi 111002, India*
[b] *Assistant Professor Orthopaedics, King George Medical University, Lucknow, India*
[c] *Assistant Professor, King George Medical University, Lucknow, India*
[d] *Senior Resident, King George Medical University, Lucknow, India*
[e] *Project Fellow, UGC, Maulana Azad Medical College & Lok Nayak Hospital, New Delhi 111002, India*
[f] *Specialist Orthopaedic Surgeon, Aruna Asaf Ali Hospital, Civil Lines, New Delhi 11002, India*
[g] *Professor, King George Medical University, Lucknow, India*

ARTICLE INFO

Article history:
Received 7 November 2015
Accepted 12 November 2015
Available online 8 December 2015

Keywords:
Axial alignment
Anatomical axis
Mechanical axis
Valgus angle
Medial inclination of tibial plateau

ABSTRACT

Background: To evaluate data on the normal axial alignment of the lower extremity in Indian adults and its relevance in knee arthroplasty.
Methods: The axial alignment of the lower extremity in one hundred young male adults was measured on the weight bearing scanogram of the entire lower limb under standardized conditions. The angles measured were – neck shaft angle, lateral distal femoral angle, medial proximal tibial angle, tibiofemoral angle and valgus angle.
Results: Medial inclination of the tibial plateau in our subjects was 4°; this was greater than reported for American subjects but less than that for Chinese. It was significantly noted that valgus angle was 6.2° at an average with the range of 5–7°.
Conclusions: Axial alignment of lower extremity differs in various ethnic groups. Indian male subjects have more varus alignment of knee and significant higher medial inclination of tibia plateau than white male subjects (p value < 0.05). Four degrees of external rotation of the femoral component instead of commonly used 3° is necessary, while performing total knee arthroplasty in Indian male subjects.

1. Introduction

Does axial alignment of lower extremity differ in various ethnic groups? Recently published study of axial alignment of lower limb in Chinese subjects proposed so and advised more external rotation of femoral component than conventionally advised.[1] The incidence of osteoarthritis in various populations differs. The osteoarthritis of knee is more common in Asians compared with Americans.[1–3] The racial difference in

* *Corresponding author*. Tel.: +91 9532081107.
E-mail address: shailendra81mamc@gmail.com (S. Singh).
http://dx.doi.org/10.1016/j.jajs.2015.11.010

axial alignment in lower extremity may be a reason for that, apart from difference in various living habits. The normal axial alignment of lower extremity has been described in various studies.[1,4,5] There have been no similar studies in Indian subjects. We performed a radiographic measurement of the lower limb alignment in Indian subjects and compared them with published data.

2. Materials and methods

Medical records of one hundred apparently normal males screened for recruitment to the city police force in the age group of nineteen to twenty five years with a mean age of twenty-one years were studied. Any lower limb deformity being a criterion for disqualification, a scanogram was a part of the screening. A scanogram was done with barefoot subject standing with patellae facing forwards under standardized conditions. Both lower extremities were included in one scanogram.

The axial alignment was measured as described by Hsu, Moreland and Tang[1,4,5] with some modifications. The centres of femoral head, the knee and ankle were identified as described by Moreland and Tang. The mechanical axes of femur and tibia were the line joining the centre of femoral head to centre of knee and centre of knee to the centre of ankle respectively. The femoral shaft anatomical axis was drawn from a point about 10 cm above the knee joint axis in the middle of the femoral canal to the another point in the middle of the medullary canal in the midpart of the femoral shaft similar to femoral anatomical axis II described by Moreland and Tang.[1,5] One line tangent to most distal points of femoral condyles was drawn. Another line tangent to proximal tibial condyles was drawn. These two lines according to us are more accurate while calculating the tibial and femoral inclination rather than one joint line passing through the distal femoral condyles, taken as transverse axis of the knee joint. The angles created by intersection of these lines, namely neck shaft angle (A), lateral distal femoral angle (B), medial proximal tibial angle (C) tibiofemoral angle (D) and valgus angles (E) were measured by finely calibrated protractor [Fig. 1]. All radiographs were measured twice, so as to remove the intra observer difference. The results were statistically analyzed and results compared with published series. Our subject population was of average age 21 years. This excludes the effect of various degenerative changes on the lower extremity, and bone growth is also complete. This according to us is representative of the most normal population subgroup with regards to axial alignment of the lower extremity [Fig. 2].

3. Results

Angle A represented the neck shaft angle. In our study neck shaft angle was a mean (and standard deviation) of $128.6 \pm 5.4^\circ$ (range 120–138°) on the right side and $126.8 \pm 4.5^\circ$ (range 120–137°) on the left side. Average neck shaft angle with both right and left sides included was 127.7 ± 5.

Angle B represents the lateral distal femoral angle. It was measured between the anatomical axis of femur and the line tangent to distal femoral condyles. The mean value was 82.1 ± 1.9 on the right side (range 79–87°) and $82.4 \pm 2^\circ$ (range 78–88°) on the left side. The average mean for both sides was 82.3 ± 2.

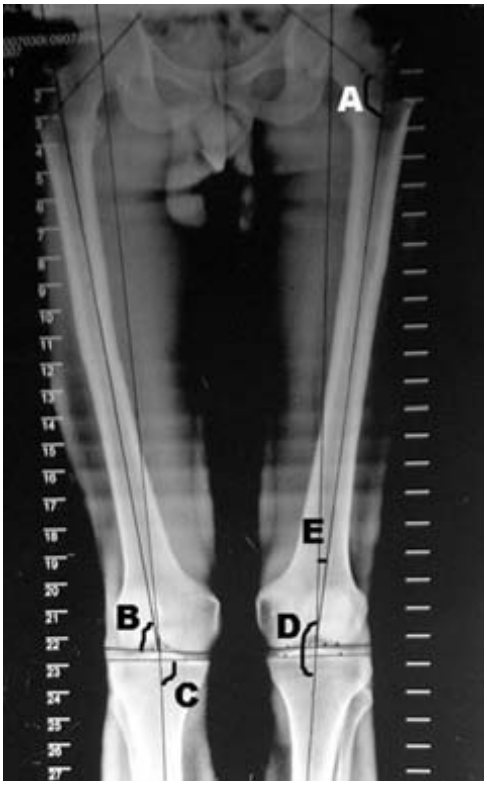


Fig. 1 – Scanogram showing the various angles measured.

Angle C is medial proximal tibial angle. It is measured between the tangent to proximal tibial condyle and mechanical axis of tibia. The knee joint surface is perpendicular to mechanical axis if this angle is 90°. This angle is index of obliquity of the knee joint. The angle C was $86.1 \pm 2.2^\circ$ (range 80–90°) on the right side and $85.8 \pm 2.7^\circ$ (range 80–90°) on the left side. The angle C was $86 \pm 2.4^\circ$ in on both right and left side in our subjects. The mean medial inclination of medial joint surface in our subjects was $4 \pm 2.4^\circ$. The other studies have taken angle C as the inferolateral angle between the knee joint transverse axis and mechanical axis of the tibia. We have measured inferomedial angle between the mechanical axis of tibia and line tangent to proximal tibial condyles. This in our view is more direct measurement of the obliquity of the tibial articular surface, which we try to reconstruct while doing total knee replacement or proximal tibial osteotomy.

Angle D represents the overall alignment of the lower extremity. The angle D was mean 177.2 ± 2.9 (range 172–188°) on right side and 176.2 ± 2.6 (range 170–180°) on the left side. The alignment for both right and left sides was $176.7 \pm 2.8^\circ$. The extremities in the Indian subjects had a mean of $3.3 \pm 2.8^\circ$ of varus alignment.

Valgus angle of femur, angle E in our subjects on right side was mean $6.1 \pm 0.7^\circ$ (range 5–7°), and it was $6.3 \pm 0.6^\circ$ (range 5–7°) on the left side. The alignment for both right and left sides was $6.2 \pm 0.7^\circ$.

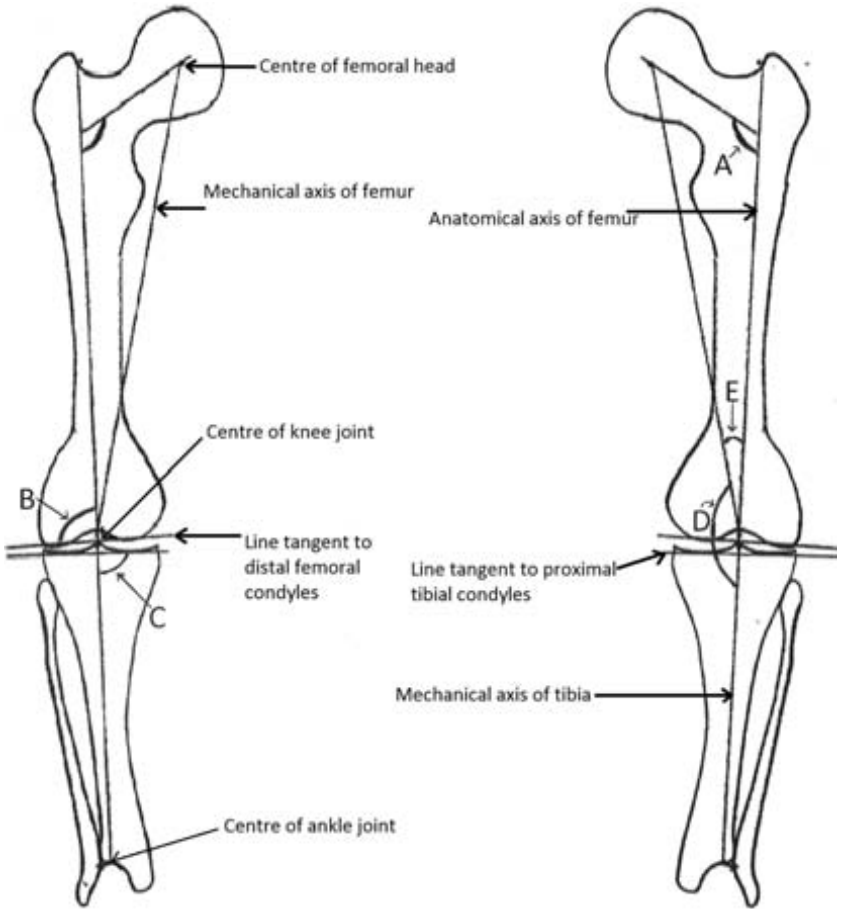


Fig. 2 – Line diagram showing various axes and angles. (A) Neck shaft angle. (B) Lateral distal femoral angle. (C) Medial proximal tibial angle. (D) Tibiofemoral angle. (E) Valgus angle.

The results are summarized in Table 1.

4. Discussion

The knee joint is one of the most common sites for osteoarthritis because of its weight bearing requirement, high mobility and lack of intrinsic stability.[4] The eccentric redistribution of normal stresses is induced by abnormal axial alignment. The reconstructive surgery around knee joint involves the correction to normal axial alignment either by osteotomy or joint replacement. There are substantial individual variations and controversies regarding the normal anatomy to be restored with reconstructive procedures also.[4–7] It is advised that components of total knee replacement be placed in such a way that transverse axis of the artificial knee joint is perpendicular to mechanical axis of femur and tibia.[7]

In 34 measurements out of 200, i.e. 17% we got the classical value of tibiofemoral angle measuring 180°. The mean tibiofemoral angle in our patients was 176.7 ± 2.8°. All the knees were found in varus or neutral alignment but one. Our findings are different from series of Moreland (178.5 ± 2 R,

Table 1 – Comparison of knee angle measurement in various studies.

Angle	Series of Moreland		Series of Hsu	Series of Tang	Present series
	Right	Left		Right and left	Right and left
A					127.7 ± 5
B					82.3 ± 2
C					85.9 ± 2.4
C*	93.0 ± 1.6	92.6 ± 1.4	91.0 ± 1.4	94.9 ± 2.3	
D	178.5 ± 2	178.9 ± 2.1	177.7 ± 2.3	177.8 ± 2.7	176.7 ± 2.8
E	4.0 ± 0.7	4.1 ± 0.9	4.4 ± 1.7	3.6 ± 0.8	6.2 ± 0.7

C* is the inferolateral angle between the knee joint surface and mechanical axis of tibia.

178.9 ± 2 L, range 173.5–183), Hsu (177.2 ± 2.3) and Tang (177.8 ± 2.7, range 172–182.5). This means Indian male subjects have more varus alignment of knee than Chinese or white male subjects and this difference is statistically significant (p value < 0.05).

In this study, the medial inclination of tibial articular surface with respect to the mechanical axis of tibia was a mean of 4°. Insall and Hungerford described a 3° varus alignment of the knee joint surface with reference to the mechanical axis of the tibia.[6–9] Therefore, if the tibial cut is placed perpendicular to its mechanical axis, 4° of external rotation of the femoral component instead of commonly used 3° is necessary to produce a rectangular flexion gap in Indians.

Most of the instrumentation systems offer a standard 6° cutting block for distal femoral cut to match 6° of physiological valgus of the distal femur, which is acceptable for Indian population considering the mean valgus angle in this study of 6.2 ± 0.7 in study population.

In our study, we had obtained scanogram for all our patients rather than the conventional long film radiographs. Whether this will have bearing on the various angles measured, we are not sure. Moreover, none of the female subjects were included in the study. We recommend that similar study should be performed on the female subjects also.

4.1. *Conclusion*

A foregone conclusion that durability of the total knee replacement is partially dependent on the postoperative axial alignment of the lower extremity. The question of individualizing reconstructive or prosthetic procedure has also been raised. However, data on the normal alignment of the lower extremity in Indian adults were not available before this study. We conclude that Indian male subjects have more varus alignment of knee than Chinese or White male subjects. It was significantly noted that valgus angle of femur was 6.2° at an average with the range of 5–7°. Medial inclination of tibial plateau in Indian subjects was 4° which differs from white and Chinese subjects (p value < 0.05). Thus 4° of external rotation of femoral component, instead of the commonly reported 3°, may be required to obtain a rectangular flexion gap in total knee arthroplasty in our subjects.

Conflicts of interest

All authors have none to declare.

REFERENCES

1. Tang WM, Zhu YH, Chiu KY. Axial alignment of the lower extremity in Chinese adults. *J Bone Jt Surg.* 2000;82-A: 1603–1608.
2. Ahlberg A, Linder B, Binhemd TA. Osteoarthritis of the hip and knee in Saudi Arabia. *Int Orthop.* 1990;14:29–30.
3. Hoaglund FT, Yan ACM, Wong WL. Osteoarthritis of the hip and other joints in southern Chinese in Hong Kong. Incidence and related factors. *J Bone Jt Surg.* 1973;55A:545–557.
4. Hsu RWW, Himeno S, Coventry MB, Chao EYS. Normal axial alignment of the lower extremity and load bearing distribution at the knee. *Clin Orthop.* 1990;225:215–227.
5. Moreland JR, Bassett LW, Hanker GJ. Radiographic analysis of the axial alignment of the lower extremity. *J Bone Jt Surg.* 1987;69-A:745–749.
6. Hungerford DS, Kenna RV, Krackow KA. The porous coated anatomic total knee. *Orthop Clin N Am.* 1982;13:103–122.
7. Insall JN, Surgical techniques and instrumentation in total knee arthroplasty. 2nd ed. Insall JN, Windsor RE, Scott WN, Kelly MA, Aglietti P, eds. *Surgery of the knee.* vol. 2. New York: Churchill Livingstone; 1993: 739–804.
8. Jiang CC, Insall JN. Effect of rotation on the axial alignment of the femur. Pitfalls in the use of femoral intramedullary guide in total knee arthroplasty. *Clin Orthop.* 1989;248:50–56.
9. Lotke PA, Ecker ML. Influence of positioning of prosthesis in total knee replacement. *J Bone Jt Surg.* 1977;59-A:77–79.

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/jajs

Case Report

A rare association of Pierre Robins sequence with bilateral developmental dysplasia of hip—A case report

Raghavendra S. Kembhavi *, *Boblee James*

Sree Lakshmi Narayana Institute of Medical Sciences & Hospital, Osudu, Agaram Village, Villianur Commune Kudupakkam Post, Puducherry - 605 502, India

ARTICLE INFO

Article history:
Received 30 July 2015
Accepted 11 November 2015

Keywords:
Micrognathia
Dysplastic hip
Pierre Robins sequence
Waddling gait
Glossoptosis

ABSTRACT

Four year old female child brought by her mother with history of difficulty in swallowing with frequent leaks of fluids through nose on feeding, speech difficulties, poor growth and abnormal gait. Intelligence was normal. No other members in her family had similar problems. Thorough clinical examination revealed Pierre Robin sequence like facial features, like micrognathia, U shaped cleft palate, glossoptosis with multiple caries in teeth and hypoplastic midface. Hearing and vision were normal. Child also showed hypoplastic thumb, exaggerated lumbar lardosis and bilateral developmental dysplasia of hips. Radiological examination showed bilateral dysplastic hips with acetabular index around 45° on both sides. Skeletal survey radiography ruled out features of spondyloepiphyseal dysplasia. Such a combination of Pierre Robins sequence with bilateral dysplastic hips are rare association and have been described only few times in literature.

1. Introduction

Pierre Robins sequence refers to a congenital condition with triad of facial abnormalities which includes U-shaped cleft palate, micrognathia and glossoptosis. The triad is usually associated with syndromes like Sticklers syndrome, Marshal Syndrome or velocardiofacial syndrome or can be presented alone. Among these syndromes, skeletal manifestations are seen in Sticklers and Marshall syndrome in the form of joint laxities and early onset of osteoarthritis, but they do not show skeletal involvement in the form of bilateral developmental dysplasia of hips. Though none of these recognized syndromes show association of Pierre Robins sequence with bilateral dysplastic hips, there have been few case reports on these unusual associations.[1,8] Hence in this article we present such a rare association which is worth reporting.

1.1. *Case presentation*

Four year old female brought to our hospital by her mother with history of repeated flow of liquids through nose on

* Corresponding author at: Fellow in Arthroscopy and Sports Medicine, Institute of Arthroscopy and Sports Medicine, Aware Global Hospital, Saroor Nagar, Sagar Ring Road, Hyderabad, 500035.
E-mail address: kembhavi.raghavendra@gmail.com (R.S. Kembhavi).

http://dx.doi.org/10.1016/j.jajs.2015.11.008

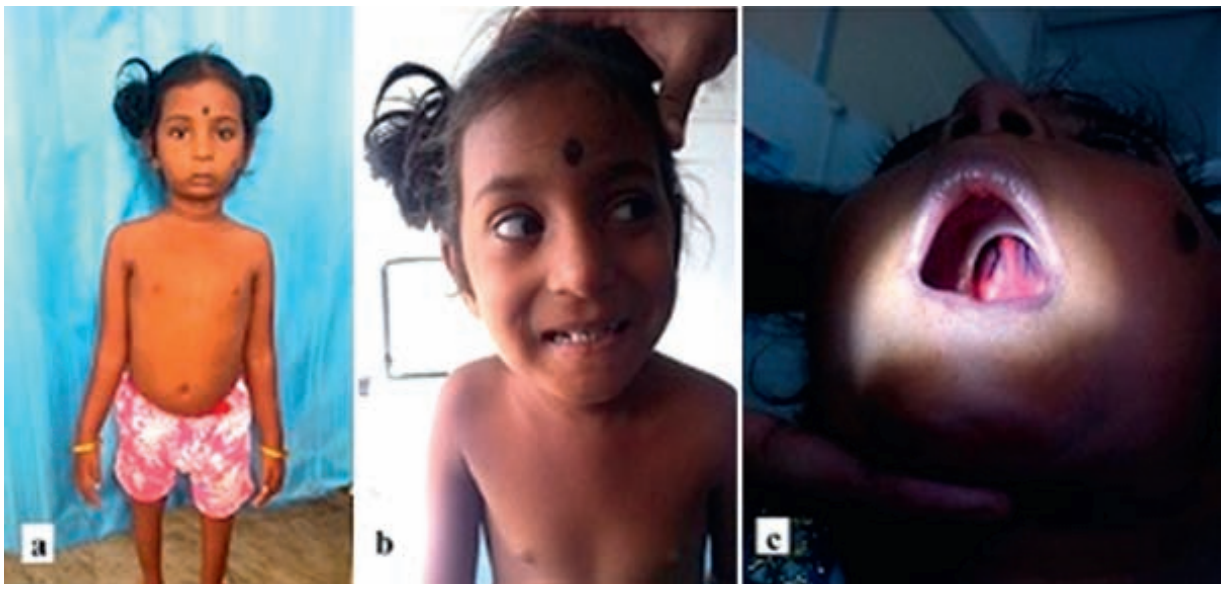


Fig. 1 – (a) Showing facial features of child with hypoplastic midface, smaller cheek bones, micrognathia. Posture is lardotic, (b) showing multiple caries in teeth, (c) Oral examination showing U- shaped cleft palate with absent uvula.

feeding, speech difficulties, poor growth, failure to gain weight and abnormal gait. She was the second child of her mother, the first child being normal. There were no history of similar complaints among other family members. Antenatal history was uneventful with no unusual drug intake during pregnancy by the mother. On general examination, the child's weight and height were significantly reduced for her age. She weighed only 10 kilos and her height was 84 cm. Intelligence appeared normal. She showed typical facial features with underdeveloped midface, smaller cheek bones, micrognathia, multiple caries in teeth, U shaped cleft palate with absent uvula and glossoptosis (Fig. 1). These features were resembling with Pierre Robins sequence. Child also had hypoplastic thumb on both sides, exaggerated lumbar lordosis and typical waddling gait (Fig. 2). Hip examination showed proximal migration of bilateral trochanter with positive Trendelenbergs and Telescopy tests. Abduction movement were restricted to 30° on both sides. There were no signs of joint laxity in any other joints (Fig. 3). Neuromuscular examination showed normal tone, power and reflexes in all four limbs.

1.2. *Investigations*

All routine blood investigations were normal. On radiological examination, both the hips were dislocated with the head of the femur in superolateral quadrant formed by Hilgenreiner's and Perkin's lines. Acetabulum was poorly formed with acetabular index nearly 45° on both sides with difficulty in identifying lateral edge of acetabulum (Fig. 4). There was a break in Shenton's line. Spine radiology showed no features of spondyloepiphyseal dysplasia or kyphotic deformity. Rest of the skeletal survey radiology was normal. Computed tomography (CT) showed similar picture with shallow acetabulum (Fig. 4). Head of femur showed no signs of avascular necrosis. Audiogram, echocardiogram and ultrasound abdomen were normal.

Fig. 2 – (a) Showing hypoplastic thumb on both sides, (b) exaggerated lumbar lardosis seen on supine position due to bilateral hip pathology.

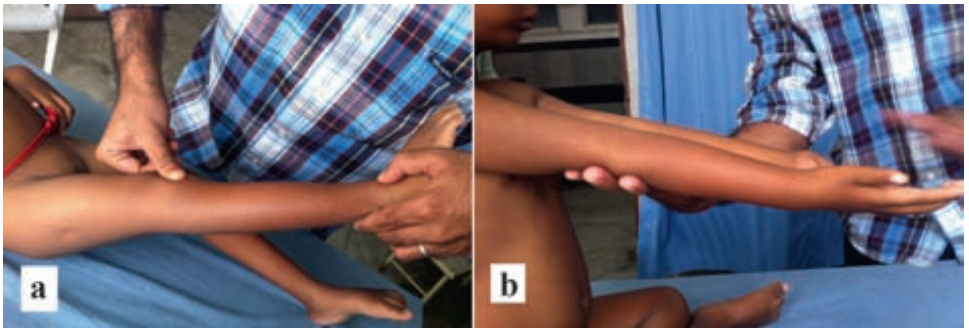


Fig. 3 – No laxities were seen in knee joints (a) and elbow joints (b).

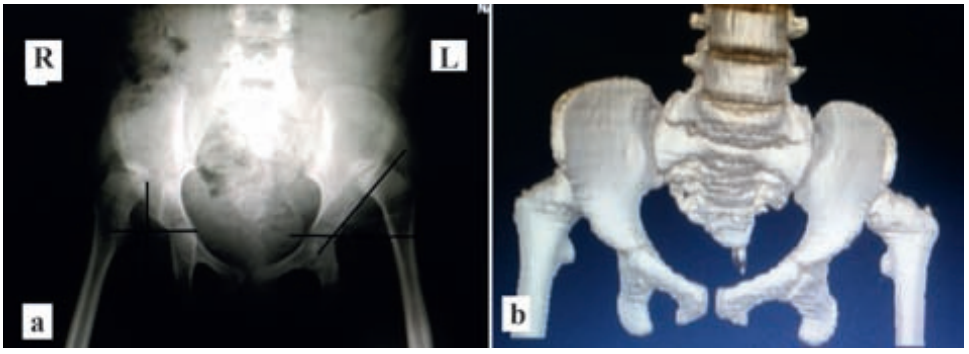


Fig. 4 – (a) X-ray of pelvis with both hips showing dislocated hip on both sides. Head of femur in superolateral quadrant formed by Hilgenreiner's and Perkin's lines (shown on the right side). Acetabular index was nearly 45°(shown on the left side). Shenton's line is broken on both sides. (b) CT showing similar picture with shallow acetabulum on both sides.

1.3. *Differential diagnosis and discussion*

Pierre Robins sequence first described by Robin in 1923. It was formerly called Pierre Robins syndrome which was later regarded as 'sequence' since it is a sequence of events beginning with micrognathia which lead to glossoptosis which in turn lead to failure in palatal closure.[1] Hence, Pierre Robin sequence is a triad of clinical manifestations which include micrognathia, U-shaped cleft palate and glossoptosis.[2] It is transmitted as an autosomal recessive trait with incidence of 1 in 80,000–2,00,000 births.[3] Commonly associated syndromes with Pierre Robins sequence are Sticklers syndrome, Marshall syndrome and velocardiofacial syndrome.[4] It is also seen in other teratogenic syndromes like Fetal alchohol syndrome and Fetal Hydantoin syndrome. When it is not associated with any other syndromes it is called non-syndromic Pierre Robins sequence.[1] Among these three syndromes, skeletal involvement is seen in Sticklers syndrome and Marshall syndrome. Sticklers syndrome, which is the most common association with Pierre Robins sequence is also called 'hereditary progressive arthro-ophthalmopathy'. It is a connective tissue disorder with ocular problems, hearing loss, typical facial features and skeletal involvement.[5] Ocular problems can manifest as myopia, cataract, retinal detachment and vitreoretinal degeneration. Hearing loss can be conductive or sensorineural. Typical facial features include underdeveloped midface with depressed nasal bridge along with Pierre Robin sequence. Skeletal manifestations include joint hyperlaxity, early onset osteoarthritis, scoliosis, spondyloepiphyseal dysplasias and Scheuermann-like kyphotic deformity. In our patient there were no ocular problems. Skeletal manifestations too were different from those seen in Sticklers syndrome. The child had bilateral developmental dysplastic hips and such a hip pathology has not been described in Sticklers syndrome.[6] There were no joint laxities. Spine showed exaggerated lumbar lardosis which might be secondary to bilateral hip pathology. Hence, our patient did not satisfy Rose et al. diagnostic criteria for diagnosis of Sticklers syndrome.[7] Marshall syndrome too have clinical resemblance with Sticklers syndrome and shows features like Pierre Robins sequence along with hypertelorism, flat nasal bridge, anteverted nostrils, flat midface, deafness, ocular problems, short stature and skeletal involvement. Skeletal features include joint laxity and early onset osteoarthritis. However, hip involvement in the form of hip dysplasia is not seen in Marshall syndrome and also we did not have joint laxity in our patient as seen in Marshall syndrome and hence we could not relate our patient to Marshall syndrome.

Pierre Robins sequence, when not associated with other syndromes (non-syndromic Pierre Robins sequence), may also present with a wide array of associated malformations. Among that, dysplastic hip, though rarely found is one association and have been reported only few times in literature. There are case reports on rare association of Pierre Robins sequence with

skeletal manifestations like bilateral radiohumeral synostosis, proximal femoral deficiency and dysplastic hip along with visceral malformations like microgastria and cryptorchidism.[8] In our case we did not find any visceral malformations. Menko et al. (1992) reported a patient of Pierre Robins sequence with associated malformations like short left forearm and dysplastic hips.[1] Schuffenhauer et al. (1992) presented a patient who had psychomotor malformation along with dysplastic hip and fused cervical vertebrae from the third cervical to the sixth cervical in a patient with Pierre Robins sequence.[1] Our patient did not show psychomotor involvement. Francke et al. reported a case of infant death with atrial septal defect, corpus callosum agenesis, and dysplastic hip in Pierre Robins sequence.[1]

In conclusion, though cases have been reported where dysplastic hips are seen in Pierre Robins sequence, the association is quite rare. In our patient too we had Pierre Robins sequence with associated bilateral dysplastic hips, which was probably a non-syndromic sequence.

REFERENCES

1. Linda P a, Mary A n, James si, Carmen r&, Carmen ms, Jean-Pierre ys, Merete ge, Niels me. The genetic basis of the Pierre Robin sequence. *Cleft Palate Craniofac J*. 2006 March;43 (2):155–159.
2. Sadewitz VL. Robin sequence: change in thinking leading to change in patient care. *Cleft Palate Craniofac J*. 1992;29: 246–253.
3. Bush PG, Williams AJ. Incidence of Robin Anomalad (Pierre Robin syndrome). *Br J Plast Surg*. 1983;36:434.
4. Holder-Espinasse M, Abadie V, Cormier-Daire V, Beyler C, Manach Y, Munnich A, et al. Pierre Robin sequence: a series of 117 consecutive cases. *J Paediatr*. 2001;139: 588–590.
5. Stickler GB, Belau PG, Farrell FJ, Jones JD, Pugh DG, Steinberg AG, et al. Hereditary progressive arthroophthalmopathy. *Mayo Clin Proc*. 1965;40:433–455 [PubMed].
6. Peter S o, Nicholas U h, Howard P e, Donna gd, Joie vs, Ruth M i, Paul D p, Clair A r. The hip in Stickler syndrome. *J Pediatr Orthopaedics*. 2001;21:657–663.
7. Rose PS, Levy HP, Johnston JJ, Griffith AJ, Liberfarb RM, Francomano CA. Proposed diagnostic criteria for Stickler syndrome. *Am J Hum Genet*. 2000;67:S56 [Abstract].
8. Roberts J, Torres-Martinez W, Farrow E, Stevens A, Delk P, White KE, Weaver DD. A case of Robin sequence, microgastria, radiohumeral synostosis, femoral deficiency, and other unusual findings: a newly recognized syndrome? *Am J Med Genet A*. 2014 Feb;164A (2):287–290.

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/jajs

Case Report

34-week follow-up of suture anchor fixation for a traumatic patellar fracture overlying a total knee arthroplasty

William M. Oliver *, *Amjad G. Shaikh*, *Alexander M. Wood*

Department of Orthopaedic Surgery, Borders General Hospital, Melrose TD6 9BS, UK

ARTICLE INFO

Article history:
Received 13 December 2014
Accepted 11 November 2015
Available online 7 December 2015

Keywords:
Patella
Periprosthetic fracture
Total knee replacement
Suture
Anchors

ABSTRACT

Traumatic patellar fractures following total knee arthroplasty (TKA), in the absence of patella resurfacing, are uncommon but debilitating injuries. Open reduction and internal fixation is associated with significant complications, thus conservative management is often preferred. We report the first known publication of the fixation of a comminuted periprosthetic patellar fracture using suture anchors, with good results at 34-week postoperative follow-up. The suture anchor technique offers an alternative option in the management of traumatic periprosthetic fractures of the unresurfaced patella, where tension band and cerclage wiring are not possible due to fracture comminution and poor bone quality.

1. Case report

A 60-year-old woman underwent cruciate-retaining total knee arthroplasty (TKA) for lateral and patello-femoral compartment osteoarthritis of the right knee, using Triathlon Total Knee prostheses (Stryker Inc., Kalamazoo, Michigan, USA). The patella was not resurfaced, although a lateral retinacular release was performed (using monopolar diathermy) to address abnormal patellar tracking during intraoperative assessment. Following this, patellar tracking was observed to be normal. Postoperative recovery was unremarkable, and by 18 months the patient was mobilising freely and able to achieve 110° of active knee flexion. Accordingly, she was discharged from routine follow-up.

Three years postoperatively, the patient was brought in by ambulance to the Emergency Department with a right knee injury. The patient described falling heavily onto her right knee, with a subsequent inability to weight bear. Physical examination revealed significant anterior right knee swelling, with no external wound. The knee was diffusely tender, particularly on palpation of the patella, and assessment of range of movement (including extension and straight-leg raise) was severely limited by pain. There was no distal neurovascular deficit. Anteroposterior and lateral radiographs were performed and are shown in Fig. 1.

Anteroposterior and lateral radiographs demonstrated a comminuted fracture (consisting of 3 main fragments and multiple small fragments) of the proximal pole of the right patella, displaced from the distal portion by 20 mm at

* *Corresponding author*. Tel.: +44 7786438530.
E-mail address: william.m.oliver@doctors.org.uk (W.M. Oliver).
http://dx.doi.org/10.1016/j.jajs.2015.11.009

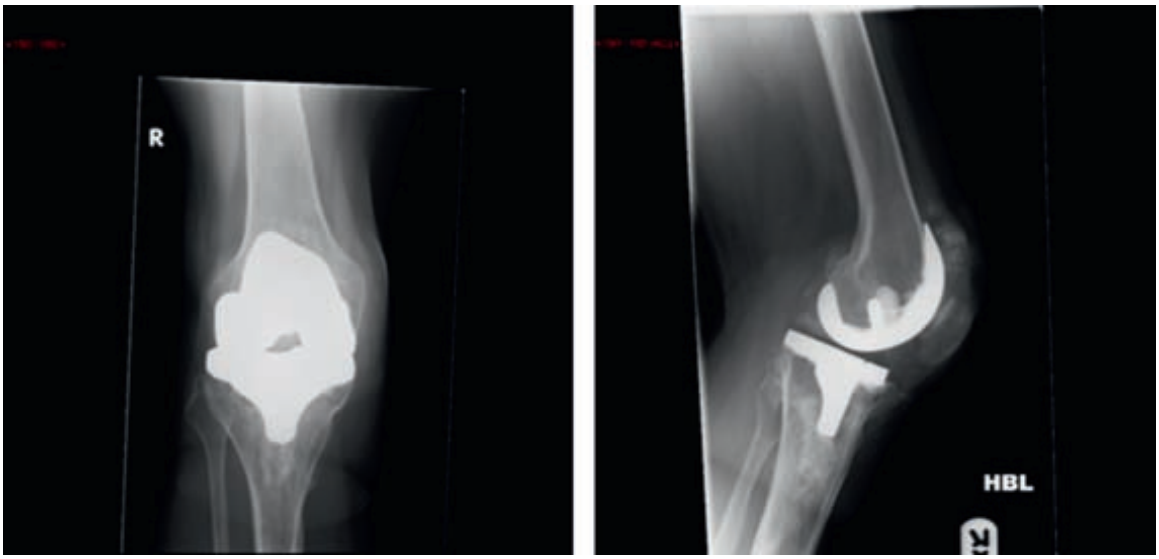


Fig. 1 – Anteroposterior and lateral radiographs of the right knee, showing a comminuted periprosthetic patellar fracture.

maximum separation. No other fractures were identified and there was no evidence of loosening of the total knee prosthesis. The patient was placed into a knee extension splint and admitted to hospital for further management.

On the basis of the radiological and intraoperative findings, the fracture was deemed to be unreconstructible using a tension-band or cerclage wiring. Thus, 3 suture anchors (G-II QuickAnchor Plus; DePuy Mitek Inc., Raynham, Massachusetts, USA) were introduced into the distal patellar fragment, and one suture was introduced into the largest of the fracture fragments. A further 2 sutures were also introduced into the largest fragments of the superior pole of the patella. Using a 2.5 mm drill, holes were bored into adjacent fracture fragments to receive threads from the suture anchors. With the knee in extension, the fragments were reduced to the intact distal patellar fragment using bony reduction forceps, before each pair of suture threads were tied together to encircle the related fracture fragment. After wound closure and dressing in the standard fashion, the patient's knee was placed into a cylindrical plaster of Paris cast. Postoperative radiographs are shown in Fig. 2.

The patient was kept non-weight-bearing through her right lower limb, and her right knee remained immobilised for 6 weeks postoperatively. Thereafter, she was placed into a hinged knee brace (with flexion restricted to 0°–20°) and advised to mobilise fully weight-bearing. At 10 and 12 weeks, the parameters of the hinged knee brace were extended to 0°–60° and 0°–90°, respectively. The patient underwent regular outpatient review out to 34 weeks, at which point she was mobilising normally, with no antalgic gait, and could achieve 0°–90° of active knee flexion (Fig. 3).

2. Discussion

Periprosthetic patellar fractures after TKA are relatively uncommon, occurring in 1.19% of cases overall.[1] These fractures can occur in both resurfaced and unresurfaced patellae[2,3]; however, the vast majority of periprosthetic patellar fractures (99.1%) involve resurfaced patellae,[1] and in unresurfaced patellae, the prevalence of fracture has been reported to be just 0.05%.[4] Most peri-prosthetic patellar fractures are atraumatic (with only 11.68% of cases occurring due to trauma) and are usually treated non-operatively (68.83%).[1]

The aetiology of periprosthetic fractures of the resurfaced patella includes mechanical weakness (due to residual patellar thickness of less than 15 mm),[5] stress concentration (as a result of patellar implants),[6] limb or prosthetic mal-alignment,[4,7] and excess stress within the patellofemoral compartment.[8] Even in the absence of resurfacing, however, technical aspects of TKA may compromise patellar vascularity, includ-

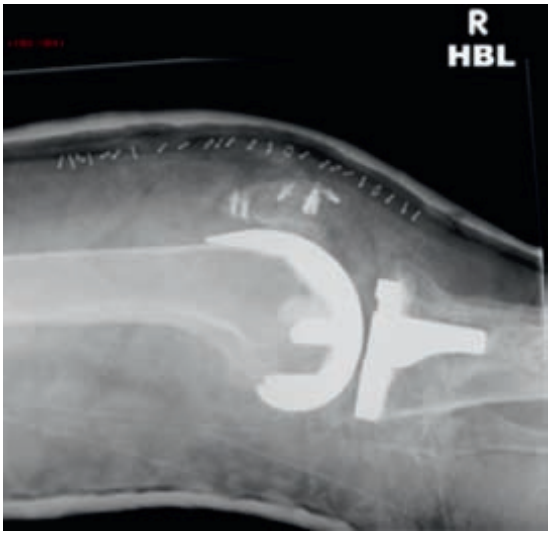


Fig. 2 – Postoperative lateral radiograph of the right knee, following suture anchor fixation.

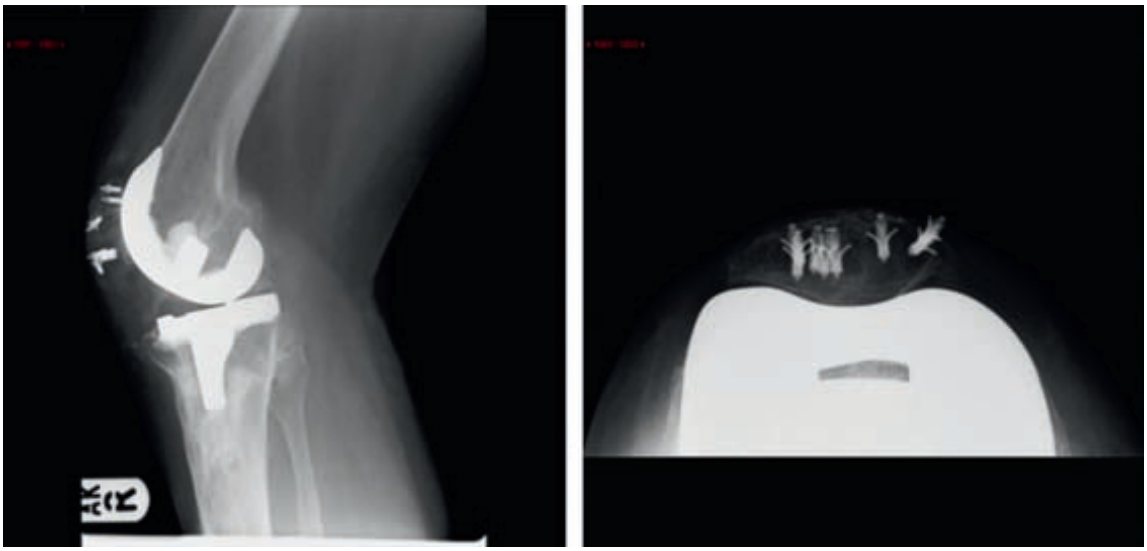


Fig. 3 – Lateral and 'skyline' radiographs of the right knee, at 34 weeks following suture anchor fixation.

ing medial parapatellar incision (disrupting the superior and inferior medial genicular vessels),[1,9] intra-operative fat pad removal (disrupting the anastomosis between medial and lateral inferior genicular vessels)[10,11] and lateral retinacular release (disrupting the superior lateral genicular vessel).[3,12–14] This patellar devascularisation and resultant osteonecrosis has been heavily implicated in subsequent periprosthetic patellar fracture.[12,15]

Where extensor mechanism disruption and significant fracture displacement exist, most authors advocate operative intervention.[16] Extensor mechanism repair can be performed using either non-absorbable suture (for the quadriceps tendon) or tension-band wiring (for the patellar tendon), with or without extensor tendon allograft.[17] Surgical treatment options for displaced patellar fracture include open reduction and internal fixation (using tension-band or cerclage wiring), and partial or complete patellectomy; where the patella has been resurfaced during the initial arthroplasty, options also include isolated revision of the patellar component or revision total knee replacement.[16] Open reduction and internal fixation for peri-prosthetic patellar fracture has, however, been associated with a high rate of surgical complications,[2,3,9,18,19] including infection, failure of fixation, fracture non-union, extensor lag and arthrofibrosis. Furthermore, patients undergoing operative fixation are reported to experience increased pain and decreased function scores when compared with non-operative treatment,[16,19] and rarely return to pre-fracture function.[20]

Maniar et al. describe repair of a spontaneous transverse periprosthetic patella fracture using anchor sutures, in which the patella had been resurfaced with polythene during the initial TKA.[21] To the best of our knowledge, there is no published literature pertaining to the use of suture anchors for fixation of traumatic comminuted peri-prosthetic fractures of unresurfaced patellae.

Unresurfaced patellae may respond better to operative intervention than resurfaced patellae – perhaps due to less pronounced devascularisation and less thinning of patellar bone at the time of arthroplasty – and the high complication rates in published literature should not deter surgeons from attempting open reduction and internal fixation. This report demonstrates use of suture anchors as a means of achieving long-term fracture reduction and union in traumatic patellar fracture overlying a TKA, even where the fracture is highly comminuted and involves bone of poor quality. The procedure is straightforward, avoiding the technical difficulty and complications of tension-band[21] and cerclage wiring,[22] and led to a good functional outcome with only a slight delay in post-operative mobilisation.

The suture anchor technique therefore offers an alternative option in the management of traumatic periprosthetic fractures of the unresurfaced patella, where tension band and cerclage wiring are not possible due to fracture comminution and poor bone quality.

Conflicts of interest

All authors have none to declare.

Acknowledgment

The authors would like to thank the subject of this case report, for her informed consent and contribution to its creation.

REFERENCES

1. Chalidis BE, Tsiridis E, Tragas AA, Stavrou Z, Giannoudis PV. Management of periprosthetic patellar fractures: a systematic review of literature. *Injury*. 2007;38:714–724.
2. Brick GW, Scott RD. The patellofemoral component of total knee arthroplasty. *Clin Orthop*. 1988;231:163–178.

3. Grace JN, Sim FH. Fracture of the patella after total knee arthroplasty. *Clin Orthop Relat Res*. 1988;230:168–175.
4. Goldberg VM, Figgie III HE, Inglis AE, et al. Patellar fracture type and prognosis in condylar total knee arthroplasty. *Clin Orthop*. 1988;236:115–122.
5. Reuben JD, McDonald CL, Woodard PL, Hennington LJ. Effect of patella thickness on patella strain following total knee arthroplasty. *J Arthroplasty*. 1991;6:251–258.
6. Windsor RE, Scuderi GR, Insall JN. Patellar fractures in total knee arthroplasty. *J Arthroplasty*. 1989;4(suppl):S63–S67.
7. Figgie III HE, Goldberg VM, Figgie MP, et al. The effect of alignment of the implant on fractures of the patella after condylar total knee arthroplasty. *J Bone Joint Surg Am*. 1989;71:1031–1039.
8. Wulff W, Incavo SJ. The effect of patella preparation for total knee arthroplasty on patellar strain: a comparison of resurfacing versus inset implants. *J Arthroplasty*. 2000;15 (6):778–782.
9. Keating EM, Haas G, Meding JB. Patella fracture after post total knee replacements. *Clin Orthop Relat Res*. 2003;416:93–97.
10. Lynch AF, Rorabeck CH, Bourne RB. Extensor mechanism complications following total knee arthroplasty. *J Arthroplasty*. 1987;2:135–140.
11. Scapinelli R. Blood supply of the human patella. Its relation to ischaemic necrosis after fracture. *J Bone Joint Surg B*. 1967;49:563–570.
12. Tria Jr AJ, Harwood DA, Alicea JA, Cody RP. Patellar fractures in posterior stabilized knee arthroplasties. *Clin Orthop Relat Res*. 1994;131–138.
13. Scuderi G, Scharf SC, Meltzer LP, Scott WN. The relationship of lateral releases to patella viability in total knee arthroplasty. *J Arthroplasty*. 1987;2:209–214.
14. Ritter MA, Herbst SA, Keating EM, Faris PM, Meding JB. Patellofemoral complications following total knee arthroplasty. Effect of a lateral release and sacrifice of the superior lateral geniculate artery. *J Arthroplasty*. 1996;11:368–372.
15. Clayton ML, Thirupathi R. Patellar complications after total condylar arthroplasty. *Clin Orthop Relat Res*. 1982;152–155.
16. Sheth NP, Pedowitz DI, Lonner JH. Periprosthetic patellar fractures. *J Bone Joint Surg Am*. 2007;89(10):2285–2296.
17. Engh GA, Ammeen DJ. Periprosthetic fractures adjacent to total knee implants: treatment and clinical results. *Instr Course Lect*. 1998;47:437–448.
18. Le AX, Cameron HU, Otsuka NY, Harrington IJ, Bhargava M. Fracture of the patella following total knee arthroplasty. *Orthopedics*. 1999;22–24:395–398.
19. Ortiguera CJ, Berry DJ. Patellar fracture after total knee arthroplasty. *J Bone Joint Surg Am*. 2002;84-A:532–540.
20. Rorabeck CH, Angliss RD, Lewis PL. Fractures of the femur, tibia, and patella after total knee arthroplasty: decision making and principles of management. *Instr Course Lect*. 1998;47:449–458.
21. Maniar RN, Nayak RM, Vatchha S, Singhi T. Periprosthetic patellar fracture fixation using suture anchors. *Orthopedics*. 2013;36(11):e1470–e1473.
22. Tharani R, Nakasone C, Vince KG. Periprosthetic fractures after total knee arthroplasty. *J Arthroplasty*. 2005;20 (4 (suppl 2)):27–32.

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/jajs

Resident's corner

Pictorial essay: The acutely painful swollen knee following injury

Clara Vella *, *Ling Hong Lee*, *Sanjeev Anand*

Department of Trauma+Orthopaedics, North Tees General Hospital, Hardwick Rd, Stockton TS19 8PE, United Kingdom

ARTICLE INFO

Article history:
Received 21 August 2015
Accepted 4 November 2015
Available online 8 December 2015

Keywords:
Knee
Injury
Fracture
Imaging
Educational

ABSTRACT

A pictorial essay based on a case study entitled: The acutely painful and swollen knee following injury.

Aim: This is an educational article with the following learning objectives: To familiarise oneself with the main causes of an acutely painful and swollen knee following injury; to highlight the importance of plain knee radiographs in assessment of knee injury; to raise awareness of osteochondral fractures and the importance of prompt diagnosis; exploration of treatment options for traumatic patellar dislocation with and without osteochondral fractures.

1. Case study

1.1. Introduction

A 36-year-old GP registrar suffered an injury to his left knee while playing football with his colleagues. The knee gave way following a twisting movement with an excruciating popping sensation. He could not bear weight and noticed immediate knee swelling. There was no significant past medical history or previous significant injury to the knee. He enjoyed playing football twice weekly. During the initial assessment in the accident and emergency, there was swelling of the knee, tenderness medial to the patella and in the lateral femoral condyle. Passive and active knee movements were restricted by discomfort. On the contralateral uninjured knee, there was genu recurvatum. Plain radiograph of the knee (Fig. 1) was performed and a routine referral to Knee Clinic was then arranged.

1.2. Initial management

Unfortunately, the significance of an osteochondral fragment was not initially recognised. The patient received physiotherapy and was not seen by an Orthopaedic Consultant until 12 weeks after injury. During that period, mobility and knee movement were reduced due to swelling and pain. Knee MRI was carried out to confirm his injury of patellar dislocation and osteochondral fracture (Figs. 2 and 3).

Following the discussion of management options, the patient underwent arthroscopic surgery to fix the osteochondral fragment. The procedure was complicated by extensive and chronic scar tissue, particularly around the osteochondral fragment. Significant chondral injury to the patellar articular

* *Corresponding author*. Tel.: +44 07736328287.
E-mail address: Claralvella@googlemail.com (C. Vella).

http://dx.doi.org/10.1016/j.jajs.2015.11.002

Fig. 1 – Lateral X-ray left knee. Short arrow: suprapatellar pouch effusion, Long arrow: osteochondral fracture fragment.

surface was also found (Fig. 3). The fragment was fixed to the lateral femoral condyle using multiple bioabsorbable pins.

Postoperatively, the patient was in a functional knee brace, non-weight bearing for 4 weeks, with a range of movement of −10–90°. Following intensive physiotherapy, he regained full range of movement of the knee.

Eight months postoperatively, although able to carry out day-to-day activities, the patient is still struggling to partake in sporting activities due to pain. He has painless crepitus in all knee movements originating from the patellofemoral joint, suggesting patellofemoral degeneration. The patient experiences occasional low-grade achiness in the knee, especially after long distance walking.

Fig. 2 – MRI coronal view left knee showing an osteochondral defect (arrow) at the lateral femoral condyle.

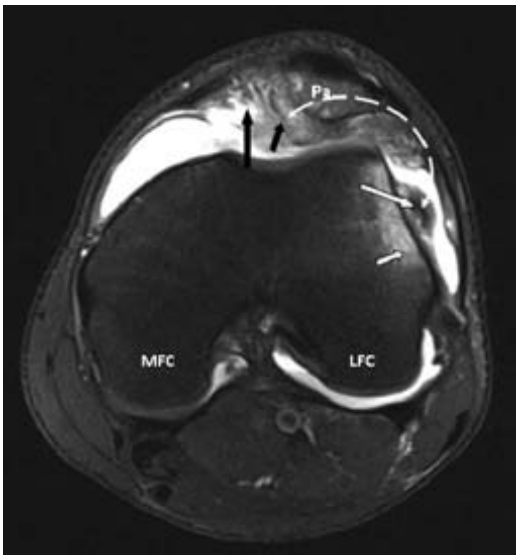


Fig. 3 – Knee MRI axial proton density fat suppressed view showing evidence of lateral patellar dislocation and osteochondral fracture of lateral femoral condyle from re-entry injury. Pa – patella (laterally subluxed); MFC – medial femoral condyle; LFC – lateral femoral condyle; long black arrow – MPFL tear; short white arrow – bone; oedema lateral femoral condyle; long white arrow – displaced osteochondral fragment; short black arrow – bone oedema inferomedial patella; double ended dashed curved arrow – direction of lateral patellar dislocation and relocation resulting in 're-entry injury'; 're-entry injury' – patella dislocates laterally. As it relocates tangentially over the lateral femoral condyle, both the lateral femoral condyle and inferomedial medial border of patella are at risk of chondral damage on impact.

2. Discussion

The above case emphasises the importance of early and accurate diagnosis in traumatic patellar dislocation with osteochondral fragment.

It is important to be aware of the main causes of an acutely painful, swollen knee following injury, so as to ensure accurate and speedy diagnosis and treatment. Clinicians should have high index of suspicion in patients presenting with acute knee injury. Early identification of these injuries allows early accurate diagnosis, counselling and appropriate rehabilitation to prevent prolonged morbidity and secondary damage to cartilage or meniscus.[1–4]

Acute traumatic knee swelling is a result of haemarthrosis and should be regarded as a serious injury until proven otherwise.[2] If aspirated, presence of fat globules in the aspirated knee fluid (lipohaemarthrosis) suggests intra-articular fracture.

Common causes of haemarthrosis following injury are:

1. Intraarticular ligament damage (40%), most commonly anterior cruciate ligament injury (47% of ligamentous injury)
2. Patellar dislocation (20%)

3. Meniscus injury (10%)
4. Osteochondral fracture

Usually, such injuries happen after significant trauma but in obese patients, a trivial mechanism of injury can cause significant damage.[5]

ACL rupture is usually associated with a twisting injury to the knee and a 'pop' or sensation of the joint 'coming apart.' Acute swelling occurs usually within 6 h of injury.[6] Simultaneous ACL rupture and acute patellar dislocation is a rare finding.[6,7]

Patellar dislocation is very commonly associated with articular cartilage injury – reported in up to 95% of patients (8). Occasionally, it may lead to a displaced osteochondral fracture, which needs to be identified on imaging.

Typical examination findings of patellar dislocation include:

- Medial patella tenderness – consistent with medial patellofemoral ligament (MPFL injury).
- Lateral femoral condyle and inferomedial patella facet tenderness – consistent with the pathognomic chondral or osteochondral injuries secondary to the traumatic tangential patellar displacement.[9]
- Patellar apprehension test (lateral subluxation of patellar) will reproduce pain and the uncomfortable sensation of a dislocating patella.

Swelling after meniscus tear is of slower onset and less dramatic compared to ACL injury or acute patellar dislocation. It is more likely due to a twisting injury with the knee in a flexed position with combination of rotation or axial loading from a fall directly onto the knee. Meniscal tears in young adults usually follow a significant trauma and require urgent specialist opinion. This is in contrast to meniscal tears in older populations, where such injuries are quite common, happen after a trivial trauma and are usually degenerative in nature.[10]

3. The importance of plain knee radiographs

Plain radiographs of an acutely injured knee are easily performed and can be useful. Fat globules along with blood in the joint – lipohaemarthrosis – may be visible as radiolucent shadows on plain X-rays (Fig. 4), suggesting an occult fracture. Small bony flakes as seen in osteochondral and Segond fractures suggest significant injuries. They should not be ignored and it is important to be able to distinguish between the two.[6]

Osteochondral fractures of the lateral femoral condyle are often caused by direct trauma or twisting injuries. There may be osteochondral fractures caused by impaction forces at the time of injury or displaced osteochondral fractures (as in this case) caused by shear forces separating the articular surface.

A Segond fracture (Fig. 5) is small vertical avulsion fracture involving the lateral aspect of the proximal tibia and is usually associated with ACL rupture. It is caused by forced internal rotation and varus stress injury of the knee and suggests significant capsular injury causing this avulsion fracture.[6]

Fig. 4 – Lipohaemarthrosis.

Fig. 5 – Segond fracture. Anteroposterior radiograph of the left knee shows an elliptic bone fragment (arrow) arising from the lateral tibial plateau (the lateral capsular sign).[11]

4. Treatment

Traumatic patellar dislocations without fracture require analgesia, reduction and initial immobilisation with a well-fitted knee splint, followed by early physiotherapy to encourage quadriceps activity and to maintain articular health. There is very little evidence to suggest that early repair of the MPFL reduces the risk of recurrent patellar dislocation.[12]

Traumatic patellar dislocation with osteochondral fracture requires early surgical intervention to deal with the displaced osteochondral fragment. Early fixation of these fragments allows the opportunity to restore the articular surface. A small fragment may need to be removed to prevent recurrent locking. Simultaneous repair of the MFPL may need to be done to prevent further redislocation.[13]

Possible sequelae of this injury include post-traumatic patellofemoral joint osteoarthritis[14] and re-dislocation. The risk factors for patellar dislocation are personal or family history of previous patellar dislocation, soft tissue abnormalities – including hyperlaxity of joints, medial

quadriceps weakness, vastus lateralis dominance – or bony abnormalities, including trochlea dysplasia, lower limb malalignment, patella alta, osteochondral defect.[15]

A missed traumatic patellar dislocation with osteochondral fracture can have serious long-term effects on quality of life. It is important to review plain radiographs thoroughly and the presence of small bony flakes should prompt MRI investigation.

Learning outcomes

1. To familiarise oneself with the main causes of an acutely painful and swollen knee following injury.
2. Highlight the importance of plain knee radiographs in assessment of knee injury.
3. To raise awareness of osteochondral fractures and the importance of prompt diagnosis.
4. Treatment options for traumatic patellar dislocation with and without osteochondral fractures.

Patient consent

Obtained.

Contributorship

Idea for article – Ling Hong Lee and Sanjeev Anand; Patient identification and management – Sanjeev Anand; Literature search – Ling Hong Lee, Clara Louise Vella and Sanjeev Anand. Writing article – Clara Louise Vella, Sanjeev Anand and Ling Hong Lee; Guarantor – Clara Louise Vella, Ling Hong Lee and Sanjeev Anand.

Conflicts of interest

All authors have none to declare.

REFERENCES

1. Bollen S. Ligament injuries of the knee – limping forward? *Br J Sports Med*. 1998;32:82–84.
2. Maffulli N, Binfield P, King JB, Good CJ. Acute haemarthrosis of the knee in athletes. A prospective study of 106 cases. *J Bone Jt Surg [Br]*. 1993;75-B:945–949.
3. Robling MR, Pill RM, Hood K, Butler CC. Time to talk? Patient experiences of waiting for clinical management of knee injuries. *Qual Saf Health Care*. 2009;18:141–146.
4. Lawrence JTR, Argawal N, Ganley TJ. Degeneration of the knee joint in skeletally immature patients with a diagnosis of an anterior cruciate ligament tear: is there harm in delay of treatment? *Am J Sports Med*. 2011;39: 2582–2587.
5. Peltola EK, Lindahl J, Hietaranta H, Koskinen SK. Knee dislocation in overweight patients. *AJR*. 2009;192:101–106.
6. Cosgrave CH, Burke NG, Hollingsworth J. The Segond fracture: a clue to intra-articular knee pathology. *Emerg Med J*. 2012;29:846–847.
7. Simonian PT, Fealy S, Hidaka C, O'Brien SJ, Warren RF. Anterior cruciate ligament injury and patella dislocation: a report of nine cases. *Arthroscopy*. 1998;14:80–84.
9. Rorabeck CH, Bobechko WP. Acute dislocation of the patella with osteochondral fracture. *J Bone Jt Surg [Br]*. 1976;58-B:237–240.
10. Englund M, Guermazi A, Gale D, et al. Incidental meniscal findings on knee MRI in middle-aged and elderly persons. *N Engl J Med*. 2008;359:1108–1115.
11. Gottsegen CJ, Eyer BA, White EA, Learch TJ, Forrester D. Avulsion fractures of the knee: imaging findings and clinical significance. *Radiographics*. 2008;28:1755–1770. http://dx.doi.org/10.1148/rg.286085503.
12. Hing CB, Smith TO, Donell S, Song F. Surgical versus non-surgical interventions for treating patellar dislocation. *Cochrane Database Syst Rev*. 2011;11:CD008106.
13. Khan S, Dowen D, Asaad S. Successful repair of an isolated osteochondral fracture of the patella presenting with locking of the knee. *Trauma*. 2012;15:91–95.
14. Vainionpaa S, Laasonen E, Silvennoinen T, Vasenius J, Rokkanen P. Acute dislocation of the patella. *J Bone Jt Surg [Br]*. 1990;72-B:366–369.
15. Tsai C-H, Hsu C-J, Hung C-H, Hsu H-C. Primary traumatic patellar dislocation. *J Orthop Surg Res*. 2012;7:21.

Instructions to Authors

Before you begin

Manuscripts submitted to *Journal of Arthroscopy and Joint Surgery* should not have been published previously or be under simultaneous consideration for publication by any other journal. Violation may lead to a retraction of the published article by the Journal and other actions as deemed necessary by the editor. All articles (including those invited) will be peer-reviewed, and accepted articles will be edited to the Journal's style. Accepted manuscripts become the permanent property of the Journal and may not be reproduced, in whole or in part, without the written permission of the editor.
Studies involving human subjects or animals should have received the approval of the institutional ethics committee. A statement to this effect and that informed consent was obtained from participating human subjects must be included in the manuscript text.

Ethics in publishing

For information on Ethics in publishing and Ethical guidelines for journal publication see http://www.elsevier.
com/publishingethics and
http://www.elsevier.com/ethicalguidelines.

Conflict of interest

All authors must disclose any financial and personal relationships with other people or organizations that could inappropriately influence (bias) their work. Examples of potential conflicts of interest include employment, consultancies, stock ownership, honoraria, paid expert testimony, patent applications/ registrations, and grants or other funding. See also http://www.elsevier.com/ conflicts of interest. Further information and an example of a Conflict of Interest form can be found at: http://elsevier6.custhelp.com/app/answers/detail/a_id/286/p/7923/.

Submission declaration and Verification

Submission of an article implies that the work described has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis or as an electronic preprint, see http://www.elsevier.com/postingpolicy, that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright holder. To verify originality, your article may be checked by the originality detection service CrossCheck http://www.elsevier.com/editors/plagdetect.

Authorship

All authors should have made substantial contributions to all of the following: (1) the conception and design of the study, or acquisition of data, or analysis and interpretation of data, (2) drafting the article or revising it critically for important intellectual content, (3) final approval of the version to be submitted. Please give contribution of each author on the cover page of the manuscript.

Changes to authorship

Ideally there should not be any change in authorship after the manuscript is submitted. In situations where there has been an omission or substantial work is done when the article is revised, an author's name may be added. This policy concerns the addition, deletion, or rearrangement of author names in the authorship of accepted manuscripts:

Before the accepted manuscript is published in an online issue: Requests to add or remove an author, or to rearrange the author names, must be sent to the Journal Manager from the corresponding author of the accepted manuscript and must include: (a) the reason the name should be added or removed, or the author names rearranged and (b) written confirmation (e-mail, fax, letter) from all authors that they agree with the addition, removal or rearrangement. In the case of addition or removal of authors, this includes confirmation from the author being added or removed. Requests that are not sent by the corresponding author will be forwarded by the Journal Manager to the corresponding author, who must follow the procedure as described above. Note that: (1) Journal Managers will inform the Journal Editors of any such requests and (2) publication of the accepted manuscript in an online issue is suspended until authorship has been agreed upon by the editor.

After the accepted manuscript is published in an online issue: Any requests to add, delete, or rearrange author names in an article published in an online issue will follow the same policies as noted above and result in a corrigendum.

Reporting Clinical Trials

All randomized controlled trials submitted for publication should include a completed Consolidated Standards of Reporting Trials (CONSORT) flowchart. Please refer to the CONSORT statement website at http://www.consortstatement.org for more information. This journal has adopted the proposal from the International Committee of Medical Journal Editors (ICMJE) which require, as a condition of consideration for publication of clinical trials, registration in a public trials registry. Trials must register at or before the onset of patient enrolment. The clinical trial registration number should be included at the end of the abstract of the article. For this purpose, a clinical trial is defined as any research study that prospectively assigns human participants or groups of humans to one or more health-related interventions to evaluate the effects of health outcomes. Health related interventions include any intervention used to modify a biomedical or health related outcome (for example drugs,

surgical procedures, devices, behavioral treatments, dietary interventions, and process-of-care changes). Health outcomes include any biomedical or health-related measures obtained in patients or participants, including pharmacokinetic measures and adverse events. Purely observational studies (those in which the assignment of the medical intervention is not at the discretion of the investigator) will not require registration. Further information can be found at http://www.icmje.org.

Copyright

Upon acceptance of an article, authors will be asked to complete a 'Journal Publishing Agreement' (for more information on this and copyright see http://www.elsevier. com/copyright). Acceptance of the agreement will ensure the widest possible dissemination of information. An e-mail will be sent to the corresponding author confirming receipt of the manuscript together with a 'Journal Publishing Agreement' form or a link to the online version of this agreement.

Role of the funding source

You are requested to identify who provided financial support for the conduct of the research and/or preparation of the article and to briefly describe the role of the sponsor(s), if any, in study design; in the collection, analysis and interpretation of data; in the writing of the report; and in the decision to submit the article for publication. If the funding source(s) had no such involvement then this should be stated. Please see http://www. elsevier.com/funding.

Submission of Manuscripts

The journal only accepts online submissions in electronic format. All new manuscripts must be submitted through *Journal of Arthroscopy and Joint Surgery* online and review website (http://ees.elsevier.com/jajs). Authors are requested to submit the text, tables, and figures in electronic form to this address. Please follow the following steps to submit your manuscript:

1. Open the homepage of the journal's website (http://ees.elsevier.com/jajs).
2. Register yourself for free by clicking on "Register" on the top and create a user profile with a desired username and mandatory details. On submission of the information, you will receive an E-mail confirming your registration along with the "Password".
3. Click "Log In" on the main navigation menu at the top of the journal screen to open the login page.
4. Enter your username and password in the appropriate fields (E-mailed to you at the time of registration). Click "Author Log in", this takes you to the "Author Main Menu".

Note: Please note that the username and password combination required for Elsevier Editorial System is different from the username and password combination used to "Track your paper" on the Elsevier "Authors' Home" website.

By submitting a manuscript, the author agrees to the following:
1. The work is original and free from plagiarism.
2. It has neither been published, nor is it not under consideration for publication at another journal.
3. All authors are aware of the authorship order. The corresponding author shall be responsible in case of dispute.
4. Once published, copyright of manuscript shall stand transferred to the Journal.
5. 'Conflict of interest' if any, must be explicitly stated at the end of the manuscript.

Manuscripts must conform to the instructions given below:

General: Type the manuscript using 'Times New Roman' font, size 12 in double space throughout. Please arrange the manuscript as follows: Title page, Abstract, Introduction, Methods, Results, Discussion, and References. Number all pages consecutively, beginning with the title page. All figures and Tables must be referred to in the manuscript. Consult a recent issue of the Journal for details. Only the Title page should bear the names and addresses of the author(s). Editorials, perspective and review articles are generally by invitation. However if you are interested in writing a review/perspective, you can send an email to the editor with the topic and a short summary of contents to be included. The editor will convey his decision in 7-10 days' time.

Length of articles: Text of original articles should be between 2000 and 3500 words. The article should not ordinarily contain more than 3 tables, 2 figures and 25 references. Case Reports are accepted only if they can be converted into 'What is your diagnosis?' format (please consult a recent issue of the Journal). Briefly, the format consists of case report of about 500 words, a diagnostic image followed by the actual diagnosis/answer and discussion (250 words) and upto 5 references. Letters discussing or criticizing material published recently in the Journal, brief presentations of data, or those pertaining to issues of relevance to health policy, practice of medicine, or the like, are welcome. These should not exceed 500 words, 1 table and 5 references.

Title page: In animal studies, the title should state the species; all other titles will refer to human studies. State names of authors (including first names), the departments and the institution where the work was done. Please do not add your academic qualifications, designation etc. State contribution of each author clearly. A short, running title, not exceeding 40 characters, should be provided. Please provide the name, postal address with PIN code, facsimile number and E-mail address of the author to whom communications and proofs are to be sent. Acknowledgements, if any, may be mentioned on this page.

Acknowledgements: These should appear at the end of the manuscript. The *source of funding* as well as a *disclosure statement* mentioning *conflict of interest*, if any, should appear under this heading.

References: Number the references in the order in which they first appear in the text and identify the reference numbers in the text in superscript. References must be placed at the end of the manuscript. Please use recent references as much as possible. The responsibility for accuracy of

references lies with the respective authors. The Journal is in agreement with the International Committee of Medical Journal Editors (www. icmje.org). The general arrangement, abbreviations of Journal names and punctuations followed are as per the Uniform Requirements for Manuscripts submitted to Biomedical Journals (www.icmje.org). Please pay attention to the style of references and punctuations as follows:

Journal article
List all authors when six or less as shown in the example below: Tallon D, Chard J, Dieppe P. Exploring the priorities of patients with osteoarthritis of the knee. *Arthritis Care and Res* 2000;13:312–9.

When there are seven or more authors, list only the first six and add et al.

Book or monograph
Following is an example: Cassidy JT. Juvenile rheumatoid arthritis. In: *Textbook of Rheumatology* 6th ed, Kelly et al (eds) Philadelphia Saunders 2000; pp. 1297–313.

Tables: Each Table should be typed on a separate page and numbered consecutively in Arabic numerals. Each table should have a title and all abbreviations should be explained in the footnote. Necessary explanatory notes, if any, may be given below the Table.

Figures/Illustrations/Photographs: Photographs of 300 dpi or higher resolution may be submitted as 'jpeg', or 'tiff' files in a zipped folder. In clinical photographs, identity of the subjects should be suitably masked; in case this is not possible, a written permission from the concerned person should accompany the manuscript.

Legends to Figures: The Figure number (numbered consecutively in Arabic numerals), title and explanations of the Figures should appear in the legend (not on the Figure). Type the legends on a separate page. Enough information should be included to interpret the Figure without reference to the text.

Units: All measurements must be in metric units, preferably with corresponding SI units in parentheses.

Editorial Process: All articles submitted to the Journal undergo initial review by the Editor/associate editor and articles that are outside the scope of Journal or are not in the journal format are excluded. Later each article is reviewed by at least two reviewers. The time to first decision is usually less than 6 weeks.

As per the policy of the *Journal*, an Editor, who is either author of a manuscript or belongs to the same institution as any of the authors, is not assigned that manuscript and is not involved in decision-making regarding its publication.
Reviewers/Editorial Board members should decline the invitation to review a manuscript which is submitted by authors from their institution.

Reprints: Reprints may be requested and are provided on payment.

Address all correspondence to: Prof. Ravi Gupta or Mr. Sanjeev Anand, Chief Editors, Journal of Arthroscopy and Joint Surgery at editorjajs@gmail.com.

ASARVA Life Sciences Pvt. Ltd.

Our Products

IN OSTEOPOROSIS

℞ Cap. SARVACAL™

Calcium Carbonate with Calcitriol
& Zinc Softgel Capsules

The Essential Calcium

In Low Back Pain & Arthritis

℞ Tab. ANKON™ 90 / 120

Etoricoxib 90/120 mg

Lets Your Patient Move ON...

IN VITAMIN D DEFICIENCY

℞ Cap. D-3 ONCE™

(Cholecalciferol 60,000 IU)

The Vitamin That Matter

In Co - ℞ With NSAID

℞ Cap. Rabitrol D™

(Rabeparazole 20 mg + Domperidome 30mg SR)

Helpline : 9582874697

All products are available at 98.4 Chemist Retail Chain

For Active life

℞ TABLETS

LAFLEX

Collagen peptide Type1 40 mg + Sodium Hyaluronate 30 mg + Chondroitin 30 mg + Vitamin C 35 mg

Indications :-

- Tendinopathies with Arthritis, Hypothroidism and Diabetes
- Traumatic tendon & ligament injury
- Prevent inflammation of joints

OUR ORTHO RANGE :

XZORB-K2
CCM 1250 mg + Vitamin K2-7 90 mcg + Vitamin D3 – 1000 IU + Methylcobalamin 1500 mcg + Magnesium oxide 50 mg + Zinc oxide 15 mg
Tablets

LAFLEX
Collagen peptide 40mg + Sodium Hyaluronate 30 mg + Chondroitin sulphate 200mg + Vitamin C 35 mg
Tablets

MELOB-G
Gabapentin 300mg + Methylcobalamin 500mcg
Tablets

MELOB-P
Pregabalin 75mg + Methylcobalamin 750mcg
Capsules

XCERIN PLUS
Diacerein + Glucosamine + MSM
Tablets

DROGBA-6/30
Deflazacort 6mg/30mg
Tablets

XDOL
Tramadol 37.5mg + Paracetamol 325mg
Tablets

XZORB FORTE
Calcium Aspartate + Calcium Orotate + Calcitriol + Zinc + Magnesium + Hydroxycobalamin + Folic acid
Tablets

XDOL Gel / Roll on
Diclofenac + Linseed oil + Methyl Salicylate + Menthol

MELOB
Methylcobalamin 1500 mcg + L-Glutamic Acid with Micronutrients **Capsules**

NANI-D3
Cholecalciferol 6000 IU)
Tablets/Sachet

MAXAMUS PHARMA PVT. LTD.

Address: 222, 2nd Floor, Sarja Market, Sector-7, Rohini, New Delhi (India)
Telephone : 011-27043906,
Email : maxamusinternational@gmail.com
Web : www.maxamuspharma.com

Over Four Centuries of Publishing Experience!

With deep roots in health sciences publishing, Elsevier helps doctors advance practice of medicine by providing world-class information which helps them make critical decisions and improve patient outcomes.

Elsevier brings to you over 2,000 health sciences journals, and works with over 7,000 journal editors, 70,000 editorial board members, 300,000 reviewers and 600,000 authors. As the world's leading publisher of science and health information, Elsevier brings to you knowledge products including:

- *The Lancet*
- *The Clinics of North America*
- *Gray's Anatomy*
- *Nelson's Pediatrics*
- *Dorland's Illustrated Medical Dictionary*
- *Netter's Atlas of Human Anatomy*

Leading Indian Journals

from the House of Elsevier

For advertisement and subscription enquiries in Elsevier journals, please write to **journals.india@elsevier.com**

Over Four Centuries of Publishing Experience!

With deep roots in health sciences publishing, Elsevier helps doctors advance practice of medicine by providing world-class information which helps them make critical decisions and improve patient outcomes.

Elsevier brings to you over 2,000 health sciences journals, and works with over 7,000 journal editors, 70,000 editorial board members, 300,000 reviewers and 600,000 authors. As the world's leading publisher of science and health information, Elsevier brings to you knowledge products including:

- *The Lancet*
- *The Clinics of North America*
- *Gray's Anatomy*
- *Nelson's Pediatrics*
- *Dorland's Illustrated Medical Dictionary*
- *Netter's Atlas of Human Anatomy*

Leading Indian Journals

from the House of Elsevier

For advertisement and subscription enquiries in Elsevier journals, please write to **journals.india@elsevier.com**