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Journal of Arthroscopy and Joint Surgery

JAJS

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

Indexed in Scopus

Volume 3 Number 3 September–December 2016

ISSN: 2214-9635

Available online at www.sciencedirect.com
ScienceDirect

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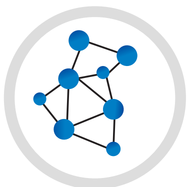

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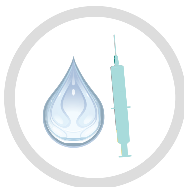

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1. Weiss C, et al, J Clin Rheumatol. 1999;5:S2-S11. 2.Gigante A et al. Rheumatology Int, 2011:31:427-444 3. Lannitti et al. Drugs R D 2011, 11(1):13-27

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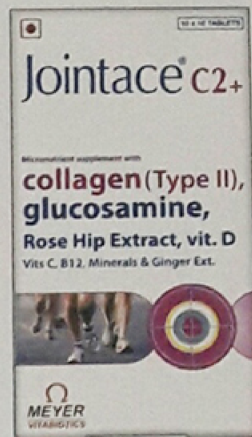

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Journal of Arthroscopy and Joint Surgery

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

(ISSN: 2214–9635)

Volume 3, Number 3, September–December 2016

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

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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 3, Number 3, September–December 2016

Published by Reed Elsevier India Pvt. Ltd.

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

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Contents lists available at ScienceDirect

Journal of Arthroscopy and Joint Surgery

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

Editorial

Are we Sheep or are we Shepherds?

Knee surgery is one of the fastest advancing fields in Orthopaedic surgery. However, because we don't have the ability to replace like for like, i.e. true anatomical parts our researchers continue to search for the holy grail of "Anatomic Reconstruction" all the while knowing that it is, at this stage, not possible.

I am referring to the incredible number of research papers published on Anterior Cruciate Ligament Reconstruction. "ACL" if put into a search engine will produce more information than almost any other orthopaedic topic.

Why is this? Surely the reason is two fold:

1) ACL injury rate is increasing dramatically as sports participation increases around the world. Over 200,000 ACL reconstructions are done annually in the USA alone. And big profile sport is a massive business. Just look at the earnings of IPL stars; British Soccer players and American Football gladiators.
2) The second reason is that this ligament has actually "got our number"!

We just cannot make it like the creator designed it, plus we cannot always properly diagnose or correct secondary damage that occurred at the time of acute or chronic injury.

Yet the search goes on. Patellar tendon was an early graft used to reconstruct this ligament.[1] Because the results were not so good vascularized grafts were tried.[2] This didn't yield a normal knee and sometimes the complications were significant (arthrofibrosis); so hamstrings were used. Quadriceps tendon is now coming into vogue. Prosthetics and allograft have failed to solve the problem.

Having found no great improvement towards normality with different grafts we started looking at where we placed the graft. Maybe we had it in the wrong place? This seems surprising because the attachments of the natural ACL are quite large and well defined anatomically. Many studies going back decades have taught us this anatomy. Then when "new" anatomic placement didn't seem to make a difference we looked at the anatomy again and re-discovered the "double bundle" nature of the natural ACL. So there was a stampede to produce the best double bundle operation with many techniques on how to fix the various bundles and at what degree of knee flexion. The Pittsburgh group insisted on fixing the Antero-Medial (A-M) bundle in 60° flexion and the Postero-Lateral (P-L) bundle near full extension because their laboratory studies indicated that these were the positions that these bundles took most load.[3] But if one stepped back and looked at what we had been doing when reconstructing mainly the A-M bundle when doing single bundle reconstructions; and we remembered the work of Rosenberg, and that of Larson and Seidles on isometry,[4] one would have realized that their A-M graft with its tunnel position would (in most patients) tighten quite significantly going into extension if fixed at 60°.

It took a number of years and many failed operations of this technique which was "sold" to the world, to realize the error of this fixation position. Double bundle grafts are now being fixed completely differently (and differently by different surgeons as well). And more literature is coming out to again show no benefits to our patients. In amongst this double bundle phase the so-called "anatomic" single bundle femoral tunnel concept developed. We were told if you put a single bundle in the centre of the ACL attachment, thus having part of the tunnel covering the AM bundle and part the PL bundle we would get better results with more normal kinematics. Firstly this is such bad terminology. There are lots of places that the femoral tunnel could be placed and be "anatomic" all within the footprint. Secondly a number of researchers started reporting higher early re-rupture rates.

This tells us that we really are no closer to solving the ACL enigma.

What we are realizing is that there are other structures (e.g. Antero lateral ligament called the ALL and the ITB) that play a role in the stabilization of the knee against rotatory moments. And maybe it is dawning on us (not surprisingly) that different individuals will have ACLs and peripheral structures that have a greater or lesser effect in this function. That is, there may be ACL dominant knees that are very lax/unstable with a primary "isolated" ACL injury and others that remain stable with the same injury (I call "periphery dominant" knees). The latter being because of the contribution of secondary stabilizers which in that individual play a prominent role.

If we truly want to reconstruct the ACL (Collins Concise Dictionary: "Reconstruct: to build up again-something in its **original** form"), we need to look more closely at how the various fascicles of the bundles interact recruiting fibres as the force and position of the knee requires under load. We need to better appreciate the twisting arrangement of the fibres and bundles which also plays a role in different degrees of flexion. Because only by re-creating this highly complex anatomical arrangement will we be able to truly reconstruct the ACL and by so doing restore the knee to normal kinematics.

We need to learn to differentiate between the different patient types as to who might need just ACL surgery and who might need lateral surgery as well. And even in this lateral surgery and in the anatomy of the structures we are "fixing" there is discord amongst the surgical fraternity.

http://dx.doi.org/10.1016/j.jajs.2016.10.001
2214-9635/

So maybe instead of going around in circles and trying to outdo nature we should admit that at this time we cannot "make it like it was". We should heed the studies of people like Andy Williams who has shown that a single bundle A-M graft with a central tibial tunnel and a "high and deep" femoral tunnel (the position that the majority of the thickest AM fibres attach to), still gives the best outcomes[5]; That we recognize the incorrectly termed "anatomic tunnel", that which lies between the centre of attachments of the A-M and P-L bundles, gives rise to higher failures (which is understandable if one looks at the isometry of this bundle-....tightens significantly more than the A-M bundle going into extension and so will see more load during the healing phase)[6]; That we need to recruit nature, not fight her, by allowing enough time for healing before returning the gladiator to the arena. And it is not just the graft that has to heal, but also the bony injury, thus allowing "joint homeostasis" as described by Scott Dye.[7]

So I would appeal to surgeons to use proven techniques based on careful examination and ellucidation of the injury, especially the secondary structures, and stick to a technique and graft source that gives predictable, good results with low morbidity. That the surgery (technique and graft choice) should be personalized to the patient being treated. Those that want to push the boundaries should more carefully and for a longer time period record their outcomes, and only when after significant time they can prove that new methods, techniques or surgeries will make a difference, then present these to the orthopaedic community so that changes made will positively affect our patients. There have been too many changes in a short period of time with no evidence of improvement, but sadly evidence of increased failure, costs and morbidity in some instances.

So be a Shepherd unto your patients and not a sheep to the pioneers. Let them find the promised land, not promise us they are finding it!

References

1. Palmer I. On injuries of the ligaments of the knee joint: a clinical study. *Acta Chir Scand.* 1938;81(Suppl 53):2–282.
2. Paulos LE, Butler DC, Noyes FR, Grood ES. Intra-articular cruciate reconstruction: 2: Replacement with vascularized patellar tendon. *Clin Ortho Relat Res.* 1983;172: 78–84.
3. Sakane M, Fox RJ, Woo SL, Livesay GA, Fu FH. In situ forces in anterior cruciate ligament and its bundles in response to anterior tibial loads. *J Orthop Res.* 1997;15(2):285–293.
4. Sidles J, Larson R, Garbini J, et al. Ligament length relationships in the moving knee. *J Orthop Res.* 1988;6:593–610.
5. Williams A, Devic N. *Graft positioning and isometry in ACL reconstruction. 2012. Chapter 16, pgs 183-194, The Knee Joint: Surgical Techniques and Strategies*. Paris: Springer-Verlag; 2012.
6. Firer P. *Anisometry of the reconstructed bundles in ACL surgery; Presentation to C.O.K.S. meeting Cape Town*. 2015.
7. Dye S, Wojtys EM, Fu FH, et al. *J Bone Joint Surg Am.* 1998;80(9):1380–1393.

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Available online 2 November 2016

Journal of Arthroscopy and Joint Surgery 3 (2016) 89–91

Contents lists available at ScienceDirect

Journal of Arthroscopy and Joint Surgery

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

Review article

How lipids hurt tendons: Current understanding

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ARTICLE INFO

Article history:
Received 1 July 2016
Accepted 13 November 2016
Available online 29 November 2016

Keywords:
Hyperlipidemia
Hypercholesterolemia
Tendons
Tendon injury
Lipids
Achilles

ABSTRACT

Hyperlipidemia has profound effects on tendon substance and mechanical properties. The common misconception is that hyperlipidemia manifests only as tendon xanthomas. Fatty streaks and signal changes are much more common than xanthomas, which may be considered as the end product of organized hyperlipidemic changes. The composition of xanthomas and the cause of lipid-mediated damage to tendons are discussed.

1. Introduction

The effect of lipids on tendon structure and healing is one of the most interesting fields of research. Hyperlipidemia has been known for many years to be a risk factor for tendon disorders, and conversely, tendon xanthomas are believed to be a risk factor for cardiovascular disease. Hyperlipidemia has been hypothesized to affect approximately 17% of the US population 20 years and older (National Center for Health Statistics 2006).[1] With an ever-increasing hyperlipidemic population the role of high lipid levels on tendon structure and healing is becoming clearer. There is still a quantum of work that needs to be done to fully understand that this topic, however we present the current state of knowledge in this review.

2. What are tendon xanthomas?

Tendon xanthomas are the classic findings of hyperlipidemia and are associated with a 3 times higher risk of cardiovascular disease among hyperlipidemic patients.[2]

Tendon xanthomas are accumulations of collagen and macrophages which contain cholesterol esters (foam cells).[3] Common locations are the Achilles tendon, wrist tendons (especially extensor) and elbow tendons. The main characteristic of tendinous xanthomas is the exceptionally high concentration in free and total cholesterol.[4] Tendon xanthomas are usually accompanied by an increase in lipid size, not only due to the xanthoma itself, but also the surrounding inflammatory reaction and edema.

The major constituent of tendon xanthoma are lipids (33% of dry weight) and collagen (24% of dry weight).[5] The lipid composition is typically 55% free cholesterol, 28% cholesterol esters and 13% phospholipids. This is similar to adult atherosclerotic lesions or fatty streaks.[4] Staining sections have revealed that unesterified cholesterol is predominantly extracellular whereas esterified cholesterol is both intra and extracellular.[6,7]

There appears to be rapid and total exchange of cholesterol between blood plasma and the xanthoma, as demonstrated by radionuclide experiment, suggesting that the xanthoma originates secondary to blood lipid levels rather than local lipid levels.[8] Within the lesion itself there is active uptake of LDL by the macrophages within the xanthoma.[9]

LDL is believed to be trapped within the collagen and glycosaminoglycan portion of the tendon ECM. Here it can become oxidized to oxLDL on contact with macrophages which then take it up intracellularly and form foam cells.[10,11]

3. Why do xanthomas form?

The short answer here is hyperlipidemia. However, not all hyperlipidemics have tendon xanthomas and vice versa. Recent research has found that only a subset of hyperlipidemic patients

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http://dx.doi.org/10.1016/j.jajs.2016.11.001

manifest with xanthomas. Xanthoma formation appears to be linked to genetic variation in specific genes for hypercholesterolemia. Oosterveer et al. (2010) found that among their 1208 hyperlipidemia patients, there was significant association between tendon xanthoma and genetic variation in the reverse cholesterol transport (RCT) and LDL oxidation genes which are the pathophysiological basis for atherosclerosis.[12]

4. Does hyperlipidemia manifest only as xanthoma?

No. In a MR based study on Achilles tendon properties among hyperlipidemic patients, Dussault et al. (1995) found that 92% of patients had abnormal signal changes within the tendon, whereas 73% had increased width of tendon itself. The abnormal signal finding was a diffuse stippled pattern with many low-signal round structures of equal size surrounded by high signal material on all pulse sequences.[13] Interestingly, in only 30% of patients did the signal changes appear like xanthoma, suggesting that there is more happening at the molecular level within the tendon substance, than simple xanthoma formation.

Thus fatty streaks and signal changes are probably a precursor to xanthoma formation. Xanthoma can be viewed as the end result of organized local hyperlipidemia. Clinical studies have noted a link among Achilles tendon thickness, hyperlipidemia and intima-media thickness of the carotid artery, suggesting thickening of the Achilles tendon as a potential indicator of atherosclerosis.[14] Thus, rather than xanthoma itself, any fatty change within the tendon proper may be an indicator of hyperlipidemia.

5. Is the type of lipid important?

Yes. It appears that the type of lipid is also important. In their study of 47 patients with Achilles tendon ruptures, Ozgurtas et al. (2003) found that Total cholesterol, TG, VLDL and LDL concentrations were significantly higher in the tear group than control group, whereas the HDL concentration was significantly lower in the tear group.[15] These findings have been confirmed by Mathiak et al.[16] Abboud and Kim (2010) further studied the effect of lipids on rotator cuffs and reached similar conclusions.[17]

6. So how does hyperlipidemia, in itself, damage the tendon?

Hyperlipidemia leads to tendon injury in several ways:

1. The deposition of cholesterol byproducts is implicated in the formation of tendon xanthomas, which may change tendon properties and result in increased propensity for tendon rupture.
2. Hyperlipidemia may alter the tendon's ECM in such a way that there is increased injury or impaired healing. Rönnemaa et al. found that embryonic fibroblasts react differently to hyperlipidemic rat serum than to normal rat serum. Hyperlipidemic serum was less likely to stimulate the formation of noncollagenous proteins or incorporate glucosamine and cytidine (components of ECM) compared with normal lipid serum.[18]
3. There is reduced baseline elastic modulus and strength of patellar tendons of hyperlipidemic mice compared with controls.[19]
4. Hyperlipidemia impairs both macro and microcirculation, but how this contributes is yet unclear.[20]

Thus hyperlipidemia has profound effects on the tendon substrate, tendon mechanical properties and tendon vascularity.

7. What is the end result of these changes?

Tendon tears and impaired tendon healing post-tear. The disruption of tendon architecture, whether in the form of fatty streaks or xanthomas, along with the reduced mechanical properties increases the propensity of tears in hyperlipidemic patients. Beason et al. showed that hyperlipidemic mice have significantly decreased elastic modulus of their patellar tendons as compared to controls, with increased liability for tendon tears.[19]

Furthermore, once a tear, whether macro or micro, has propagated, the resulting healing of the tendon is also impaired as the tendon is now working against the natural inflammatory reaction along with the hyperlipidemic changes, rather than just the inflammatory reaction, as would be the case in normal lipid patients.

8. Summary

Hyperlipidemia has profound effects on tendon substance and mechanical properties. Not all hyperlipidemia results in tendon xanthomas, which in fact can be considered as an end stage to fatty streaks. Most patients will present to us with fatty streaks than with tendon xanthomas. It is important to understand the underlying process of xanthoma formation and of hyperlipidemia on the tendon to better tailor future therapies. The one thing that is clear, is that hyperlipidemia, in any form, has negative effects on tendon.

Conflicts of interest

The authors have none to declare.

References

1. Schober SE, Carroll MD, Lacher DA, Hirsch R. Division of Health and Nutrition Examination Surveys.High serum total cholesterol – an indicator for monitoring cholesterol lowering efforts: U.S. adults, 2005–2006. *NCHS Data Brief.* 2007;(2):1–8.
2. Oosterveer DM, Versmissen J, Yazdanpanah M, Hamza TH, Sijbrands EJG. Differences in characteristics and risk of cardiovascular disease in familial hypercholesterolemia patients with and without tendon xanthomas: a systematic review and meta-analysis. *Atherosclerosis.* 2009;207(2):311–317.
3. Takahashi K, Naito M. Lipid storage disease. Part I. Ultrastructure of xanthoma cells in various xanthomatous diseases. *Acta Pathol Jpn.* 1983;33(5):959–977.
4. Vermeer BJ, Mateysen AA, van Gent CM, van Sabben RM, Emeis JJ. The lipid composition and localization of free and esterified cholesterol in different types of xanthomas. *J Invest Dermatol.* 1982;78(4):305–308.
5. Tall AR, Small DM, Lees RS. Interaction of collagen with the lipids of tendon xanthomata. *J Clin Invest.* 1978;62(4):836–846.
6. Von Bahr S, Movin T, Papadogiannakis N, et al. Mechanism of accumulation of cholesterol and cholestanol in tendons and the role of sterol 27-hydroxylase (CYP27A1). *Arterioscler Thromb Vasc Biol.* 2002;22(7):1129–1135.
7. Kruth HS. Lipid deposition in human tendon xanthoma. *Am J Pathol.* 1985;121(2):311–315.
8. Bhattacharyya AK, Connor WE, Mausolf FA, Flatt AD. Turnover of xanthoma cholesterol in hyperlipoproteinemia patients. *J Lab Clin Med.* 1976;87(3):503–518.
9. Ginsberg HN, Goldsmith SJ, Vallabhajosula S. Noninvasive imaging of 99mtechnetium-labeled low density lipoprotein uptake by tendon xanthomas in hypercholesterolemic patients. *Arterioscler Dallas Tex.* 1990;10(2):256–262.
10. Sugiyama N, Marcovina S, Gown AM, Seftel H, Joffe B, Chait A. Immunohistochemical distribution of lipoprotein epitopes in xanthomata from patients with familial hypercholesterolemia. *Am J Pathol.* 1992;141(1):99–106.
11. Rapp JH, Connor WE, Lin DS, Inahara T, Porter JM. Lipids of human atherosclerotic plaques and xanthomas: clues to the mechanism of plaque progression. *J Lipid Res.* 1983;24(10):1329–1335.
12. Oosterveer DM, Versmissen J, Yazdanpanah M, Defesche JC, Kastelein JJP, Sijbrands EJG. The risk of tendon xanthomas in familial hypercholesterolaemia is influenced by variation in genes of the reverse cholesterol transport pathway and the low-density lipoprotein oxidation pathway. *Eur Heart J.* 2010;31(8):1007–1012.
13. Dussault RG, Kaplan PA, Roederer G. MR imaging of Achilles tendon in patients with familial hyperlipidemia: comparison with plain films, physical examination, and patients with traumatic tendon lesions. *AJR Am J Roentgenol.* 1995;164(2):403–407.
14. Kiortsis DN, Argyropoulou MI, Xydis V, Tsouli SG, Elisaf MS. Correlation of Achilles tendon thickness evaluated by ultrasonography with carotid intima-media thickness in patients with familial hypercholesterolemia. *Atherosclerosis.* 2006;186(1):228–229.

15. Ozgurtas T, Yildiz C, Serdar M, Atesalp S, Kutluay T. Is high concentration of serum lipids a risk factor for Achilles tendon rupture? *Clin Chim Acta Int J Clin Chem.* 2003;331(1–2):25–28.
16. Mathiak G, Wening JV, Mathiak M, Neville LF, Jungbluth K. Serum cholesterol is elevated in patients with Achilles tendon ruptures. *Arch Orthop Trauma Surg.* 1999;119(5–6):280–284.
17. Abboud JA, Kim JS. The effect of hypercholesterolemia on rotator cuff disease. *Clin Orthop.* 2010;468(6):1493–1497.
18. Rönnemaa T, Juva K, Kulonen E. Effect of hyperlipidemic rat serum on the synthesis of collagen by chick embryo fibroblasts. *Atherosclerosis.* 1975;21(3):315–324.
19. Beason DP, Abboud JA, Kuntz AF, Bassora R, Soslowsky LJ. Cumulative effects of hypercholesterolemia on tendon biomechanics in a mouse model. *J Orthop Res Off Publ Orthop Res Soc.* 2011;29(3):380–383.
20. Brewer BJ. Aging of the rotator cuff. *Am J Sports Med.* 1979;7(2):102–110.

Journal of Arthroscopy and Joint Surgery 3 (2016) 92–96

Contents lists available at ScienceDirect

Journal of Arthroscopy and Joint Surgery

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

Research paper

Quantification of Indian femur: Dry bone anthropometry in relation to total knee arthroplasty

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ARTICLE INFO

Article history:
Received 8 May 2016
Accepted 16 August 2016
Available online 31 August 2016

Keywords:
Distal femur
Total knee arthroplasty
Indian femur
Aspect ratio
Femoral bowing

ABSTRACT

To study the distal femoral anatomy in Indian population via dry femoral bone measurements and to quantify its effect with relation to total knee arthroplasty. Accurate positioning and sizing of femoral components are important for stability and better outcome.

Anatomic measurements on 70 adult cadaveric distal femora were performed using a standardized vernier caliper. The femurs were also photographed in both sagittal and coronal view for bowing and length measurements.

The mean length was 42.85 cm (±2.82). 39 femurs belonged to the right side. There were 45 males and 25 female femurs. The mean sagittal bowing was measured by radius of curvature and found to have a mean of 109.34 cm (±25.00). Coronal bow was mostly lateral and with a mean of 4.12° (±2.78). A total of 13 patients had a medial bow with a mean bowing of 1.73° (±1.32). The mean medial AP was 57.67 mm (±3.94). Mean lateral AP was 58.42 mm (±3.73).

Asian knees are generally considered smaller than their western counterparts. Femoral medio-lateral diameter (fML) was comparatively lesser than other ethnicities published in literature (Chinese and Caucasian). No gender based significant difference was found between aspect ratio. Strong positive correlation between the length of femur and fML ($p < 0.001$) and antero-posterior (fAP) diameter ($p < 0.001$) in both sexes underline the requirement of larger sized implants in larger individual. The average aspect ratio is also less than the western knees. Moreover, a negative correlation ($p < 0.05$) between increasing AR and fAP diameter was noted. This has a crucial bearing on the fitting of the implant, permitting or mitigating the over- or under-hang of the implant.

The strength of this study is its basis on healthy non-arthritic distal femur data. The analysis provides a morphometric template for a larger study for designing of gender specific Indian knees suited implant.

1. Introduction

Much attention has been garnered by femoral component mismatch in total knee arthroplasty (TKA) in Asian patients with the use of traditional prostheses. Commercially available TKA implants do not cater to anthropometric differences observed across different ethnicities, as suggested by some recent studies.[1–3] Asians including Indians are basically mesomorphic, and in general, smaller built compared to Caucasians.[4] Furthermore, gender differences also add up to the above confounding problems. In a noteworthy study in 2000, a statistically significant number of Indian females (60.4%) had a smaller femoral antero-posterior (fAP) measurement than the smallest size of the femoral implant.[3]

During the size estimation for insertion of the femoral component, the antero-posterior diameter is important in retaining the flexion–extension gap and optimal tension in the quadriceps mechanism, whereas the horizontal diameter governs the coverage of the resected bone surface, optimal wound closure, permitting equal stress distribution, and smooth tracking of the

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http://dx.doi.org/10.1016/j.jajs.2016.08.001
2214-9635/

patellar component during flexion.[3,5,6] A study showed that femoral implant overhang of >3 mm is associated with more severe pain two years postoperatively.[7]

Most existing studies are based on arthritic knees and are CT/MRI-based. This data may be flawed in the presence of various deformities which occur in the degenerative arthritis. None of the existing studies have focused on the generation of basic morphological data of dry bone distal femurs of Indian patients. This data is essential for the calculation of average Indian distal femoral data which will form the basis of new and improved Indian TKA design. The objective of this study was the quantification of the dry bone Indian distal femur anthropometry with relation to TKA.

2. Material and methods

2.1. Study design

The study was conducted on 70 well preserved dry femoral bones in the Anatomy Bone Bank facility at our institute. Gender distinction of the femurs being studied was performed by a senior anatomist.

2.2. Measurements

The measurements were performed by two different observers and each measurement was made twice to account for inter-observer and intra-observer variability. An average of the two measured values for each observation was chosen as the final value. Digital vernier calipers (Absolute Digimatic Caliper, Mitutoyo, Japan) and a standard foot ruler were used for the measurements. Medial and lateral distal femoral condyles were measured in antero-posterior planes at their widest. Medio-lateral measurement was done at the level of the epicondylar axis. All the femurs were photographed from a fixed distance in antero-posterior and lateral views for calculation of bowing and future records.

2.3. Measurement of coronal and sagittal bowing

For the measurement of the amount of bowing present in the dry distal femurs, digital photographs of the femurs were taken and imported onto a computer.

For the measurement of coronal bowing, a photograph was taken in a direct lateral position which was established by keeping the femur on a horizontal flat surface, thus achieving a surface tangential to the most posterior point of both lateral and medial condyles and the most posterior point of the proximal femur. The method of coronal bowing measurement as described by Yau et al.[8] was used. On the digital image, the shaft of the femur was divided into four equal segments (Fig. 1). For each segment, the longitudinal axes for the most proximal and the most distal segment were drawn. These axes were extrapolated and the angle formed between them was measured with the help of a computer software Protractor (Iconico Inc., NY, USA). This angle would demonstrate the overall bowing of the shaft of femur in the coronal plane.

The measurement of the sagittal bowing was done as described by Harma et al.[9] The shaft of femur on a lateral X-ray was assumed to be part of a perfect arc of a circle. The radius of the said circle, hence calculated would provide us with the degree of sagittal bowing (Fig. 2). The distance DP was measured after taking the magnification into factor. The midpoint of distance DP was taken and a perpendicular drawn from this point meeting the shaft of femur. This distance was taken as *X*. The Pythagoras formula was used for the calculation of the radius with the available variables.

Fig. 1. Measurement of coronal bowing.

More the radius of curvature, lesser the sagittal bowing and vice versa.

3. Results

The mean length of the femur in men was 43.78 cm (±2.15) and in women was 41.16 cm (±3.13). The range of femoral length was from 34.6 cm to 47.5 cm. Of the 70 femora analyzed, 45 (64%) belonged to male gender and 37 (56%) of total number were right sided.

Sagittal bow was defined as the measurement of radius of curvature of a circle, whose arc was assumed to be forming the femoral shaft. Sagittal bow was found to have a mean of 109.34 cm (±25.00). The male femora (112.72 ± 25.58 cm) had a higher average curvature as compared to the opposite gender (103.26 ± 23.19 cm).

In the coronal plane, the bowing of the femurs was mostly lateral. Medial bowing was noted in only 13 cases (7 male, 6 medial). The average lateral coronal bow was 4.12° ± 2.78. Of the 13 femurs, maximum medial bow was noted to be up to 4°. Average medial bow in males and females was 1.82 ± 1.24 and 1.62 ± 1.51. A total of 4 femurs had neither lateral nor medial bowing.

The distal femoral medio-lateral (fML) distance measured was 64.91 ± 4.59 mm. As expected, it was higher in male (66.11 mm) as compared to females (62.75 mm). Compared to the other ethnicities, it was lower than both Caucasian[10–12] and Chinese[10,13] data across various studies. On measurement of the antero-posterior diameter, the lateral condyle was found to be larger (mean 58.42 mm) than the medial condyle (mean 57.67 mm). The average AP diameter for males and females was 60.30 ± 3.08 mm and 56.62 ± 3.40 mm. For the

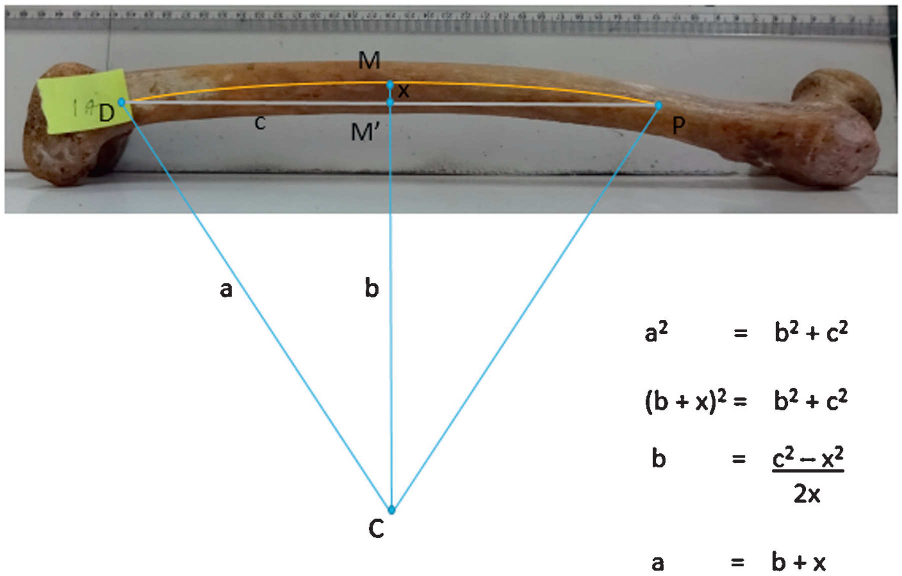

Fig. 2. Measurement of sagittal bowing and the calculation involved.

determination of AP diameter, the higher of the two values (MAP and LAP) for each femur was chosen.

The aspect ratio as calculated from the above measurements (fML/AP) was much lower (1.10) than those of other ethnicities (Caucasian 1.28, Chinese 1.12).[10,13]

On correlative analysis, in both the sexes, a strong positive correlation was found between medio-lateral and the antero-posterior diameters (males: $r = 0.6$, $p < 0.001$; females: $r = 0.66$, $p < 0.001$) and also with the length of femur for both parameters. Differential findings arose in the correlative analysis between length of femur and aspect ratio in males and females. While in females, there was a positive correlation ($r = 0.23$, $p < 0.26$), there was a negative correlation ($r = -0.11$, $p < 0.22$) in males.

4. Discussion

Asian knees are generally considered smaller than their western counterparts. Indians are genetically shorter and smaller built.[4] These differences in the build of the patients lead to various problems with respect to the implants developed on the basis of the western demographics. In relation to total knee replacement (TKA), this causes implant related mismatch difficulties, sizing issues, overhang/underhang, post-operative pain, loosening, etc. and ultimately poor patient satisfaction and function.

Significant differences in the anthropometric measurements of the knee between the different ethnic groups were observed in a previous study.[14] This is an important finding given the fact that Asians have been generally regarded to be of the same size.[15]

Most of the previous studies available in the worldwide literature for different ethnicities and those few studies published for Indian patients were all CT/MRI based studies.[3,13,16] The current study was undertaken to gather dry bone data from Indian non-arthritic distal femurs and to assess this data with relation to the available data of different ethnicities. Our study in comparison is a cadaveric dry bone study and hence gives accurate measurements of the distal femur. Also when compared to the existing MRI based studies, it precludes problems related to presence of cartilages and other soft tissue at the time of generation of 3-dimensional images. Also, it is better than those studies based on in vivo measurement of resected surfaces as resection techniques may differ by surgeon and implant used. The previously mentioned CT-based studies are mostly focused on arthritic deformed knees leading to a high propensity for erroneous data generation.

Our study is based on data generation in non-arthritic knees. This helps in removing any confounding factors because of any bony changes secondary to arthritis and hence aids us in generation of authentic data for Indian knees. This study would thus provide a framework for the development of new implants specific for Indian knees.

There is a paucity of studies on sagittal bow measurement in Indian population in existing literature with only a single study in existence.[17] Only two other notable studies have been published but they are concerned with Chinese[18] and Caucasian[19] ethnicities. A comparison with the mentioned studies did not appear fruitful as the Chinese study focused the sagittal bow measured over the proximal, middle and distal segments differently, whereas the American study measured the outcome in degrees of angle subtended (Table 1).

Coronal bow in Indian patients has been explored in 2009 by Mullaji et al.[20] They published that mean femoral bow was $3.6 \pm 2.5^\circ$ in patients with varus deformity compared to $0.4 \pm 1.2^\circ$ in control patients on hip-to-ankle standing radiographs. This finding is different from our observation. In a Korean study in 2015, the mean femoral bowing was $1.96 \pm 1.53^\circ$.

The basic distal femur measurements such as fML and AP diameters were smaller in females compared to males, thus giving

Table 1
Previous studies in literature on femoral sagittal bow/radius of curvature measurement.

Study	Number of femur	Bowing	Remarks
Tang et al.[18]	100	Proximal – 1081.6 Middle – 926.2 Distal – 715.1	No single measurement or average value of bowing for whole femur Max curvature in distal femur
Yehyawi et al.[19]	166	Proximal – 4.2 Middle – 0.2 Distal – 3.1	Measurement in degrees Maximum curvature in proximal femur

Table 2
Comparison of femoral medio-lateral, antero-posterior and aspect ratio in various ethnicities.

Study	Ethnicity	Number of femurs	Method of examination	fML	fAP	Aspect ratio
Our study	Indian	70	Bone measurement	66.11 ± 3.99 (M) 62.75 ± 4.89 (F)	60.30 ± 3.08 56.62 ± 3.40	1.09 ± 0.05 1.10 ± 0.06
Yue et al.[10]	Chinese	40	CT based	82.6 ± 3.6 (M) 72.8 ± 2.6 (F)	65.0 ± 2.8 (M) 58.8 ± 2.5 (F)	1.27 ± 0.03 (M) 1.24 ± 0.04 (F)
Yue et al.[10]	Caucasian	36	MRI based	86.0 ± 5.6 (M) 76.4 ± 4.0 (F)	67.5 ± 3.6 (M) 59.7 ± 2.6 (F)	1.28 ± 0.07 (M) 1.28 ± 0.06 (F)
Lim et al.[21]	Korean	115	MRI based	81.5 ± 5.7 (M) 76.7 ± 3.7 (F)	59.0 ± 4.1 (M) 58.4 ± 3.1 (F)	
Ha and Na[22]	Korean	1168	Intra-operative	74.8 (M) 68.2 (F)	66.3 (M) 60.8 (F)	
Berger et al.[11]	American	75	Bone measurement	85.6 ± 5.1 (M) 75.4 ± 2.3 (F)	68.1 ± 4.6 (M) 60.2 ± 2.0 (F)	
Mensch and Amstutz[12]	American	30	Plain radiography	82.1 ± 4.7 (M) 69.9 ± 2.6 (F) 76.8 ± 7.2 (C)		
Hussain et al.[14]	Malay	100	CT based	74.88 ± 3.55 64.53 ± 3.12	63.93 ± 3.36 57.39 ± 3.29	1.17 ± 0.05 1.13 ± 0.05
Cheng et al.[13]	Chinese	172	CT based	74.4 ± 2.9 (M) 66.8 ± 3.1 (F) 71.0 ± 3.0 (C)	66.6 ± 2.4 (M) 61.0 ± 2.7 (F) 64.1 ± 2.7 (C)	1.12 ± 0.03 (M) 1.09 ± 0.04 (F) 1.11 ± 0.03 (C)

credence to the need for options for smaller implant. Correlation analysis showed an anticipated strong positive relationship between the ML and AP diameters and also of each with the length of the femur.

Another significant finding discovered was differences in the various measurements even amongst the Asian ethnicities which are otherwise considered as one. The fML and AP measurements when compared were smaller than the other ethnicities including the Caucasians, Chinese and Malay.[10–12,14]

But, only the availability of a smaller sized implant for Indian knees would not solve all the problems. The ratio of fML and AP diameters i.e. aspect ratio (AR) also differs from that found in Caucasians. The aspect ratio as determined in the present study is 1.10 ± 0.05, considerably different from the Caucasian (1.28) and the Chinese (1.12). Thus for a given antero-posterior diameter of the Indian distal femur, the medio-lateral diameter is much less than what is expected, if the AR of 1.28 is considered (Table 2).

Another surprising factor noticed was a negative correlation between the length of femur and the aspect ratio. With an increasing length of the femur, the AP diameter increases more than the ML diameter ($r = -0.11$, $p < 0.22$). Also, 15 femurs with a high AP diameter of >62 mm had a lower than average aspect ratio of 1.07 ± 0.04. Thus, at larger sizes too, an implant mismatch is an inevitability. This negative correlation was primarily noticed in male gender femurs. This difference was mainly attributable to a more strongly linked changes in the AP diameter with the length ($r = 0.72$, $p < 0.001$) than with fML ($r = 0.51$, $p < 0.001$). In females, both the parameters changed at the same rate (AP: $r = 0.64$, $p < 0.001$; fML: $r = 0.65$, $p < 0.001$). This negative correlation has also been noticed in a Chinese study.[13]

The strength of this study is its basis on healthy non-arthritic distal femur data. The analysis provides a morphometric template for a larger study for designing of gender specific Indian knees suited implant.

The drawback of the present study is the comparatively smaller number of the femurs used for analysis. Also, a correlation of the collected anthropometric data with the morphometry of the available TKA implant would be ideal in revealing the mismatch based on the ethnicity and gender.

5. Summary

Indian patients are generally smaller and hence require availability of smaller size implants than currently available. This study also showed other important facts like smaller aspect ratio and a negatively correlated AR with respect to the length and subsequently height of the patient. A correlation between length of femur and aspect ratio (positive for females and negative for males) supports the need for gender specific knee implants. This study thus provides a basis for a larger study on dry bone Indian femurs and the need for development of specific implants and also with gender variations.

Conflicts of interest

The authors have none to declare.

References

1. Ho WP, Cheng CK, Liau JJ. Morphometrical measurements of resected surface of femurs in Chinese knees: correlation to the sizing of current femoral implants. *Knee.* 2006;13(January (1)):12–14.
2. Urabe K, Miura H, Kuwano T, et al. Comparison between the shape of resected femoral sections and femoral prostheses used in total knee arthroplasty in Japanese patients: simulation using three-dimensional computed tomography. *J Knee Surg.* 2003;16(January (1)):27–33.
3. Vaidya SV, Ranawat CS, Aroojis A, Laud NS. Anthropometric measurements to design total knee prostheses for the Indian population. *J Arthroplasty.* 2000;15(January (1)):79–85.
4. Hoaglund FT, Low WD. Anatomy of the femoral neck and head with comparative data from Caucasians and Hong Kong Chinese. *Clin Orthop Relat Res.* 1980;(October (152)):10–16.
5. Ranawat CS. The patellofemoral joint in total condylar knee arthroplasty. *Clin Orthop Relat Res.* 1986;(April (205)):93–99.
6. Krackow KA. *The Technique of Total Knee Arthroplasty*. St Louis: CV Mosby; 1990.
7. Mahoney OM, Kinsey T. Overhang of the femoral component in total knee arthroplasty: risk factors and clinical consequences. *J Bone Jt Surg Am.* 2010;92:1115–1121.
8. Yau WP, Chiu KY, Tang WM, Ng TP. Coronal bowing of the femur and tibia in Chinese: its incidence and effects on total knee arthroplasty planning. *J Orthop Surg (Hong Kong).* 2007;15(April (1)):32–36.
9. Harma A, Germen B, Karakas HM, Elmali N, Inan M. The comparison of femoral curves and curves of contemporary intramedullary nails. *Surg Radiol Anat.* 2005;27(December (6)):502–506.
10. Yue 10.B, Kartik MV, Songtao A, Tingting T, Harry ER, Guoan L. Differences of knee anthropometry between Chinese and White men and women. *J Arthroplasty.* 2011;26(January (1)):124–130.
11. Berger RA, Rubash HE, Seel MJ, Thompson WH, Crossett LS. Determining the rotational alignment of the femoral component in total knee arthroplasty using the epicondylar axis. *Clin Orthop Relat Res.* 1993;(January (286)):40–47.
12. Mensch JS, Amstutz HC. Knee morphology as a guide to knee replacement. *Clin Orthop Relat Res.* 1975;(October (112)):231–241.
13. Cheng FB, Ji XF, Lai Y, et al. Three dimensional morphometry of the knee to design the total knee arthroplasty for Chinese population. *Knee.* 2009;16: 341–347.

14. Hussain F, Kadir MRA, Zulkifly AH, et al. Anthropometric measurements of the human distal femur: a study of the adult Malay population. *Biomed Res Int.* 2013;2013:175056. http://dx.doi.org/10.1155/2013/175056.
15. Kwak DS, Surendran S, Pengatteeri YH, et al. Morphometry of the proximal tibia to design the tibial component of total knee arthroplasty for the Korean population. *Knee.* 2007;14(August (4)):295–300.
16. Shah D, Ghyar R, Ravi B, Hegde C, Shetty V. Morphological measurements of knee joints in Indian Population: comparison to current knee prostheses. *Open J Rheumatol Autoimmune Dis.* 2014;4:75–85.
17. Singh SP, Singh S. A study of anterior femoral curvature in Indian subjects. *Acta Anat (Basel).* 1972;83:416–425.
18. Tang WM, Chiu KY, Kwan MFY, Ng TP, Yau WP. Sagittal bowing of the distal femur in Chinese patients who require total knee arthroplasty. *J Orthop Res.* 2005;23(January (1)):41–45.
19. Yehyawi TM, Callaghan JJ, Pedersen DR, O'Rourke MR, Liu SS. Variances in sagittal femoral shaft bowing in patients undergoing TKA. *Clin Orthop Relat Res.* 2007;464(November):99–104.
20. Mullaji AB, Marawar SV, Mittal V. A comparison of coronal plane axial femoral relationships in Asian patients with varus osteoarthritic knees and healthy knees. *J Arthroplasty.* 2009;24(September (6)):861–867.
21. Lim HC, Bae JH, Yoon JY, Kim SJ, Kim JG, Lee JM. Gender differences of the morphology of the distal femur and proximal tibia in a Korean population. *Knee.* 2013;20(January (1)):26–30.
22. Ha CW, Na SE. The correctness of fit of current total knee prostheses compared with intra-operative anthropometric measurements in Korean knees. *J Bone Jt Surg Br.* 2012;94:638–641.

Journal of Arthroscopy and Joint Surgery 3 (2016) 97–101

Contents lists available at ScienceDirect

Journal of Arthroscopy and Joint Surgery

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

Research paper

Inter-rater reliability of common quantitative knee X-ray parameters in the Indian scenario

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ARTICLE INFO

Article history:
Received 27 April 2016
Accepted 26 October 2016
Available online 5 November 2016

Keywords:
Reliability
Knee X-rays
Insall Salvati index
Blackburne Peel index
Sulcus angle

ABSTRACT

Purpose: The reliability of knee radiograph measurements is an important factor to consider for these measurements to be a useful tool in patient evaluation. Inter-rater reliability of the common knee radiograph measurements like patellar height and sulcus angle has never been established among observers of varied expertise in the Indian setting. Research has established that ethnic differences exist in knee morphology among different races and deep squatters like Indians have different knee anatomy. Globally, there is very limited published literature evaluating reliability of sulcus angle measurement on X-rays.
Aim: We performed a study to evaluate the inter-rater reliability of 3 patellar height indices and sulcus angle in the Indian scenario among observers of varied expertise.
Method: The participants were males and females between 18 and 54 years, both, with anterior knee pain and without any knee complaints. Three independent observers from Sports Medicine, Orthopaedic Surgery and Radiology assessed 148 radiographs including 74 lateral and 74 axial views from 74 participants. All the measurements were analysed for Intraclass Correlation Coefficient (2,1).
Results: All patellar height indices had moderate to good reliability. Insall Salvati index (ICC 0.74) and Caton Deschamp index (ICC 0.74) had better reliability among our observers than Blackburne Peel index (ICC 0.67). Sulcus angle had an excellent reliability (ICC 0.92) in our study.
Conclusion: In the Indian scenario, there is an excellent inter-rater reliability for sulcus angle and moderate to good reliability for Insall-Salvati index, Caton-Deschamp index and Blackburne-Peel index, in that order, among 3 independent raters of varied expertise.

1. Introduction

Plain knee radiographs continue to be the initial investigation of choice for evaluation for many knee pathologies. Measurement of patella height and sulcus angle have been traditionally described on X-rays.[1] These measures help diagnose conditions such as patella alta and wide sulcus angle which are implicated in many lower limb and knee pathologies; for example, anterior knee pain and patellofemoral instability.[2,3] Many management decisions and surgical procedures are guided by these measurement values.[4] For a measurement to be useful, the measurement itself has to be evaluated. An essential feature of any measurement is whether it is reliable or not. Since these X-ray measurements are subjective, the inter-rater reliability of these measurements needs to be evaluated.

Some authors have assessed the inter-rater reliability of measurement of patella height[5–12] and sulcus angle[3,5] in the past. A meta-analysis in 2011 had concluded that the evidence for this inter-rater reliability is limited mainly due to small sample sizes and inadequate information on observer's experience or training.[13] Recent studies have had larger sample sizes[5,8–12] but many of them do not mention the description of the observers.[8,10,11] The study by Smith et al[5] in a large sample suggested that clinical experience of the observers could influence the results reported. However, previous research by Remy et al. has suggested that there is no influence of the observer's experience.[14]

Abbreviations: AKP, anterior knee pain; ISI, Insall Salvati index; CDI, Caton Deschamp index; BPI, Blackburne Peel index; ICC, Intraclass Correlation Coefficient.

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http://dx.doi.org/10.1016/j.jajs.2016.10.002
2214-9635/

In the Indian context, where University hospitals experience large volume of outpatients, doctors with varied expertise do the initial X-ray evaluation. In view of this, it is important to know the inter rater reliability of these X-ray measurements among observers of different expertise in this Indian setting. Besides, research has positively established that ethnic differences do exist in the knee morphology and patellar height among the different races.[15–17] Importantly, literature suggests that deep squatters like Indians have different tibial and patellar anatomy which makes it difficult to identify certain bony landmarks in them.[18] Consequently, this is suggested to affect certain X-ray measurements like Blackburne Peel index in Indians.[18] On the basis of the above factors, it is imperative to know the inter-reliability of measurements in Indian population and among Indian observers of varied expertise rather than directly inferring it from foreign literature. However, to our knowledge, no study has assessed the inter-rater reliability of these parameters in the Indian context.

The aim of our research was to study the inter-rater reliability of 3 common patella height indices and sulcus angle in an Indian University hospital, among 3 doctors with varied expertise.

2. Materials and methods

2.1. Participants

One hundred and forty eight knee X-rays from 74 participants were included in this study. Each participant underwent one lateral and one axial X-ray each. The participants were part of a larger case control study on Anterior Knee Pain (AKP) conducted at a University hospital in India. Participants underwent knee X-rays as part of that primary study. Ethical approval for the same was obtained from the Institutional Ethics committee. Participants included both, cases with a diagnosis of AKP and controls without any knee complaints. Out of the 74 participants included in this study, there were 37 AKP patients and 37 pain free controls. The cases were patients diagnosed with 'Anterior Knee Pain' in the outpatient department of Arthroscopy and Sports Medicine and department of Orthopaedics of the same hospital. Age and sex matched controls were chosen from other patients, from attendants of patients and from University staff and students, all of whom did not have any current or past lower limb complaints in 2 years. Both males and females of ages 18–54 years were included in this study. The exclusion criteria for participants were:

1. Pregnancy
2. General illness
3. Inability to lie on one side for testing
4. Symptoms and signs of knee ligament or meniscal injury
5. Tibiofemoral osteoarthritis
6. Past knee surgery or knee trauma
7. Medial patellofemoral ligament tear
8. Patellar subluxation
9. Current significant pathology affecting other lower extremity joints
10. Specific AKP diagnosis like patellar tendinitis, Osgood Schlatter Disease, Hoffa's fat pad syndrome, etc.

2.2. Image acquisition

All participants were explained the nature of the study and an informed consent was obtained from each participant. The painful knee of AKP patients was X-rayed. Either the right or left knee of the pain free control participants was X-rayed depending upon their matched case's complaint knee in accordance with the primary study.

The computed knee radiographs were obtained using a single standard machine (HF 400 mA, GE Healthcare, Milwaukee, WI, USA) for all participants. Lateral radiographs were obtained in 30° knee flexion to obtain a true lateral image. Axial images were taken in the Laurin's view position at 20° knee flexion. The principal investigator was present during all radiographs to ensure uniformity in the radiography procedure. A senior radiographer performed the X-rays in the presence of the principal investigator. A single Gollehon Extendable Goniometer with 1° increments (Model 01135 Lafayette Instrument Company, USA) was used to ensure the stated flexion angles in both positions and in all participants. The goniometer was placed at the knee with the anatomical reference of the lateral femoral epicondyle, greater trochanter and lateral malleolus to measure the knee flexion. As part of the primary study, antero-posterior view of the knee was also taken to rule out any other bony abnormalities. Positioning of the participants and capture of all the 3 X-rays together took about 10–15 min per participant.

2.3. Observers and X-ray assessment

The 3 observers were the principal investigator who is a Sports Physician with 4 years experience after post graduation, an Orthopaedic Surgeon with 2 years experience after post graduation and a Musculoskeletal Radiologist with 8 years of experience after post graduation. Each observer independently made 3 measurements on the lateral X-ray and 1 measurement on the axial X-ray. The 3 patellar height measures – Insall Salvati index (ISI), Caton Deschamp index (CDI) and Blackburne Peel index (BPI) were made on the lateral image and the sulcus angle was made on the axial image. All observers were provided with a brief document outlining the method of assessing each measurement with images as shown in Table 1. All observers entered their values in separate data entry sheets prepared for this study. Whereas the time taken for these measurements was not specifically noted, it took approximately 10 min per participant. Each observer was blinded to the measurements taken by the other 2 observers and also blinded to whether the participant had complaints or was painfree. The Physician and the Surgeon used a standard hand held ruler and X-ray goniometer (Saehan SH5106) for all measurements on physical prints of the digital images, and the Radiologist made measurements on the digital images using the inbuilt scales of the software - Medsynapse. Since clinicians and radiologists routinely adopt these respective techniques for measurements, this method was chosen to replicate the practical situation.

2.4. Statistical analysis

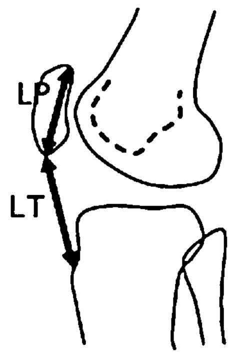
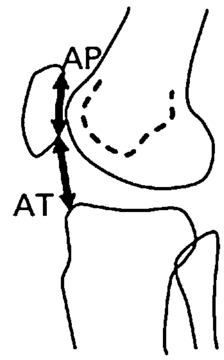
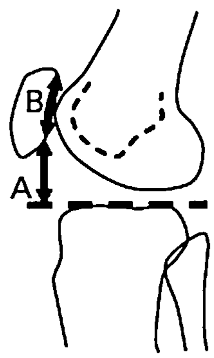
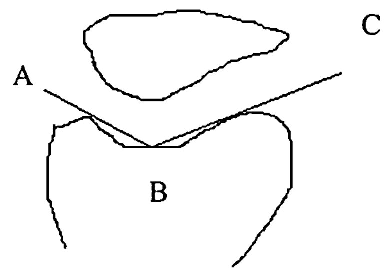
All the data was collated on a spreadsheet (Excel 2007, Microsoft, Seattle, WA, USA). Desccriptive analysis was done using the GraphPad quickcalcs (GraphPad Software, Inc. CA, USA) software online. Intraclass Correlation Coefficient (ICC 2,1) was chosen to compute the inter-rater reliability of the data since they were continuous variables. Reliability was assessed between all 3 observers. The ICC (2,1) value with 95% confidence interval was reported for all the measurements. MedCalc software (version 15.11.0, Ostend, Belgium) was used for statistical analysis.

3. Results

41 males and 33 females were included in the study. The demographic details of the participants are in Tables 2 and 3.

The Intraclass Correlation Coefficients (ICC) and 95% confidence interval for all the measurements are reported in Table 4. For ICC, reliability is defined as good or excellent (>0.75), moderate (0.5–0.75), acceptable (>0.6) and poor (<0.5).[10,12,21,22] To be useful, ICC

Table 1
Method of measuring each parameter.[19,20]

Insall-Salvati index Length of patellar tendon (LT) Length of patella (LP) Ratio = LT:LP		*Caton-Deschamp index* Distance between the inferior edge of Patellar Articular Surface (PAS) to the anterosuperior angle of tibial plateau (AT) Length of PAS (AP) Ratio: AT:AP	
Blackburne Peel index A horizontal line projected anteriorly from tibial plateau. Height from this line to inferior edge of PAS (A) Length of PAS (B) Ratio = A:B		*Sulcus angle* ABC is the angle formed by 2 lines drawn from the deepest point of the trochlear groove to the highest point on the medial and lateral femoral condyles	

should be 0.6 or more.[23] The inter-rater reliability among the 3 observers was moderate to good for all the patella height measurements. However, the ICC was higher for the ISI (0.74) and CDI (0.74) than BPI (0.67). The ICC for sulcus angle was excellent at 0.92 among all 3 observers and between each pair with narrow confidence interval.

Table 2
Gender distribution among the participants.

Patients		Controls	
Male	Female	Male	Female
20	17	21	16
37		37	

Table 3
Average age of participants.

	Patients		Controls	
	Male	Female	Male	Female
Mean age years (SD)	33.3 (10)	32.6 (8)	32.2 (8.6)	32.6 (11.1)
Median age years	33	33	32	30.5

4. Discussion

This study indicates that the inter-rater reliability for the commonly measured patella height indices – ISI, CDI and BPI is moderate to good and that for sulcus angle is excellent among the 3 observers of varied expertise in the Indian scenario. To our knowledge, this is the first time a study has been conducted in the Indian scenario and this is one of the few such studies worldwide in a large sample size. All the earlier studies[3,5–8,10–12] which have researched the inter-rater reliability of these indices except one[9] have been in the western setting in Europe and United States of America with many of them being lesser powered studies. Moreover many of the earlier studies assessed the reliability between 2 observers only[6,8,10,11] and many did not mention the description of the observers between whom the reliability was assessed.[6–8,10,11]

Our study was planned with a larger sample and 3 observers with varied expertise. Our study concluded that the patella height indices had moderate to good inter-rater reliability similar to the earlier reliability studies, but there was a difference compared to some of the previous studies in the most reliable index for patellar height. Our study reported a higher ICC for ISI (0.74) and CDI (0.74) than BPI (0.67). A very recent study by Duijvenbode et al. published in 2016 found the highest inter-rater reliability for ISI but the least

Table 4
Intraclass Correlation Coefficients (ICC) and 95% confidence interval for all the measurements.

	Insall Salvati index	Caton Deschamp index	Blackburne Peel index	Sulcus angle
ICC – single measures	0.74	0.74	0.67	0.92
95% CI	0.65–0.81	0.64–0.82	0.57–0.77	0.89–0.95

ICC, Intraclass Correlation Coefficient; For ICC, reliability is defined as good or excellent (>0.75), moderate (0.5–0.75), acceptable (>0.6) and poor (<0.5).

for CDI.[12] Retrospective nature of their study with no strict standardisation of procedure for lateral X-rays might be a reason for a low reliability of CDI. Previous studies by Chareancholvanich et al. and Nizic et al. also reported highest reliability with ISI and least with CDI.[9,11] However, the reliability values between the indices in the study by Nizic et al. differed only marginally and cannot be considered significant. On the other hand, Chareancholvanich et al. reported an ICC of 0.969 for ISI and 0.735 for CDI. Reliability of their study could be influenced by the fact that all their 3 observers were orthopaedic residents and no musculoskeletal radiologist was included like in our study or the study by Duijvenbode et al.

CDI was reported to have best inter observer reliability in a study by Aparicio et al.[24] However, they studied growing children unlike our study and the participants of most reliability studies. Smith et al. also obtained higher reliability for CDI compared to ISI and BPI in their study between pairs of 5 reviewers.[5] However, 95% confidence intervals were consistently wide for all measures in their study and lesser experienced reviewers had higher errors. Our results are unlike this study because we obtained narrow 95% confidence intervals.

BPI most consistently reproduced the patellar height index in studies by Seil et al. and Berg et al.[6,7] It is to be noted that the sample sizes in these 2 studies were only 22 knees and 15 patients respectively. Besides, the description of the observers and their experience was not mentioned in either of the studies. Even Lee et al. who reported an excellent reliability for BPI and ISI ($ICC > 0.94$), did not describe the profile of both their observers.[10] Our study reported BPI to have the lowest reliability among the 3 common indices. BPI requires that a parallel line be drawn along the tibial plateau. As discussed previously by Upadhyay et al. and Kate et al., projecting a line forward from the tibial plateau is difficult in squatters due to the presence of the quadricipital groove formed due to pressure of the ligamentum patellae on the upper end of tibia.[18,25] This might have been the cause of a lower BPI reliability in our study of squatting Indian population.

Similar to the previous studies on inter-rater reliability of radiographic patellar height indices, our study also concluded these indices had more than acceptable reliability. However, the most reliable among the 3 common indices did not concur with all previous research. Reliability of BPI in this Indian population was lesser proably due to less clear bony landmarks. Similar to BPI, CDI also requires precise identification of the proximal joint surface leading to lesser reliability in some studies where true lateral X-rays were not insisted upon.[12] Similarly, measurement of the ISI requires the precise location of the patellar tendon and its tibial attachment limiting its use in certain situations like osteoarthritis. For example: in osteoarthritis patients, Rogers et al. acknowledged difficulty of identifying the patellar tendon (ICC for ISI was 0.58).[8] We suggest the use of ISI, CDI and BPI in that order for measuring patellar height in the Indian population we studied – i.e. with anterior knee pain and normal population without knee complaints.

In our study the inter-rater reliability for sulcus angle was excellent between the 3 observers. Very few studies have assessed the reliability of sulcus angle in the past.[3,5] Similar to our study Davies et al. reported an excellent reliability of ICC -0.92 in their study.[3] However, Smith et al. concluded it to have poorer inter-rater reliability in their study.[5] Since the sample size of study by Smith et al. was large, the different study population of patellar instability patients can be the most probable reason for the discrepancy. Smith et al. had themselves discussed this discrepancy of variation in study population between their study and the previous study by Davies et al. The high reliability and narrow 95% confidence intervals of sulcus angle measurement obtained in our study in a large sample is conclusive that plain X-ray imaging is a reliable method for sulcus angle measurement in AKP patients and normal population in Indian scenario.

5. Conclusion

Our study concluded that there is an excellent inter-rater reliability for sulcus angle and moderate to good inter rater reliability for Insall-Salvati index, Caton-Deschamp index and Blackburne – Peel index among 3 independent raters of varying expertise. The reliability of ISI and CDI was higher than BPI in this Indian scenario.

6. Clinical significance and future

This is the first study to report the inter rater reliability of 4 commonly made X-ray measurements in the Indian scenario in a large Indian population. A lower reliability of the BPI compared to the ISI in this study could be due to the difficulty in projecting a horizontal line from the tibial plateau[18] in the squatting Indian population and thus signifying the importance of research in Indian context. This study is also among the few such inter-rater reliability studies worldwide with a large number of participants and with clear description of all 3 observers. It thus addresses the limitations of previous reliability studies which were highlighted in an earlier metaanalysis, ultimately adding light to the existing pool of knowledge. Knowledge of the most reliable patella alta index in Indians can guide clinicians and radiologists in reporting as well as for routine clinical use. Also, a high inter rater reliability of sulcus angle suggests that this X ray measurement can be reliably made in the scenario described. Whereas this is the 1st step towards establishing reliability of indices in Indian scenario, further steps would be to establish construct reliability of these measurements using Magnetic Resonance Imaging and Computed Tomography.

Authors contributions

Dr. Tvisha K. Parikh, P. Suresh, and Dr. Prabhu Radhan collected the data for the study, and in association with Dr. K.A. Thiagarajan, Dr. Prashant Jawahar, and Prof. S. Arumugam conceptualized and designed the study, interpreted the results, drafted and critically revised the article, as well as approved the article version to be submitted.

Conflicts of interest

The authors have none to declare.

Acknowledgements

The X-rays during the study were funded by the GATE – Young Faculty grant – 117/Dean/2012. Our sincere thanks to Head of department of Radiology, the Orthopaedics faculty and the Biostatistics faculty of the University for their Guidance. We thank Dr. Sharief Hendricks of for his critical comments on the manuscript. Our humble thanks to all the radiographers for their continuous co-operation.

References

1. Murray TF, Dupont JY, Fulkerson JP. Axial and lateral radiographs in evaluating patellofemoral malalignment. *Am J Sports Med.* 1999;27(5):580–584.
2. Teng HL, Chen YJ, Powers CM. Predictors of patellar alignment during weight bearing: an examination of patellar height and trochlear geometry. *Knee.* 2014;21:142–146.
3. Davies AP, Costa ML, Shepstone L, Glasgow MM, Donell S. The sulcus angle and malalignment of the extensor mechanism of the knee. *J Bone Joint Surg [Br].* 2000;82:1162–1166.

4. Sillanpaa P, Mattila VM, Visuri T, Maenpaa H, Pihlajamaki H. Ligament reconstruction versus distal realignment for patellar dislocation. *Clin Orthop Relat Res.* 2008;466:1475–1484.
5. Smith TO, Cogan A, Patel S, Shakokani M, Toms AP, Donell ST. The intra- and inter-rater reliability of X-ray radiological measurements for patellar instability. *Knee.* 2013;20:133–138.
6. Seil R, Müller B, Georg T, Kohn D, Rupp S. Reliability and interobserver variability in radiological patellar height ratios. *Knee Surg Sports Traumatol Arthrosc.* 2000;8(4):231–236.
7. Berg EE, Mason SL, Lucas MJ. Patellar height ratios: a comparison of four measurement methods. *Am J Sports Med.* 1996;24(2):218–221.
8. Rogers BA, Thornton-Bott P, Cannon SR, Briggs TWR. Interobserver variation in the measurement of patellar height after total knee arthroplasty. *J Bone Joint Surg [Br].* 2006;88-B:484–488.
9. Chareancholvanich K, Narkbunnam R. Novel method of measuring patellar height ratio using a distal femoral reference point. *Int Orthop.* 2012;36:749–753.
10. Lee P, Chalian M, Carrino J, Eng J, Chhabra A. Multimodality correlations of patellar height measurement on Xray, CT, and MRI. *Skelet Radiol.* 2012;41:1309–1314.
11. Nizic D, Pervan M, Kovacevic B. A new reference line in diagnosing a high-riding patella on routine digital lateral radiographs of the knee. *Skelet Radiol.* 2014;43(8):1129–1137.
12. Duijvenbode DV, Stavenuiter M, Burger B, Dijke CV, Spermon J, Hoozemans M. The reliability of four widely used patellar height ratios. *Int Orthop.* 2016;40(3):493–497.
13. Smith TO, Davies L, Toms AP, Hing CB, Donell ST. The reliability and validity of radiological assessment for patellar instability. A systematic review and meta-analysis. *Skelet Radiol.* 2011;40:399–414.
14. Rémy F, Chantelot C, Fontaine C, Demondion X, Migaud H, Gougeon F. Inter and intraobserver reproducibility in radiographic diagnosis and classification of femoral trochlear dysplasia. *Surg Radiol Anat.* 1998;20:285–289.
15. Mahfouz M, Fatah EEA, Bowers LS, Scuderi G. Three-dimensional morphology of the knee reveals ethnic differences – symposium: papers presented at the annual meetings of the knee society. *Clin Orthop Relat Res.* 2012;470(1):172–185.
16. Choon DSK. Commentary: position of the patella in adults in central India: evaluation of the Insall-Salvati ratio. *J Orthop Surg.* 2013;21(1):3.
17. Leung YF, Wai YL, Leung YC. Patella alta in Southern China. *Int Orthop.* 1996;20(5):305–310.
18. Upadhyay S, Raza HKT, Srivastava P. Position of the patella in adults in central India: evaluation of the Insall-Salvati ratio. *J Orthop Surg.* 2013;21(1):23–27.
19. Phillips CL, Silver DAT, Schranz PJ, Mandalia V. The measurement of patellar height. A review of the methods of imaging. *J Bone Joint Surg [Br].* 2010;92:1045–1053.
20. DeJour D, Saggin PRF. Disorders of the Patellofemoral Joint. In: Scott NW, ed. In: *Insall & Scott surgery of the knee* 5th ed. Philadelphia: Elsevier; 2012:601.
21. Dawson B, Trapp RG. Research question about one group.In: *Basic & clinical biostatistics*. 4th ed. McGraw Hill; 2004:119.
22. Wrobel JS, Armstrong DG. Reliability and validity of current physical examination techniques of the foot and ankle. *J Am Podiatr Med Assoc.* 2008;98(3):197–206.
23. Bruton A, Conway JH, Holgate ST. Reliability: what is it and how is it measured? *Physiotherapy.* 2000;86(2):94–99.
24. Aparicio G, Abril JC, Calvo E, Alvarez L. Radiologic study of Patellar height in Osgood-Schlatter disease. *J Pediatr Orthop.* 1997;17(1):63–66.
25. Kate BR, Robert SL. Some observations on the upper end of the tibia in squatters. *J Anat.* 1965;99:137–141.

Journal of Arthroscopy and Joint Surgery 3 (2016) 102–103

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Case report

An isolated displaced coronal shear fracture of humeral trochlea – A case report

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ARTICLE INFO

Article history:
Received 5 August 2016
Accepted 29 August 2016
Available online 10 September 2016

Keywords:
Coronal shear fracture of humeral trochlea
Laugier's fracture
Double arc sign
Osteochondral fracture
Shearing forces

ABSTRACT

Fracture of distal humerus usually involves capitellum and variable part of trochlea.[1] Trochlea fracture also known as Laugier's fracture, first coined by Laugier in 1853, rarely occurs in isolation. Coronal shear fracture of trochlea is rare because of deep location within the elbow joint and forces transmitted through coronoid of ulna are compressive rather than shearing and has no ligament or muscular attachments.

We would like to present an isolated displaced coronal shear fracture of trochlea in a young patient that was treated by open reduction and internal fixation.

1. Case report

A 25-year-right-handed man met with motor vehicle accident and fell down from motorcycle on an outstretched hand and presented with pain and swelling of right elbow on same day. Clinical examination revealed swelling and tenderness over medial aspect of elbow. Movements were painful and restricted. Neurovascular functions were intact.

2. What is your diagnosis

Radiographs revealed a half moon shaped fragment lying anterior and proximal to distal humerus in the lateral view (Fig. 1). In anteroposterior view, the fracture appeared to involve the trochlea. Computed tomography (CT) revealed fracture trochlea in coronal plane (Fig. 2). Informed consent was taken and open reduction and internal fixation done with 4 mm partial threaded screw through nonarticular surface by medial approach of elbow (Fig. 3). Postoperative period was uneventful. Early joint mobilisation was started. Patient was followed up over the time and was pain free with good range of motion without any instability (Fig. 4).

3. Discussion

Osteochondral fracture of distal humerus usually involves capitellum; similar injuries to trochlea are rare.[1] Forces transmitted from ulna across trochlea tend to produce compressive force by its wedging action than a shear. Shearing forces can be generated during elbow dislocation.[2] Trochlear fractures are associated with

Fig. 1. Lateral radiograph of elbow joint showing half moon shaped fragment lying anterior and proximal to diatal humerus – double arc sign.

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http://dx.doi.org/10.1016/j.jajs.2016.08.002
2214-9635/

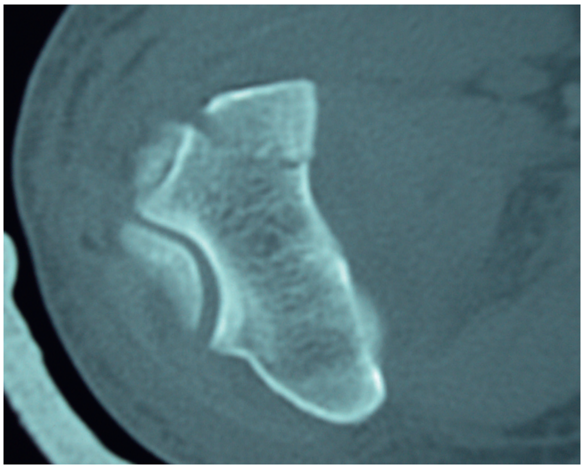

Fig. 2. CT showing trochlear fracture in coronal plane.

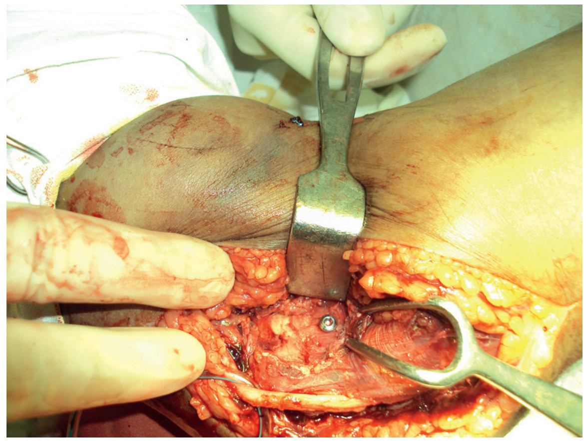

Fig. 3. Intraoperative photograph showing trochlear fracture fixed with partially threaded screw after anatomical reduction.

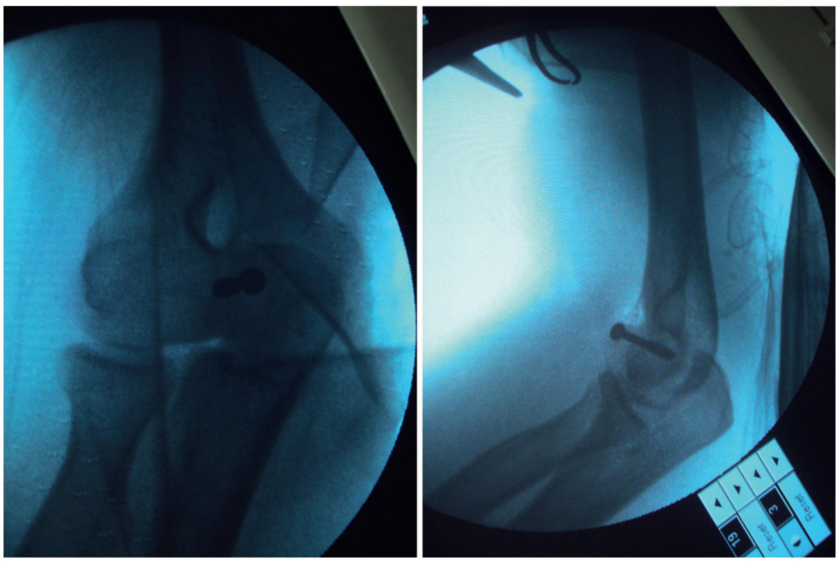

Fig. 4. Postoperative image showing trochlear fracture fixed with partially threaded cancellous screw.

elbow dislocation, capitellar fracture, ligament injuries, radial head or olecrenon fractures, extra-articular condylar fractures.[1,2]

Mechanism of injury is still uncertain. Worrel attributed the cause of an isolated trochlear fracture to a force transmitted from the palm through the ulna and to trochlea following a fall on an outstretched hand with extended elbow.[4] These fractures are difficult to assess on standard radiographs. In lateral view, half moon shaped fragment can be seen lying anteriorly and proximally involving the adjacent part of trochlea by double arc sign.[1,3] In AP view fracture of the trochlear region medial to midline should arise suspicion of trochlea fracture. Correlation with clinical findings is essential, when in doubt CT is helpful for delineating the extent and type of fracture more accurately.

For undisplaced fracture non-operative treatment is recommended. For small fragments, excision and early motion is described, but this may result in loss of articular surface and concomitant elbow instability.[1,5] For displaced fracture, anatomical reduction and internal fixation is essential but these are equally difficult to treat because of the limited availability of subchondral bone for stable internal fixation.[3] Early recognition, anatomical reduction, stable fixation and early motion reliably restore elbow function.

4. Conclusion

Isolated coronal shear fracture of humeral trochlea is rare and displaced fractures should be anatomically reduced and internally fixed. Early mobilisation is essential for good functional outcome.

Conflicts of interest

The authors have none to declare.

References

1. Dubberley JH, Faber KJ, Macdermid JC, Patterson SD, King GJ. Outcome after open reduction and internal fixation of capitellar and trochlear fractures. *J Bone Jt Surg Am.* 2006;88(1):46–54.
2. Hotchkiss RN, Fracture and dislocations of elbow. 4th ed. Rockwood CA, Green DP, Bucholz RW, Heckman JD, eds. *Fracture in Adult.* vol. 1. Philadelphia: Lippincott-Raven; 1996: 929–1024.
3. McKee MD, Jupiter JB, Bamberger HB. Coronal shear fractures of the distal end of the humerus. *J Bone Jt Surg Am.* 1996;78(1):49–54.
4. Worrel RV. Isolated displaced fracture of the trochlea. *N Y State J Med.* 1971; 71(19):2314–2315.
5. Mehdian H, McKee MD. Fractures of capitellum and trochlea. *Orthop Clin N Am.* 2000;31:115–127.

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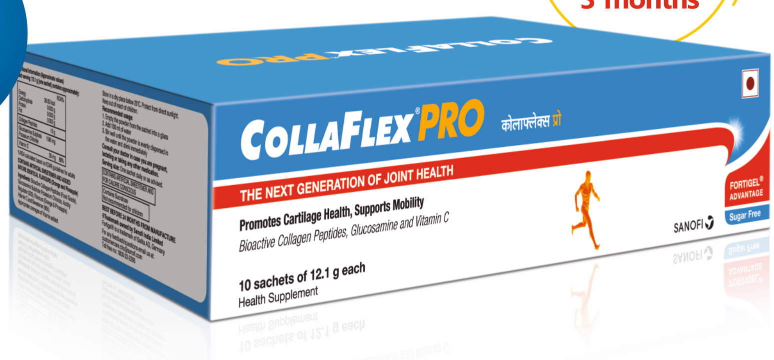

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