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Knee & Shoulder Arthroscopy And Arthroplasty ISKSAA

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

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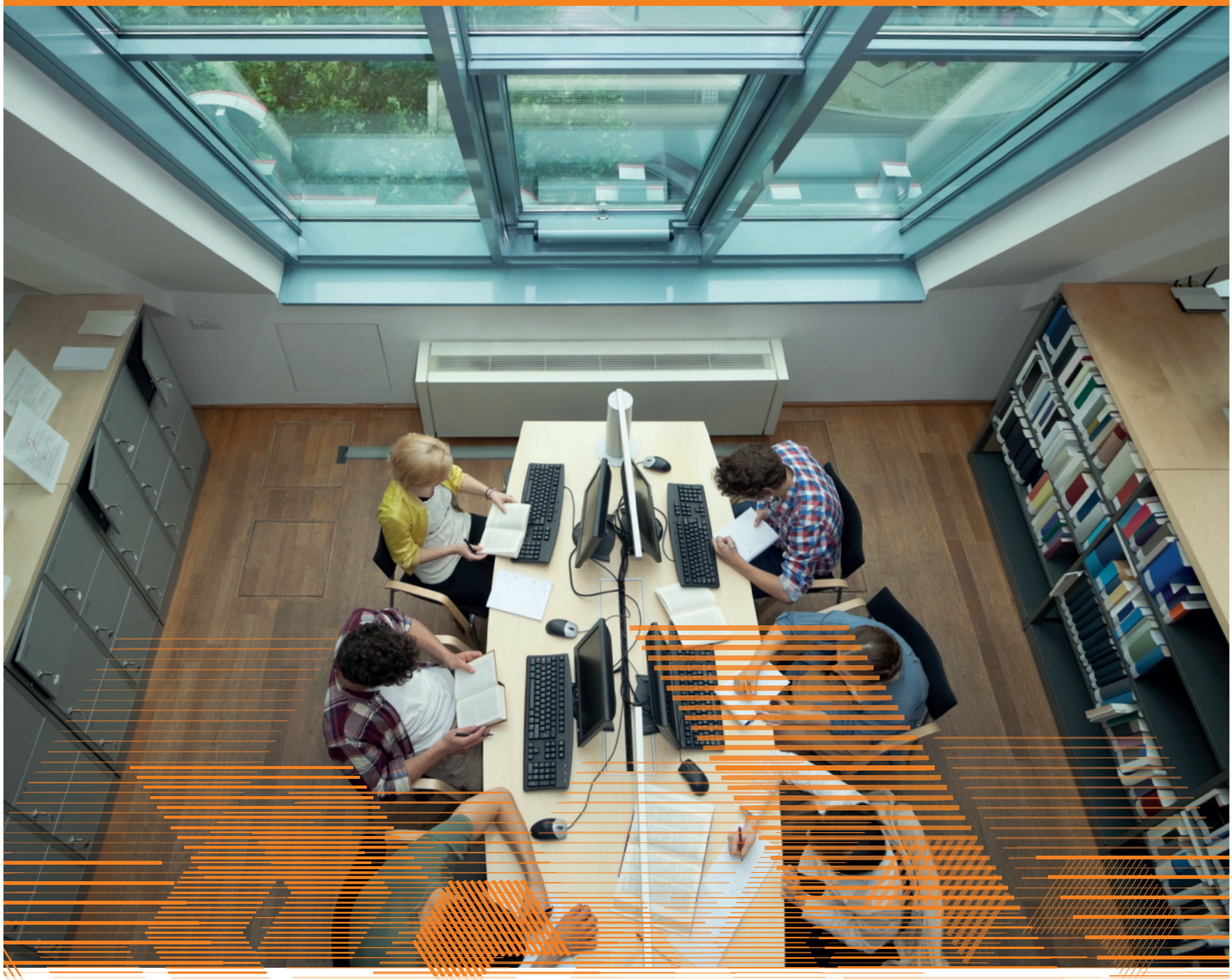

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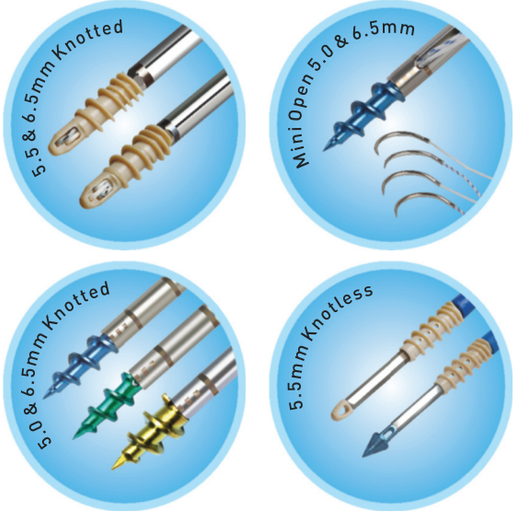

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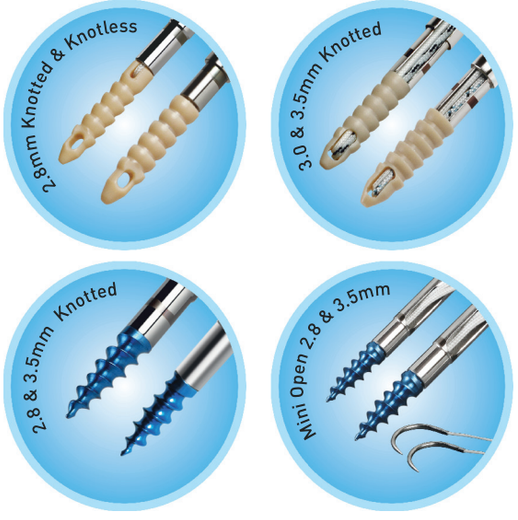

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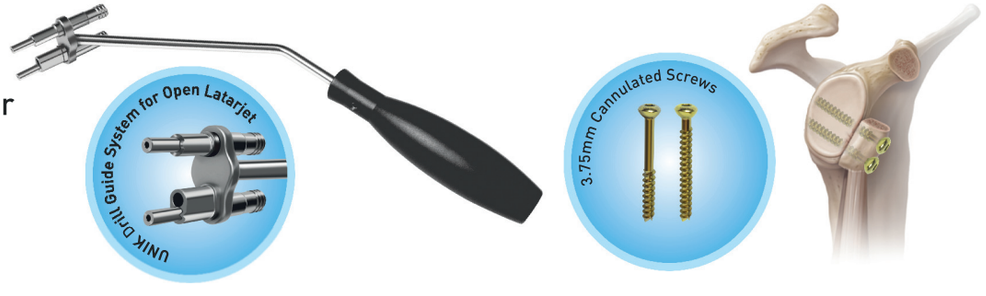

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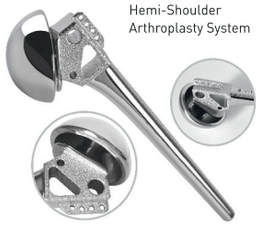

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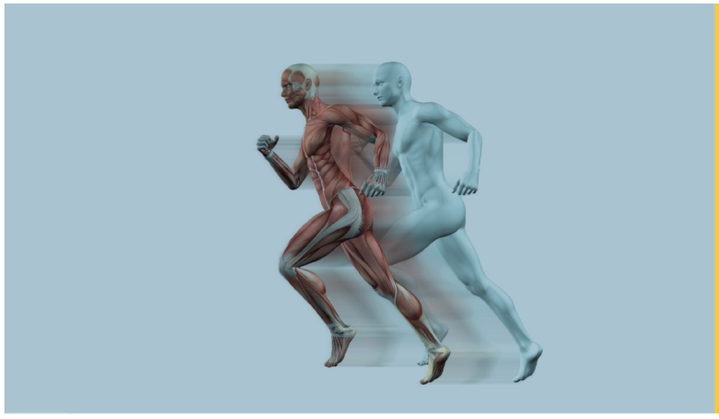

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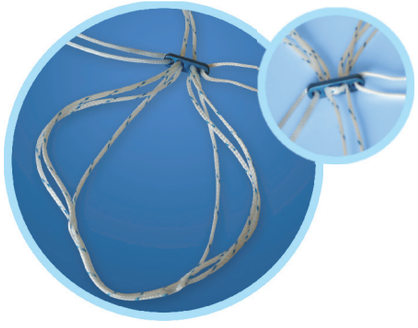

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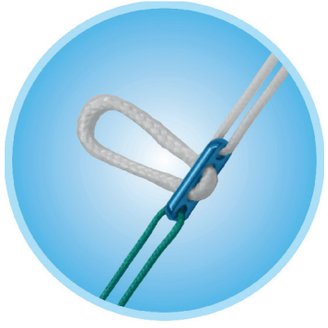

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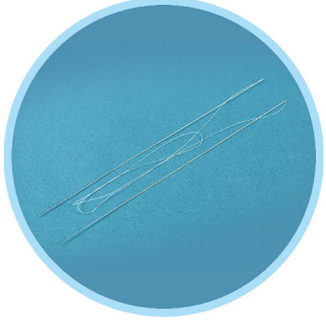

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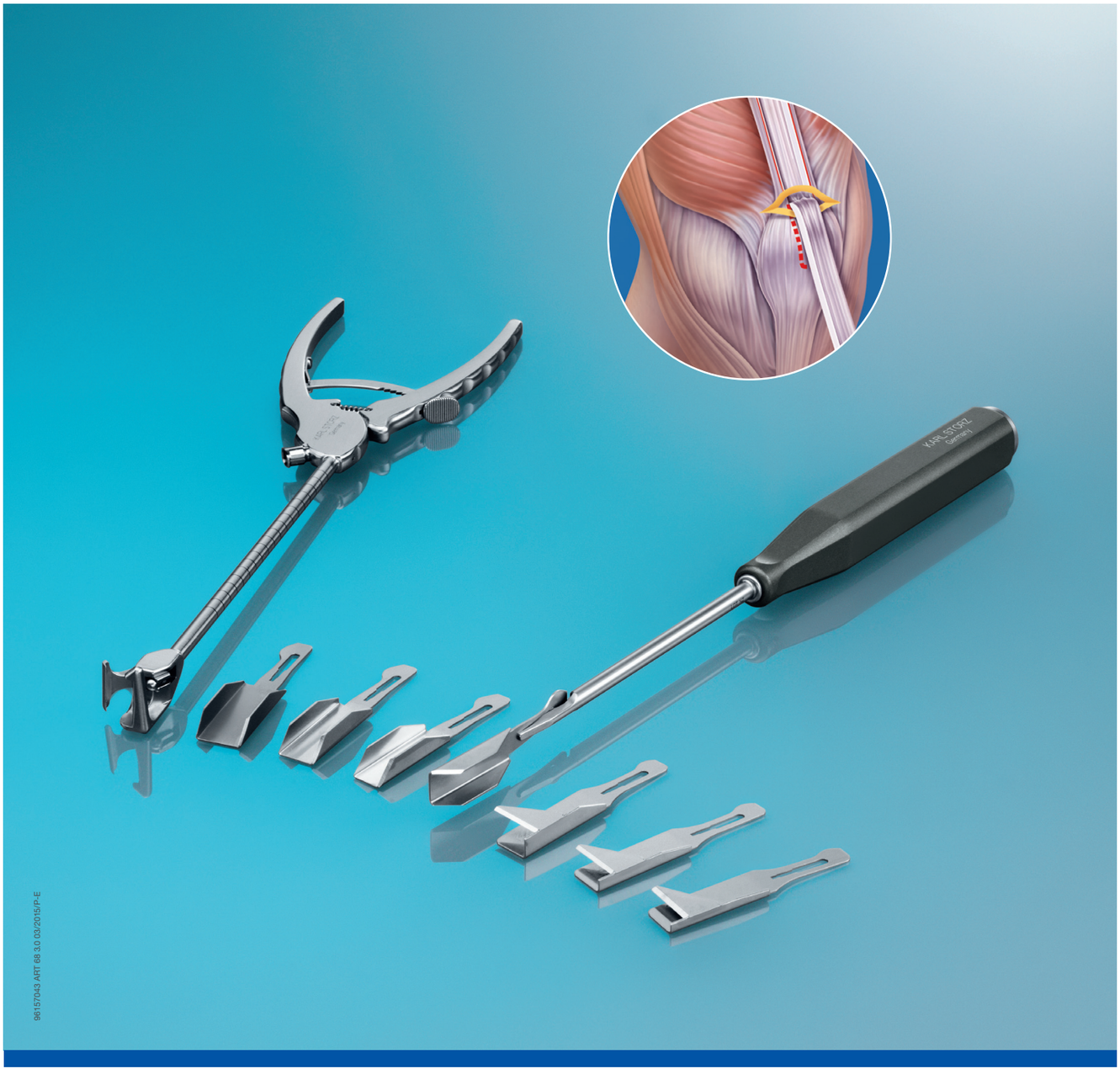

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Does Anterior Cruciate Ligament Reconstruction prevent or initiate Knee Osteoarthritis? -A critical review

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ABSTRACT

Anterior Cruciate Ligament (ACL) injuries are common in the knee and are often caused by sports injuries. These injuries are common among the young population of the society and are significant causes of morbidity and functional impairment. Arthroscopic ACL Reconstruction (ACLR) is considered as a gold standard in the management of ACL injuries. ACLR has been shown to restore the joint stability, and improve the functional outcome. Nevertheless, the role of ACLR in the prevention of development and progression of osteoarthritis (OA) of the knee has remained controversial. While some authors are of the view that ACLR has a protective effect in the prevention of OA of the knee, others share a contrary view that ACLR potentiates the progression of OA in these operated cases. This research paper aims to review the effects of ACLR in the prevention, development, and progression of OA, alongside other factors that may modulate these effects on patients.
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1. Introduction

Anterior Cruciate Ligament (ACL) injuries are common injuries to the knee and the incidence of ACL injuries is increasing due to greater involvement of the younger population in the sports activities.[1] These injuries are common among the young population of the society and are significant cause of morbidity and functional impairment. It is estimated that about 40% of all knee injuries are the ACL injuries.[2] The majority of complete ACL tear are now being treated surgically. However, in some cases with partial ACL tears, patients with low demand, etc. can be treated conservatively.[3] Arthroscopic ACL Reconstruction (ACLR) is considered as a gold standard for the management of ACL injuries.[4] It has been shown to restore the joint stability, and improve functional outcome. Nevertheless, the role of ACLR in the prevention, development, and progression of osteoarthritis (OA) of the knee has remained at best controversial. While some authors are of the view that ACLR has a protective effect in the prevention of OA of the knee, others are of the opinion that ACLR potentiates the progression of OA in these operated cases. This research paper aims to review the effects of ACLR in the prevention, development, and progression of OA, alongside other factors that may modulate these effects on patients.

1.1. Association of ACLR and knee OA

Arthroscopic ACLR, using autograft or allograft is the mainstay in the treatment of ACL injuries.[5–7] Opinions differ in the surgical techniques,[8] but the basic principles which include tunnel placement and graft fixation are universally applicable. The favorite choice of autograft includes patellar tendon, semitendinosus, and gracilis grafts. No autograft variety is found to have an advantage over the other in the protection against the development of OA, whether it is a hamstring or patellar tendon graft that is used.[9] The allografts available for ACLR are a patellar tendon, hamstring tendon, Achilles tendon graft, posterior tibialis tendon as well as the anterior tibialis tendon grafts. Tensions is usually maintained on the graft while bio-screws is used to fix the reconstructed ligament onto the femoral and tibial tunnels in case of bone-patellar tendon-bone (BPTB). The ACLR is widely used in the treatment of ACL injuries because of its proven benefits, like restoration of angular and rotational stability of the joint, restoration of the joint kinematics, improvement of the functional capacity of the patient, and improvement of the patient's well-being.[10–13] However, there is no consensus yet on the role of ACLR in the prevention of OA in the patients that had ACL injuries (Table 1).

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Table 1
Proposed effects of ACLR and Knee OA.

S/N	AUTHORS	YEAR	REFERENCE NUMBER	PROPOSED EFFECT
1	Paschos NK	2017	5	Deleterious
2	Leiter JRS et al.	2013	14	Deleterious
3	Neuman et al.	2008	15	Deleterious
4	Brambilla et al.	2015	16	Deleterious
5	Luc B et al.	2014	23	Deleterious
6	Struewer J et al.	2011	17	Beneficial
7	Lin SH	2017	22	Beneficial
8	Roemer FW et al.	2014	10	None
9	Lohmander LS et al.	2004	20	None
10	Feller J	2004	21	None
11	Magnussen RA	2013	26	None
12	Oiestad BE et al.	2010	28	None

In a study of 74 patients who had ACL injuries over a 12-year follow-up, Leiter et al. discovered that there was radiographic OA in 19% of the reconstructed knees as compared to 4% in the non-reconstructed knees.[14] They, therefore, concluded that individuals who had ACLR had a higher chance of developing OA than the people who did not have repairs.

In a study of 94 patients who had ACLR and were monitored for 15 years, Neuman et al. found that there was a relatively lower prevalence of patella-femoral OA in patients who had non-operative treatment compared to the patients that had an ACLR.[15] Patients treated conservatively had a prevalence of 3% as compared to the ACLR group where prevalence was 26.6%. They, therefore, concluded that ACLR might not be able to prevent the development of OA in ACL injured patients. Several factors (Table 2) have been proposed to increase the risk of development of OA.[16–18] Some of these factors like obesity are intrinsic to the patients while some predate the onset of the injury.

In a 13 year follow-up of 773 patients who had isolated ACL rupture and subsequently had ACLR, it was shown that 20% of the subjects had OA during the period under review.[19] Another study also showed that 6% of 221 subjects that ACLR had OA after being followed up for 12 years while the prevalence was 2.5% in the contralateral non-injured knees.[20] In a similar study of 249 patients who had single bundle ACLR following ACL injury that was monitored over seven-year period showed that the prevalence of radiographic OA in comparison with the contralateral knee was 39%.[21]

Whereas the works above showed that ACLR was to a reasonable extent associated with increased prevalence of OA, but some other works proved to the contrary. Roemer et al. (2014) showed that the prevalence of radiographic tibiofemoral and patella-femoral OA were 12% and 19% respectively in a study of 20 patients that had ACL injuries who were followed up for five years irrespective of the option of treatment used. In a similar study, it was found out that there was no significant difference in the prevalence of OA between the people who had ACLR and those that were treated non-operatively amongst 103 female soccer players who were monitored over a 12 year period.[22] Feller reported that there is no difference in the radiographic outcome between patients treated operatively and those that had conservative management among 238 male soccer players who followed up for 14 years after sustaining ACL injuries.[23] He concluded that ACLR did not protect against the development of OA.

The timing of surgery is also an essential factor that influences the development and progression of OA in ACL injured patients. In a review of 11,921 patients, Lin Sheng-Hsiung et al. pointed out that ACLR can only have a protective effect against the development of OA if the repair is done within one month of injury.[24] According to them, reconstruction done after one month of injuries does not protect against the development of OA. Hence, early arthroscopic ACLR reduces the chances of development and progression of OA in patients with ACL injuries.

1.2. Pathogenesis of ACL injury and knee OA

Osteoarthritis of the knee may be a late complication of ACL injury.[25] Individuals who had ACLR are at higher risk of developing OA than the general population. The exact pathogenic mechanisms through which ACL injuries cause OA are not known. However, some theories that attempt to explain the relationship between ACL injuries and the development of OA have been proposed (Table 3).

Initial impact at the time of the injury is believed to cause injury to the articular cartilage.[26] It is the forerunner of chronic degeneration of the cartilage and subsequently leads to OA. Moreover, there is a defect in the neuromuscular function following ACL injury that causes instability of the knee. In the injured knee, the synoviocytes and chondrocytes are stimulated to produce inflammatory mediators like interleukins 1, 6 and 8 as well as tumor necrosis factor (TNF). These chemical substances are believed to cause degradation of proteoglycans, collagen destruction, and chondrocytes necrosis. The resultant effect of these is the destruction of articular cartilage and subsequent development of OA. Steroids may have a role in the inhibition of these injurious cytokines which may again be tested at large scale. Similarly, the role of biological treatment like platelet-rich plasma (PRP) and stem cells have not been researched extensively. Hence their relevance remains at best experimental.

Changes in the axial loading of the injured are also responsible in the development and progression of OA. It is because an ACL injury causes joint instability which increases shear stress on the menisci and articulating surfaces of the knee and invariably leads to chronic degeneration and development of OA.

Meniscal and cartilage injuries have been implicated in the

Table 2
Factors responsible for increased risk of OA after ACLR.

INHERENT	
1	Concomitant or secondary meniscal tear
2	Concomitant or secondary articular cartilage injury
3	High Body Mass Index (BMI)
4	Older age of the patient at the time of ACLR
5	Metabolic response of the joint to operative trauma
SURGICAL	
1	Operative trauma to the cartilage
2	Menisectomy
3	Post-operative haemarthrosis
4	Post-operative ankylosis
5	Abnormal joint mechanisms following surgery
6	Prolonged inflammation post-operatively

Table 3
Pathogenesis of ACL injury and Knee OA.

Pathogenesis of ACL injury and Knee OA	
1	Concomitant articular cartilage injury
2	A defect in neuromuscular function
3	Production of inflammatory mediators
4	Changes in the axial loading of the knee
5	Concomitant meniscal injury

development and progression of OA in ACL injured knees.[27–30] In a particular study, the prevalence of OA in isolated ACL injury was 13% compared to 48% where there was associated meniscal injuries. Menisectomy either done before ACLR or done concurrently increases the likelihood of developing OA. Menisci help in the maintenance of the anteroposterior stability of the knee joint.[31] Menisectomy reduces the contact area and increases the shear stress on the knee. It also reduces the load-bearing capacity of the joint thereby causing derangements of the structural integrity of the joint. Therefore, ACL injuries in combination with meniscal injuries lead to increased joint instability, distortion of the joint kinematics, as well as causing differential axial loading of the joint. Moreover, a combination of meniscal injury and cartilage increase the chances of developing OA of the knee in ACL injured patients. It is because articular cartilage damage is one of the early events in the development of Knee OA. These entire factors will lead to development and progression of OA in ACL injured patients. Besides, meniscal repair is also found to increase the prevalence of OA. Nevertheless, the intact meniscus is better than absent meniscus. Meniscal repair is preferable to menisectomy with regards to reduction of OA in ACL injured patients undergoing ACLR.

Surgical techniques can also influence the development of OA in ACL injured patients. Although the choice of grafts and tunneling techniques may not play any role in the development of OA, recreating normal biomechanics remains a challenge. A too tight or too lax ligament, abnormal placement of the tunnels, and an iatrogenic injury to the ligament may potentially increase the chances of OA. Surgical outcome improves with experience, and the use of technology will be of much help in reducing the prevalence of OA. Choice of reconstruction method and rehabilitation can better be utilized to improve outcome and therefore reduce the prevalence of OA in ACL injured patients.

The timing of the surgery is also crucial in determining the development of OA. The prolongation of interval time between onset of injury and surgical intervention can lead to increased joint instability. It is because there will be progressive continuous disruption of the intra-articular structures if the repair is not done early enough especially if there are concomitant osteochondral injuries. The chances of development of OA in an ACL injured knee is said to increase at the rate of 0.6% per month of delay. Hence, it is advisable that if repair contemplated, it should be done within one month of injury. Increased length of follow-up also increases the risk of OA. In a study of 249 patients who underwent ACLR following ACL injuries, Li et al. showed that 64.8% of the individuals who had prior menisectomy had OA while 84.2% of the patients that had concurrent menisectomy developed OA. In the same study, only 34.6% of the patients that did not have menisectomy developed OA.

2. Conclusion

Anterior cruciate ligament (ACL) injuries are common in sportsperson especially in the young segment of the population. These injuries often lead to loss of person-hours and reduced functional capacity of the affected individuals. Arthroscopic ACL reconstruction (ACLR) is considered the gold standard of treatment because it gives good functional restoration and improved patients' satisfaction. Contrary to popular belief, an ACLR has been shown not to protect against the development and progression of osteoarthritis (OA) of the affected knee. Development and progression of OA of the affected knee are potentiated in the presence of meniscal or chondral injuries or when surgery of the meniscus is carried out. Hence, we recommend that the patient who had ACL injury should be thoroughly evaluated to rule out associated osteochondral and meniscal injuries. These patients should not only be counseled on the standard of treatment of arthroscopic ACLR but should also be informed that an ACLR may not protect their injured knee against the development of OA. The surgery may even lead to an early onset of OA, especially if the surgery is not done early or if there is presence of meniscal and osteochondral injuries.

Conflicts of interest

The authors declare that there is no conflict of interest.

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Nil.

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Is chronic ACL tear a cause of adult acquired flat foot?

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ABSTRACT

Purpose: To verify the concept of adult acquired flat foot following ACL rupture by Podogram method comparing injured and non injured sides.
Material and method: From January 2017 to July 2017, Patients who had unilateral and chronic ACL rupture, confirmed clinically and on MRI, formed the material of present study. In all the patients who could stand a Podogram was obtained of foot on a Graph paper including both injured and uninjured sides. On the podograms the area occupied by weight bearing portion of foot was measured.
Results: Total number of patients studied were 23. Total number of podograms were 46. The mean value of area occupied on podogram on injured and non injured side were 115.26 and 102.36 respectively. The range of difference between the podograms of both limbs (ACL ruptured and normal) was 0.00 cm^2 −43.75 cm^2 calculated p value was 0.0109 which was statistically significant.
Conclusion: The Podogram data of ACL ruptured limb and uninjured contralateral limb are in support of our hypothesis of Adult Acquired Flat foot in ACL ruptured patients.
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1. Introduction

The knee joint is the most commonly injured of the all joints and the ACL is the most common injured ligament.[1] The modern high speed vehicle trauma and sporting lifestyle has lead to increased ligament injury to the knee. The ACL is the primary stabilizer of the knee which prevents anterior translation of knee[2] and provides secondary rotational stability.[3]

In the United States The annual incidence is 68.6 per 1,00, 000 persons per year, in India no accurate statistical data available as no centralized registry to be followed but in all major centers arthroscopic ACL reconstruction is a regularly done surgery accounting for approximately 80% of post traumatic knee arthroscopy. Incidence is significantly higher in male patients than in females. Age specific pattern differs in male and female with peak incidence between 14 and 18 years in females and 14 to 25 in males.[4]

ACL insufficiency results in deterioration of the normal physiological knee bending leading to increase in anterior tibial translation, internal tibial rotation and increase in valgus instability. This leads to increased mean contact stress in the posterior, medial and lateral compartments, producing early OA changes in the knee.[5] To counter act valgus instability in ACL deficient knee, patients develop flattening of medial arch producing flat foot on the affected side. This type of adult acquired flat foot is less recognised and published studies on this peculiar aspect of adult acquired flat foot in ACL ruptured limbs are rare.

According to our knowledge and experience this is the first study of its kind. This article aims to assess twenty three cases of ACL ruptured knee, evaluated using podogram and compared with contralateral foot to find out any statistical significance. We hypothesize that there is no difference in podogram of a normal knee and an ACL ruptured knee.

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2. Material and method

This is a consecutive case study done in department of Orthopaedics, from January 2017 to July 2017. It includes 23 cases of isolated unilateral chronically ruptured (>6 months) ACL deficient knees. It also includes cases of failed ACL reconstruction. We excluded patients with multi ligamentous injury, isolated PCL injury and patients with pre existing causes of flat foot.

After taking proper history of selected patients, all patients were evaluated clinically with Lachman test, Anterior drawer test by the same senior surgeon. MRI was done for all patients.

All MRI proven ACL injured patient's podogram taken pre operatively for both the feet. For taking podogram, first both feet washed and then cleaned with spirit. After that thorough ink applied with ink pad evenly all over one foot. Then subject is asked to stand on one graph paper on plain surface with single leg stance, and footprint recorded on graph paper. Same procedure is then repeated on other side. Borders of footprint are marked on graph paper and then squares covered by foot print measured and area calculated in square centimetres (Figs. 1 and 2).

3. Results

Out of total 23 cases evaluated, 18 patients were male and 5 were female.

Maximum age was 49 years and minimum being 17 (mean age – 32.2 years). Maximum age among male patients was 47 years and minimum was 19. In female patients maximum age was 49 and minimum 17 (Table 1).

Right side was affected in 14 patients and left in 9.

Highest difference among the calculated area between affected and non affected foot was 43.75 cm^2. One patient had no difference between the affected and non affected feet.

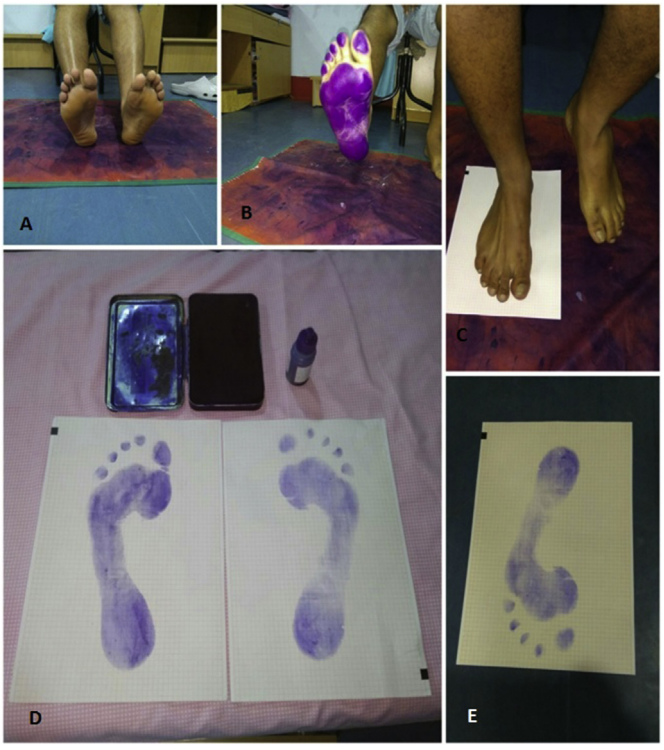

Fig. 1. 1 A-prepared feet after cleaning with spirit 1 B- ink applied thoroughly on the foot 1 C- podogram being taken with full weight bearing on one leg. 1 D & E-shows podogram of both the feet.

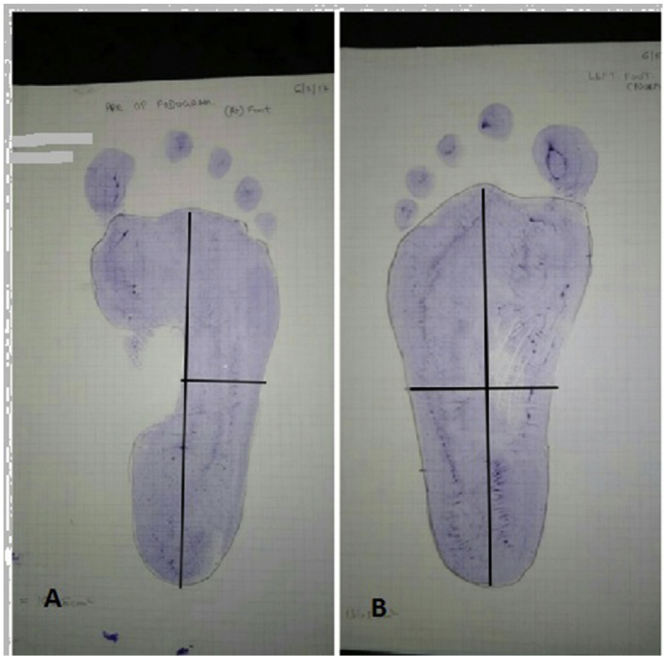

Fig. 2. 2 A-podogram of the unaffected limb measuring 106.5 cm^2 2 B- podogram of the affected limb measuring 131.5 cm^2.

In a study of 23 cases of ACl injury, after statistically analyzing data by PSPP software after using appropriate statistical test we found mean of area occupied by affected leg is 115.26 cm^2 (SD = 18.92) compared to 102.36 cm^2 (SD = 13.57) on non affected leg which comes out to be statistically significant after applying paired *t*-test (Fig. 3). Standard error of mean is 4.855 with 95% confidence interval of 3.1156 (lower) and 22.6844 (upper). P value came 0.0109, as it is < 0.05, it is statistically significant (Table 2).

4. Discussion

Several theories and anatomical variation have been described to explain pes planus like posterior tibial tendon dysfunction, tarsal coalition, inflammatory arthropathy, tarsometatarsal osteoarthritis, neuromuscular disease or traumatic dysfunction of mid foot, but after vast literature search, none of the studies has thrown light on flat foot acquired in ACL deficient knee. ACL being a common injury nowadays with increased sports injuries and road traffic accidents, it can be a measure cause of adult acquired flat foot.

Study by Paulo Cesar de Cesar[6] concluded that people having high medial longitudinal arch are more prone for ACL injury, but their study doesn't comment upon what changes occur in foot arch after ACl rupture.

Podogram has been used to assess the flat foot in many studies.[7,8] Yifang Fan[9] conducted a study using 3D foot scanning system to obtain static footprints from subjects adopting a half-weight-bearing stance.

We found only one research, conducted by Engin Cetin,[10] evaluating distribution of plantar pressure in patients who have ACL deficiency, comparing preoperative and postoperative changes. Using pedobarography they found out reduced hind foot pressure and increased mid foot pressure in ACL deficient knee. They concluded ACL-deficient patients have altered plantar pressure distributions and ACL reconstructions restore these changes to normal. They attributed this to quadriceps weakening and quadriceps avoidance gait. This increased mid foot pressure can be the cause of flat foot which we recorded in the form of increased area in

Table 1
Showing podogram area on affected and non affected side along with difference.

S. no.	Age (years)	Sex	Affected side	Pre op podogram area on affected side (cm^2)	Pre op podogram area on non affected side (cm^2)	difference	%Difference (as compared to non affected side)
1.	27	M	RT	130	125	5	4
2.	49	F	RT	88.5	78	10.5	13.46
3.	25	M	LT	109.25	107.75	1.5	1.37
4.	35	M	LT	131.5	106.5	25	23.47
5.	20	M	LT	115.4	111.5	4	3.56
6.	27	M	RT	100	96.5	3.5	3.62
7.	39	M	RT	112.5	111	1.5	1.35
8.	47	M	RT	125	117	8	6.83
9.	19	M	LT	110.5	110.5	0	0
10.	33	M	RT	145	117.5	27.5	23.4
11.	17	F	LT	89.25	85	4.25	4.7
12.	40	F	LT	85	75	10	11.76
13.	25	M	LT	115	99.75	15.25	13.26
14.	37	M	RT	142.5	122.5	20	16.32
15.	28	M	RT	117.5	109	8.5	7.79
16.	44	M	LT	131.25	99	32.25	24.571
17.	29	M	RT	122.5	110	12.5	11.36
18.	30	M	RT	150	106.25	43.75	41.27
19.	41	F	LT	91.25	82.5	8.75	10.60
20.	26	M	RT	135	101.25	33.75	33.33
21.	46	F	RT	103.375	91.75	11.62	11.24
22.	23	M	RT	99	94.37	4.63	4.92
23.	34	M	RT	101.87	96.75	5.12	5.29

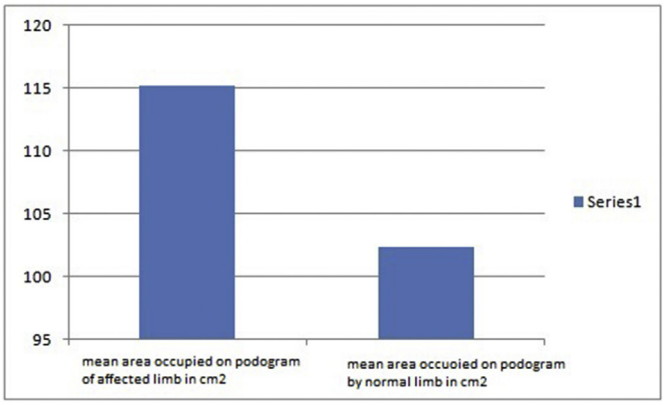

Fig. 3. Bar diagram showing mean area occupied by affected and normal limb on podogram in cm^2.

Table 2
Mean podogram area in cm^2 with Standard deviation and p value of affected and non affected foot.

	Mean (cm^2)	Sd	P value
Preoperative affected	115.26	18.92	
Preoperative non affected	102.36	13.57	0.0109

the respective podogram.

Shabani[11] et al. conducted a 3D kinematic assessment of 30 ACL deficient knee and compared them to 15 normal healthy knees. They noticed significant lower extension of the knee joint during stance phase and significant difference in tibial rotation angle. The patients with ACLD rotated the tibia more internally during the mid-stance phase. In another study done by Xiaobing Yu[12] et al. using 3D motor analysis system, results showed that flexion extension rotation angle (FERA), internal and external rotation angle (IERA) and varus eversion rotation angle (VERA) were significantly different between the ACL injury group and the healthy control group. In the swing phase of a gait cycle, knee flexion angle, tibial external rotation and varus reached maximum. In the stance phase of a gait cycle, the extension, tibial internal rotation, varus angles reached maximum. In the healthy control group, FERA, IERA and VERA varied within a narrow range, while in the ACL injury group, FERA, IERA and VERA varied at a significantly larger range.

Guoan Li[13] and co workers in their study focused more on mediolateral translation and varus-valgus rotation of knees in ACL deficient people where ACL deficiency alter both the mediolateral tibial translation and valgus –varus rotation under various loding condition, the increased medial tibial translation shifts the contact in the medial compartment towards medial tibial spine. So in our study we assumed that to compensate the knee valgus foot tries to accumulate more space and goes in flat foot position. We took podogrm before surgery so hamstring deficiency post ACL reconstruction is not contributing to additional valgus. Due to loss of ACL, instability occurs causing loss of secondary restrain to knee varus–valgus movements, which is compensated by flat foot position, or due to loss of proprioception feedback mechanism, foot require more space on ground for better stability, which is seen as a flat foot.

There are many studies on flat foot showing flat foot people are more prone for ACL injury during normal landing and deceleration. In a meta analysis Tong[14] concluded that increased lower extremity injuries are associated with both high arch and flat foot. Flat foot leading to ACL injury can be distinguished with ACL injury leading to flat foot by unilateral nature of the flat foot, difference in the area occupied by the affected and non affected on the podogram and finally by the reversal of the flat foot after ACL reconstruction.

In a long term study comparing gait and initial impact loading between healthy cohort and ACL reconstructed group, results suggest that there continues to be unresolved gait adaptations that lead to greater impact loading even after rehabilitation has been completed.[15] In another study comparing gait pattern post reconstruction states that the gait parameters shift towards the normal pattern.[16] So a long term follow up is required post ACL reconstruction to find out effect of ACL reconstruction on this type of acquired flat foot.

As with other studies, this study also has limitations. A large

sample size can add more information to this topic. As isolated chronic ACL tears are rare, a longer duration is required for study to increase the sample size. Sample size involving different demographic areas can be more beneficial. Another parameter for evaluation of flat foot can be added in the form of weight bearing radiographs. This will help in more accurate evaluation of affected and non affected limbs. Further studies with long term follow up after ACL reconstruction can throw light on whether this kind of adult acquired flat foot is reversible or irreversible after proper physiotherapy.

5. Conclusion

The Podogram data of ACL ruptured limb and uninjured contralateral limb do not support our null hypothesis. There is significant difference between the area measured on podogram between ACL deficient knee and normal knee indicating that it is a kind of acquired flat foot due to ACL rupture which causes changes in gait pattern.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jajs.2019.06.002.

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Comparing clinical and patient reported outcomes of suture anchor and transosseous repairs of quadriceps tendon rupture

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ABSTRACT

Quadriceps tendon ruptures are relatively uncommon but severe injuries to the extensor mechanism are usually treated surgically. The purpose of this investigation was to compare the results following a standard transosseous (TO) repair to a suture anchor (SA) repair. A retrospective cohort was analyzed from a single institution with a total of 10 SA and 17 TO repairs meeting inclusion criteria. Average clinical follow up was 5.8 months and 15.2 months for the SA and TO groups, respectively. Re rupture rates were 9% and 13%, with total complication rates of 27% and 32% for the SA and TO groups, respectively. Knee flexion was 117° for SA repairs and 128° for TO repairs after a minimum of 3 months. Mean Lysholm scores were 63 and 72.8, recorded at a mean of 4.7 years and 5.5 years after the SA and TO repairs, respectively. Operative time was similar between both groups at 93 min and 90 min for the SA and TO groups, respectively. This study showed that the clinical results, re rupture rates, complications, and operative times were similar between suture anchor and transosseous repairs of the quadriceps tendon. Therefore both techniques are appropriate for the management of this debilitating injury.
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1. Introduction

A rupture of the quadriceps tendon is a relatively uncommon injury representing 1.3% of musculoskeletal soft tissue injuries, and typically occurs in patients that are older than forty years of age.[1] A tension failure of the extensor mechanism often occurs via a forceful contraction of the quadriceps muscles on an eccentrically loaded knee, as may occur while catching a fall. Frequently these patients have conditions that predispose them to having an unhealthy tendon, such as diabetes, renal failure, hyperparathyroidism, rheumatoid diseases, metabolic abnormalities, and/or collagen diseases. Other reasons for an unhealthy tendon include obesity, and use of certain medications such as anabolic steroids, corticosteroids, statins, or quinolones.[2] Ruptured tendons have been shown to harbor histopathological degenerative changes such as hypoxic degenerative tendinopathy, mucoid degeneration, tendolipomatosis, and calcifying tendinopathy.[3] A rupture of the quadriceps tendon usually disrupts the extensor mechanism, causing a persistent extensor lag and precludes efficient ambulation. Physical examination findings often include a palpable suprapatellar gap, acute anterior knee pain, and the inability to extend the knee. Due to the often-poor results of non-operative treatment, surgical intervention is usually the treatment of choice.[2,4]

The end-to-end repair of quadriceps tendon injuries has been reported as far back as 1887, when McBurney repaired the tendon with catgut and silver wire with perfect recovery of function. In the first large-scale report of the injury, Siwek and Rao reported on 33 patients with 36 quadriceps ruptures. Based on their experiences, they advocated immediate end-to-end repair with immobilization in a cylinder cast for 6–10 weeks. Some of their repairs were augmented by Bunnell pull-out wires, rectus femoris tendon flaps, or circumferential wires through the intact quadriceps tendon secured to a *trans*-patellar bolt.[5] Contemporary authors have advocated end-to-end repair for mid-substance tears or a technique of transosseous suture repair for avulsions of the tendon from the patella ([6,7]). Given the rarity of quadriceps tendon ruptures, the

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evolution of treatment options has lagged behind other more common soft tissue injuries, such as those occurring in the shoulder and ankle.[8,9]

Suture anchors have recently been employed in quadriceps tendon repair.[10–14] Suture anchors have been noted to have equivalent strength to the transosseous tunnels in biomechanical testing, but no clinical comparisons between standard and suture anchor repairs are available. In order to obtain a better understanding of the viability of this new technique, we performed a retrospective series to compare all suture anchor (SA) repairs and transosseous (TO) repairs performed at our institution over a ten-year period. In particular, there was a focus on the complication rates, clinical outcomes, and patient reported outcomes of each technique.

2. Materials and methods

Patients were selected by searching our surgical database for those who had undergone quadriceps tendon repair at our institution between 2004 and 2014. Patients were excluded if their repair wasn't acute (more than 2 weeks after injury), if they failed to follow-up, if a technique other than transosseous sutures or suture anchors was used, and if the injury was not isolated to the quadriceps tendon. Approval from our institution's institutional review board was obtained. A total of 55 patients were identified with 27 meeting our inclusion criteria. Four patients were excluded due to graft augmentation, 2 had direct repairs, 1 had a chronic TO repair, and 1 had a SA repair in the setting of a total knee arthroplasty. Of the remaining eligible patients 20 were lost to follow-up prior to their 2-month clinical check.

Operative reports, radiographs, and follow up notes were available for review. Patient demographics including age, gender, body mass index (BMI), and comorbidities were recorded. Details about the operation including the surgical time, type of repair, number and type of sutures and/or suture anchors, and suture configuration were also noted. Postoperatively, attention was paid to their strength, range of motion, and if the presence of an extensor lag existed. The charts were specifically reviewed for complications including the occurrence of re-rupture, superficial or deep infection, reoperation for any cause, and venous thromboembolism.

To determine patient reported outcomes a standardized telephone questionnaire was administered. Patients were asked: 1) Have you undergone any further surgeries or procedures for your knee? 2) Are you satisfied with the results of your quadriceps tendon repair? The Lysholm score, a validated patient reported outcome score focusing on activities of daily living, was also recorded for each patient.[15] In the case of patients with bilateral injuries no effort was made to obtain separate scores for each knee.

2.1. Surgical technique

The patient is placed supine on the operating table and induced with general anesthesia. A pneumatic tourniquet is placed on the proximal thigh and the extremity is prepared and draped in sterile fashion. The limb is exsanguinated and the tourniquet is inflated. A midline incision is made from about 6 cm proximal to the patella extending to just past the proximal pole for SA repair or just distal to the distal pole for TO technique. At this point the dissection is carried down to find the quadriceps tendon rupture. The retinaculum is inspected on both the medial and lateral sides to visualize the extent of tearing. All hematoma is debrided, along with the frayed edges of tendon and any fibrous tissue is removed from the proximal pole of the patella. The superior pole of the patella is decorticated to create a small trough to expose a bleeding cancellous bone surface.

For the transosseous tunnel repair 2 heavy non-absorbable sutures are woven into the quadriceps tendon utilizing a locking Krackow whipstitch.[16] Depending on surgeon preference, #2 or #5 Fiberwire (Arthrex, Inc., Naples, Florida) or Ethibond (Ethicon Inc., Johnson & Johnson, Somerville, NJ) were utilized. Three parallel drill holes are made through the patella from proximal to distal (1 central, 1 medial, and 1 lateral). The 4 strands of suture are subsequently shuttled through the drill holes (2 centrally) and tied over the distal patella with the knee in full extension.

For the suture anchor repair (see Fig. 1) a pilot drill hole may be made to the intended depth of anchor placement with a 2.5 mm drill, depending on surgeon preference. In general 2 suture anchors are placed in the superior pole of the patella. The most commonly used anchors at our institution have been 5 mm and 6.5 mm titanium corkscrew anchors (Arthrex Inc., Naples, Florida), though biocomposite and all suture anchors have also been utilized. These are loaded with #2 Fiberwire which is then woven into the quadriceps tendon using a modified Mason-Allen configuration as described in previous reports.[12–14,17]

Following the tendon repair, the retinaculum is repaired and the skin is closed according to surgeon preference. The patient's leg is placed in a knee immobilizer or hinged knee brace locked in extension and the patient is made weight bearing as tolerated with crutches. The physiotherapy regime includes physical therapy focusing on passive range of motion for the first six weeks, followed by active range of motion until 12 weeks and finally gradual resistance training until 6 months.

2.2. Statistics

For categorical data the Fischer's exact test was utilized. For continuous data the student's t-test was utilized. Significance values were set at 0.05. Patients with re-rupture or hardware failure were excluded from ROM and strength analysis. A power test was not performed at the beginning of the study due to the low incidence of this type of injury (<1.37/100,000 patients per year).[25]

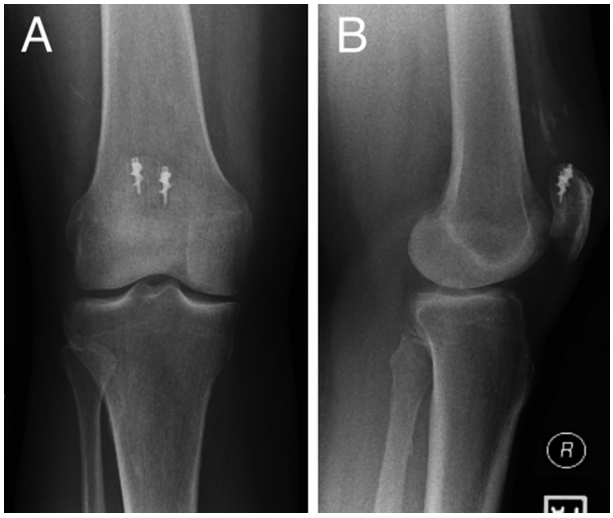

Fig. 1. (A) Anteroposterior and (B) lateral radiographs following SA quadriceps tendon repair with two titanium anchors.

3. Results

3.1. Demographics

Out of patient who met our inclusion criteria we identified 10 patients with 11 repairs in the suture anchor group and 17 patients with 22 repairs in the *trans*-osseous tunnel group. The mean age was 54 years (range 35–74) for the SA group and 49 years (range 33–68) for the TO group (Table 1, $p = 0.18$). There were 8 males and 2 females in the SA group with 15 males and 2 females in the TO group. Average BMI was 33.9 for SA and 34.5 for TO ($p = 0.89$). In aggregate 40.7% of patients had a BMI less than 35 and 59.3% had a BMI of 35 or greater. Clinical follow-up averaged 5.8 and 15.2 months for the SA and TO groups, respectively.

There were nine surgeons who performed the repairs, an average of 2.61 days (range 0–13 days) after the injury. The clinical diagnosis of a quadriceps tendon rupture, which was confirmed during surgery, was based on the mechanism of injury, inability to maintain a straightened knee, tenderness superior to the patella, and a palpable defect in the quadriceps tendon.

3.2. Clinical outcomes

The last clinical follow up averaged 5.8 months (range 2.6–11.5) and 15.2 months (range 2–69.5) for the SA and TO groups, respectively ($p = 0.12$). Fourteen patients were reached for a phone interview (6/10 for anchors and 8/17 for tunnels) with a mean follow up of 4.7 years and 5.5 years for the anchor and tunnel groups, respectively.

At final clinical follow-up the mean knee flexion angles were 109° (Table 2, range 80–135) in the SA group and 126° (range 85–135) in the TO group, a significant difference ($P = 0.039$). When patients with less than 3 months of clinical follow-up were excluded from the analysis mean flexion was 117° and 128° for patients with SA and TO repairs, and didn't reach significance ($p = 0.23$). Quadriceps strength was similar for both groups, averaging 4.83/5 for SA patients and 4.73/5 for TO patients ($p = 0.63$).

3.3. Operative time

Operative time was similar for both cohorts ($p = 0.76$). Surgical time averaged 93 min for the SA repair and 90 min for the TO repair.

Table 1
Demographics of subjects.

	Group		
	SA (n = 10)	**TO** (n = 17)	**Total** (n = 27)
Age (mean, range)	54, (35–74)	49, (33–68)	51.4
BMI (mean, range)	33.9, (21.8–57.8)	34.5, (21.7–77.3)	34.9
Sex (male)	80%	88%	85%
Injury Mechanism (%)			
Simple fall	60	56	57
Fall down stairs	10	17	14
Fall from height	0	11	7
Other	30	16	22
Co-morbidities (%)			
Hypertension	70	47	56
Diabetes	50	29	37
Kidney disease	10	0	4
Other	40	18	26
Injury Side (no.)			
Right	4	6	10
Left	5	6	11
Bilateral	1	5	6

Abbreviations: SA, suture anchor; TO, transosseous; BMI, body mass index; no., number.

Table 2
Results.

	Group	
	SA	TO
Knee flexion (mean all subjects)	109° *	126° *
Knee flexion (mean >3mo follow-up)	117°	128°
Quadriceps strength (mean)	4.8/5	4.7/5
Operative time (mean)	93 min	90 min
Re-rupture (%)	9	14
Complications (%)	27	32
Lysholm Score (mean, range)	63, (33–100)	72.8, (24–100)
Satisfied (% Yes)	67	88

Abbreviations: SA, suture anchor; TO, transosseous; *, $p < 0.05$.

3.4. Complications

There were three total complications (27%) in SA repairs, including one re-rupture (9%). One patient had a superficial wound dehiscence in the immediate post-operative period that was treated with a negative pressure dressing. Another patient had one anchor (out of 3 total) pull out of the patella, as seen radiographically. He was still able to maintain a straight leg raise without an extensor lag. In the TO group there were seven total complications (32%), including 3 re-ruptures (14%). One of the re-ruptures was associated with a wound dehiscence that occurred due to vigorous knee flexion at physical therapy, requiring operative debridement. One patient developed a deep vein thrombosis (DVT). Two patients were found to have arthrofibrosis that required arthroscopic lysis of adhesions. One individual was placed on oral antibiotics for a superficial wound infection. There were no significant differences between the groups for re-rupture ($p = 1.0$) or total complications ($p = 1.0$).

3.5. Subjective and functional outcomes

Fourteen patients were reached for a phone interview (6/10 for SA and 8/17 for TO) with a mean follow up of 4.7 years and 5.5 years for the SA and TO groups, respectively. Lysholm scores were slightly higher in the TO cohort (72.8), compared with the SA group (63), though this was not found to be significant ($p = 0.53$). When looking at those patients with the lowest scores: one patient with a score of 24 had a clinical course significant for DVT. Another patient with a score of 36 required revision surgery for a re-rupture. 67% of SA repairs and 88% of TO repairs were satisfied with their results.

4. Discussion

This is the first study that we are aware of to compare suture anchor and transosseous repairs of acute quadriceps tendon ruptures. Previously 10 cases of quadriceps tendon repair with suture anchors have been described in the literature as case reports and small case series.[10–12,14,18] Mille et al. have further provided a level IV report of 13 cases.[13]

When comparing the study demographics of our cohort with previously published reports of quadriceps tendon rupture, the age (51.4 years) of our patients was similar to other studies (mean 57 years).[19] The low velocity mechanism of injury in 74% of our patients was also comparable to the reported 61.5% sustaining simple falls and 23.4% having a fall from stairs. Bilateral, simultaneous rupture was relatively common at 15% in our cohort. In a review of bilateral quadriceps tendon ruptures, Shah identified that those patients with multiple chronic diseases where more susceptible to such an injury.[20] Forty-three percent of their 66 cases had renal disease, and duration of renal dialysis was related to spontaneous

rupture. Only one of our patients had renal disease and we didn't note any spontaneous ruptures. The majority of our patients were obese, with an average BMI of 34.9, which we believe was the most significant predisposing factor towards quadriceps tendon rupture in our cohort.

The aggregate rate of re-rupture in our study was 12%, which was slightly higher than other reports (range 0–8.3%),[19] but similar to the 15% reported by Mille et al. The only significant difference between the two repairs in our study was in knee flexion (favoring the TO technique), however when excluding patients with less than 3 months of clinical follow-up this difference failed to reach significance. The average knee flexion achieved in our study (117° for SA and 128° for TO) was also similar to previous reports. Lysholm scores and satisfaction rates were higher in the TO repair group in our study, however the difference was not significant.

There were a number of limitations to this study. A large number of patients were lost to follow-up (42.5%), which is likely due to the population of patients seen at a Level I urban trauma center and the difficulty in ensuring these individuals return for post-operative care. Previously reported dropout rates have been 0–42.8%.[19] Due to the retrospective nature of this study and the large number of surgeons there was also no standardized therapy protocol. While the length of clinical follow-up was relatively short in our study, we believe that it was sufficiently long to capture functional recovery. It has been shown that by the twelfth postoperative week 100% of patients can regain their ROM to within 10° of the uninjured side.[21]

Petri et al. have shown that under cyclic loading suture anchors resisted significantly more gap formation compared with transosseous suture tunnels in a cadaveric model of quadriceps tendon rupture. Gap formation averaged 33.3 mm in the suture tunnel group and 1.9 mm and 1.5 mm for titanium and hydroxyapatite suture anchors, respectively. Load to failure of the titanium anchors averaged 740 N, compared to hydroxyapatite anchors and transosseous sutures that averaged 572 N and 338 N, respectively.[22] In another study of quadriceps tendon rupture in 12 unmatched fresh frozen cadaveric specimens, Sherman et al. compared transosseous tunnel repairs with suture anchor repairs.[23] They utilized three 4.5 mm titanium anchors double loaded with #2 Fiberwire (Arthrex) for their anchor repair and #2 Fiberwire through 2.5 mm drill tunnels for their transosseous technique. Ultimate load to failure was not significantly different between the two groups (mean 286 N for suture anchors and 250.5 N for transosseous tunnels). The load to failure of the anchor repair in this study was much less than seen in other biomechanical evaluations, which may be explained by the smaller (4.5 mm) anchor size or the method of cyclical testing prior to the load to failure. A significant difference favoring the anchor group was found in cyclic testing, with less gap formation and less variability in displacement.

Ettinger et al. compared suture anchor repairs with transosseous repairs in a model of patella tendon ruptures in 15 matched pairs of fresh frozen cadavers.[24] Transosseous repairs utilizing 4 strands of #2 Ultrabraid (Smith & Nephew, Andover, MA) through three drill holes where compared with two 5.5 mm anchors (titanium or hydroxyapatite) loaded with two #2 Ultrabraid sutures. In cyclic loading, the gapping was significantly smaller for the suture anchors. Maximum average load to failure was greatest in the hydroxyapatite anchor repair (689 N) followed by 597 N for the titanium anchors, and 301 N for the transosseous suture repairs. Of note, the mode of failure also varied between the three groups: in the titanium anchor group 5 had an anchor pullout and 5 had a tendon pullout, in the hydroxyapatite group 7 had a suture failure at the anchor eyelet and 3 had a tendon pullout, in the transosseous group 4 had a knot failure and 6 had a tendon pullout.

Given what we know about the increased strength of suture anchors compared with transosseous tunnels, along with their resistance to form a gap at the repair site, the biomechanical benefits would seem to justify this technique in quadriceps tendon repair. Our study, however, was unable to find improved clinical outcomes in the SA group. Furthermore, the rates of complications and re-rupture were similar between the two cohorts. Perhaps with a larger sample size and increased length of follow-up the improved biomechanical profile of suture anchor repairs would become evident. The issue of implant cost, though not addressed in this study, is also pertinent when comparing the two repair methods. Each suture anchor costs approximately $300 USD, compared with a cost of approximately $50 USD for a transosseous repair. If two anchors are used, this results in a cost differential of over $500.

5. Conclusion

With the similar clinical results, operative time, and complications of suture anchor and transosseous repairs in our study, both techniques appear to be viable solutions. Further study of the clinical and functional outcomes of quadriceps tendon repair would benefit from prospective randomized controlled trials.

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Bucket handle horizontal cleavage tear of medial meniscus with congenital deformity– A case report★

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ABSTRACT

Bucket Handle tears occur most commonly in the medial meniscus. A typical Bucket Handle tear is a vertical tear from femoral surface of meniscus to tibial surface and extending longitudinally along the length of the meniscus from the anterior horn or body to the posterior part of the meniscus. The reported case is a rare one of horizontal cleavage tear of meniscus which developed bucket handle tear extending from anterior third of body to the posterior body in an ACL deficient knee and valgus deformity of lower limb and agenesis of 5th Metatarsal. The type of meniscal tear along with other contributory clinical findings makes this case unique. This has been successfully treated using outside in sutures and ACL reconstruction.

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1. Introduction

Medial Meniscal tears occur more frequently than Lateral with a ratio of 2:1.[1] In the chronically ACL deficient knee, incidence of meniscal injury has been found to be as high as 98%.[2] Bucket Handle tear occurs when a vertical tear of the meniscus in the rim occurs over a long enough portion of the meniscus to make it unstable and the central segment displaces into the joint causing locking. The reported one is a rare case of Bucket Handle horizontal cleavage tear along with ACL deficiency in a 22 year old lady with a congenital deformity of the lower limb which could have caused this complex type of tear.

2. Case report

A 22 year old lady presented with Right knee pain of 2 years duration worse for 1 week prior to presentation. She had acute pain of same knee 1 year ago which was treated conservatively. There were on and off episodes of knee pain since then. There was no history of clicking/locking or swelling of the knee and no definite history of trauma. She was born with deformed divergent 4th and 5th toes. Clinically she had 2 + ACL laxity, Meniscal signs were +ve. Right lower limb valgus of 10° and splayed 4th and 5th toes with absent 5th metatarsal. There was no family history of congenital anomalies. CT scannogram showed a valgus deformity of proximal third tibial shaft with an angle of 3.5° at the CORA, a dysplastic lateral femoral condyle and tibial eminence (Fig. 1a). Radiograph of the foot showed splayed 4th and 5th toes, bases of proximal phalanges of both toes articulating with the head of 4th metatarsal, and an absent 5th metatarsal. Fibula was intact (Fig. 1b). MRI of the knee confirmed an absent ACL and medial meniscal horizontal cleavage tear (Fig. 2a and b).

Examination under anaesthesia revealed Lachman 2+, Anterior Drawer 2+, Pivot shift + ve, PCL, PLC intact and collaterals were intact. Arthroscopy revealed an absent ACL and a bucket handle tear of femoral side flap of horizontal cleavage tear of medial meniscus which was reducible (Fig. 3a). The meniscal tear was reduced and an outside in repair was done (Fig. 3b) with the help of Meniscal Menders (Smith & Nephew). ACL was reconstructed using All inside ACL Reconstruction system (Arthrex) using Semitendinosis tendon graft (Fig. 4a and b). At 6 weeks and 3 months follow up, her knee was stable, she had full Range of movements and mobilised full weight bearing without support.

3. Discussion

ACL deficiency is known to occur with Fibular hemimelia.[3] With absent ACL, medial meniscus is at risk of tear and the risk increases

★ The manuscript represents an honest work from the author.
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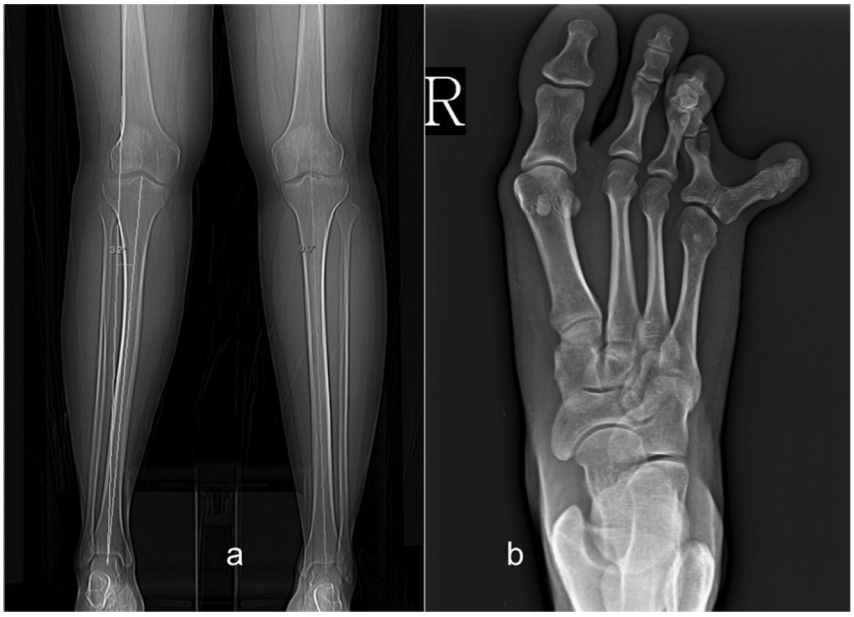

Fig. 1. a) Lower limb alignment view showing Valgus deformed tibial shaft. b) Radiograph of foot showing absent 5th Metatarsal and divergent 4th and 5th toes.

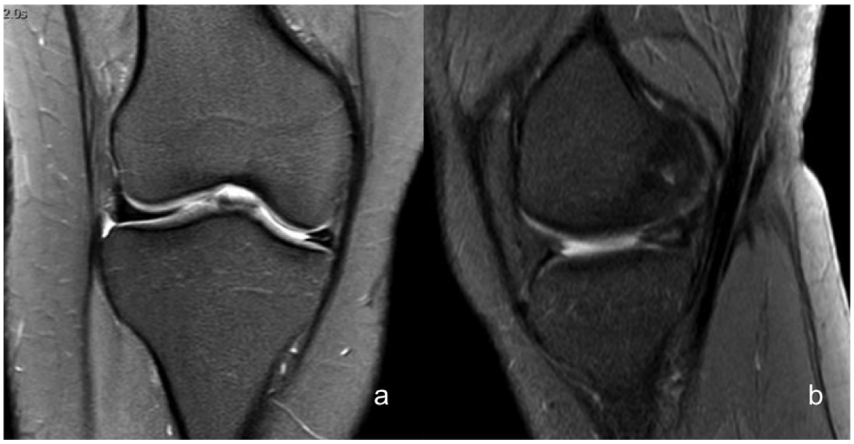

Fig. 2. a) MRI of knee showing horizontal cleavage tear of medial meniscus. b) Increased signal within the posteromedial meniscus indicating tear.

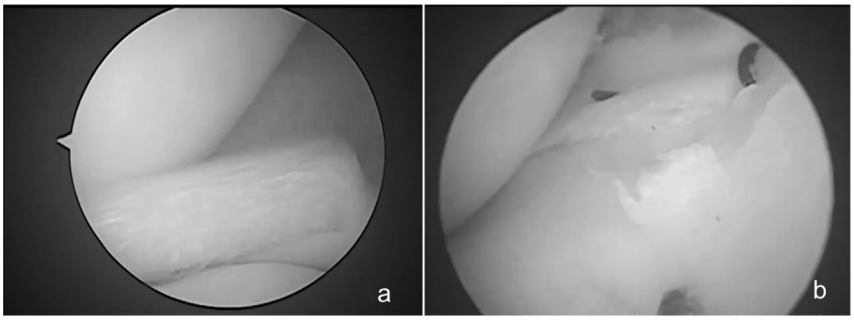

Fig. 3. a) Arthroscopic view of Bucket Handle tear of horizontal cleavage tear of medial meniscus. b) Arthroscopic view after repair of meniscus.

if associated with a malaligned limb. Although the fibula appears normal in our case, the valgus deformity of the tibia indicates Achterman and Kalamchi Type 1 Fibular Hemimelia. Aplasia of 5th Metatarsal is known to occur with Fibular hemimelia. A morphologically similar case was reported in the literature involving lateral meniscus. Lee et al.[4] reported a double layered lateral meniscus in which the upper meniscus was dislocated resembling a bucket handle tear while the lower layer of meniscus

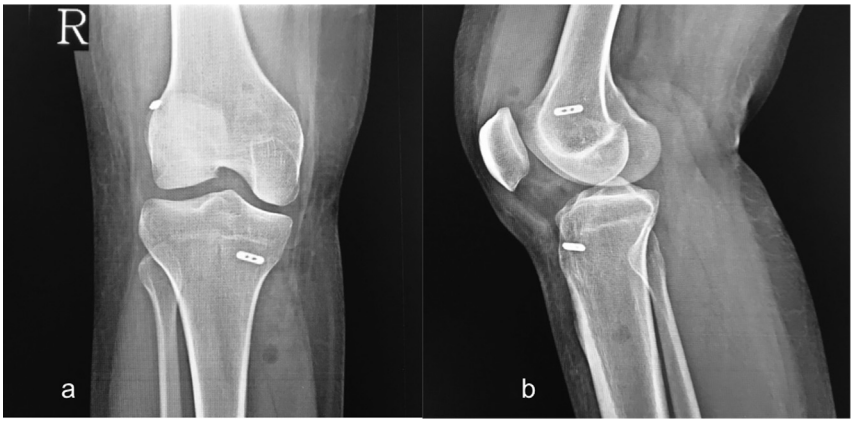

Fig. 4. a) Post op radiograph of knee AP view All Inside ACL reconstruction. b) Post op radiograph of knee Lateral view.

was intact. The patient reported here had history of acute knee pain one year prior to presentation at which stage she may have had tear of the meniscus, possibly the horizontal cleavage part. The latest episode must have created the bucket handle tear involving the rim of the femoral side of the cleaved meniscus creating the current picture.

Radiological appearances suggesting aplasia of cruciate in the literature include dysplastic tibial eminence,[5] dysplasia/hypoplasia of lateral femoral condyle[6] and narrow intercondylar notch. A hypertrophied meniscofemoral Ligament of Humphrey was found by Gabos et al.[3] in ACL deficient knees but this was not found to be in the above case.

In conclusion, there should be a low index of suspicion in patients with congenital limb deficiencies and limb malalignment for meniscal pathologies and the reported case is a rare one of bucket handle tear of part of a horizontal cleaved meniscus successfully treated by outside in meniscal repair and ACL reconstruction. Correction of malalignment of the limb and instability at an early age may have averted the meniscal pathology.

Conflict of interest

None.

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Kidney in the knee?

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ABSTRACT

Synovial giant cell tumour is typically a mono-articular disease, which affects mainly young adults, with the highest incidence occurring in the third and fourth decades of life. It most frequently occurs on the hand, and rarely on the ankle and knee. We present a rare case of a kidney shaped synovial giant cell tumour of the knee joint which was successfully treated through a mini-open excision.
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Introduction

Synovial giant cell tumour is a benign neoplasm, most frequently occurring on the hand, and rarely on the ankle and knee.[1] Around the knee, it is most commonly located in the epiphyseal region of the long bones such as distal femur and proximal tibia,[2] both of which are intra-osseous locations. The synovial giant cell tumour, an intra-articular tumour, has an estimated annual incidence of 1.8 per million people, with equal gender distribution.[3,4] We present a rare case of a surgically treated intra-articular kidney shaped giant cell tumour of the knee joint. (see Figs. 1–11)

Case report

A 31 year old male patient presented with a history of atraumatic pain and swelling in his right knee since 1.5 years. There was no history of any prodromal symptoms or fevers. There was no palpable mass, and only a generalised effusion in the knee with global tenderness. The rest of the clinical examination was unremarkable with no limitation to motion and only a terminally painful extension. The patient's Xrays were essentially normal. Patient underwent two synovial fluid aspirations which showed no infective or malignant pathology. Patient was initially managed conservatively and the pain reduced to negligible, however CRP continued to increase and swelling persisted.

MRI of right knee joint showed moderate synovial effusion with large lobulated intermediate signal intensity lesion in the anterior compartment of the knee joint posterior and inferior to the patella and involving the patella-femoral joint extending to the anterior aspect of tibio-femoral joint-likely synovial neoplastic lesion.

He had an USG guided aspiration of the intra-articular mass which showed cells of low cellularity, clusters of singly lying synoviocytes showing eccentrically placed round to oval nuclei and moderate amount of cytoplasm. No signs of inflammation or granuloma and no evidence of malignancy were seen.

An initial arthroscopic evaluation of the knee joint showed a large adherent mass which was difficult to remove with clear margins arthroscopically. Hence, patient then underwent a mini-open excision of the mass through a medial para-patellar approach where a large kidney shaped mass was found adherent to Hoffa's fat pad with a projecting stalk to the anterior tibial plateau. The mass was removed enbloc with clear margins.

On gross examination of the specimen, it was an irregular greyish yellow tissue piece measuring $7 \times 7 \times 0.8$ cm. The outer surface appeared vaguely multi-nodular. Interestingly, the mass appeared adherent to the anterior tibial plateau with a stalk, giving the pseudo-appearance of a kidney with its ureter attached.

Cut section appeared yellowish brown with areas of congestion. Focal haemorrhage was also noted.

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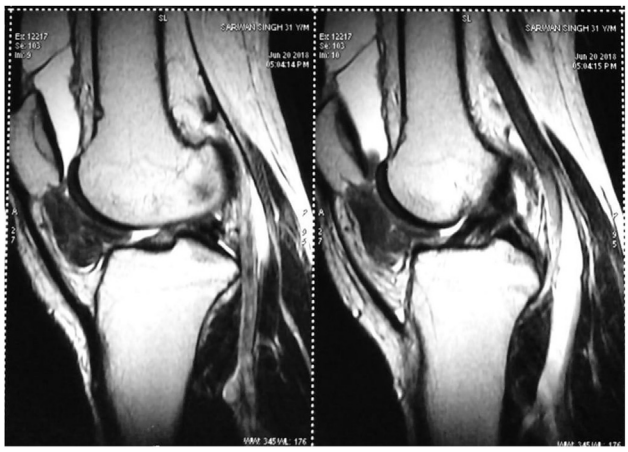

Fig. 1. MRI of the knee joint.

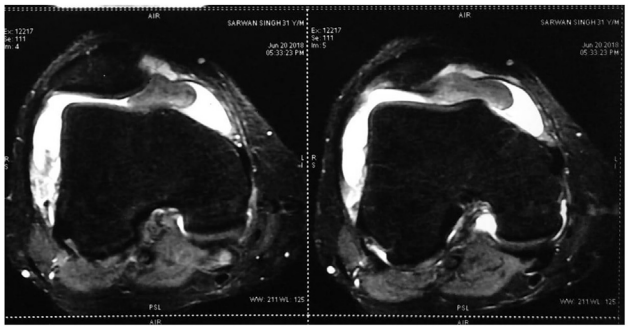

Fig. 2. MRI of the knee joint.

Biopsy of the mass showed normal lining epithelium tissue with focal hyperplasia. The sub-epithelium showed sheets of xanthoma cells along with fibroblastic and histolytic proliferation. Many hyalinised blood cells and multi-nucleated giant cells were seen. Areas of hyalinisation were seen on the surface as well as within the lesion. No necrosis or atypical mitosis was seen. Overall features

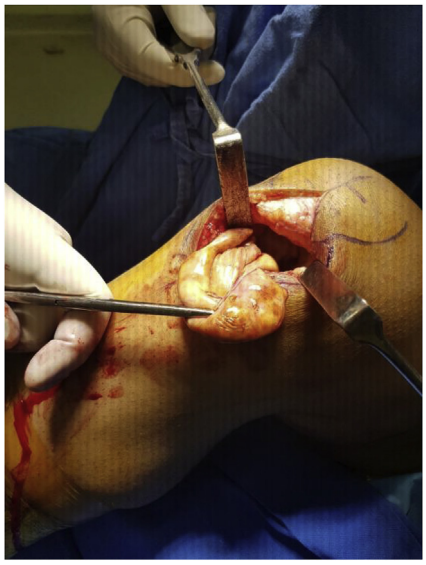

Fig. 3. Mass being removed intra-op.

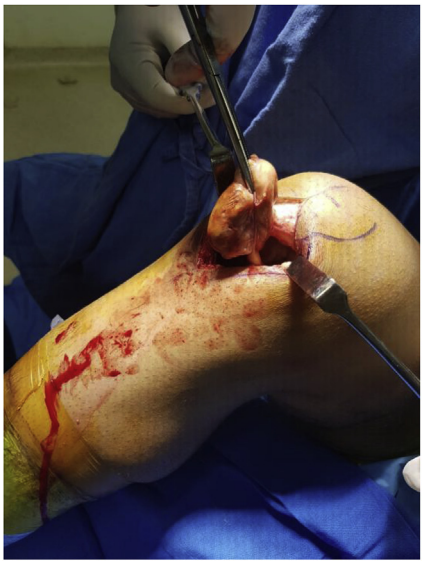

Fig. 4. Mass being removed intra-op.

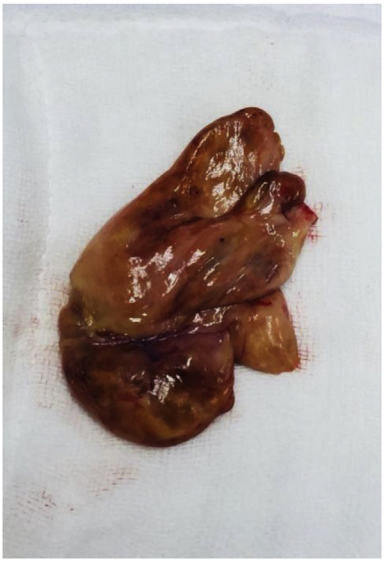

Fig. 5. Gross examination.

were of benign lesion morphologically synovial giant cell tumour/ pigmented villonodular synovitis.

Postoperatively, patient was immobilized in a knee brace and advised nil weight bearing for 2 weeks with transition to full weight bearing post suture removal. Knee range of motion was initiated from day 1 along with cryotherapy and strengthening was added from week 1 post-operatively. Patient underwent an aggressive rehabilitation programme from week 2 onwards.

The patient has progressed in recovery postoperatively. His Lysholm knee scores have been as follow:

2 weeks pre-op- 83/100
2 weeks post-op- 70/100
4 weeks post-op- 89/100

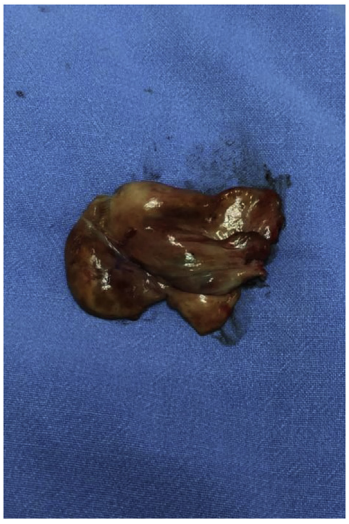

Fig. 6. Gross examination.

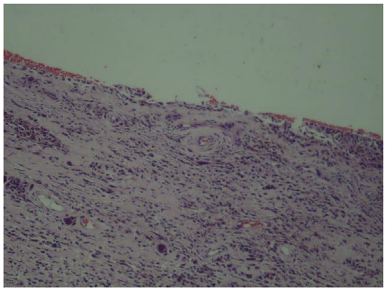

Fig. 7. Microscopic examination.

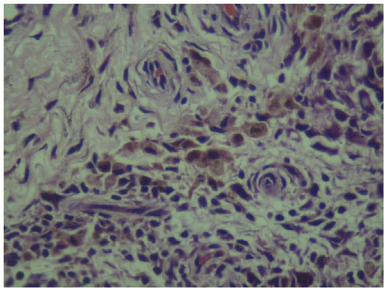

Fig. 8. Microscopic examination.

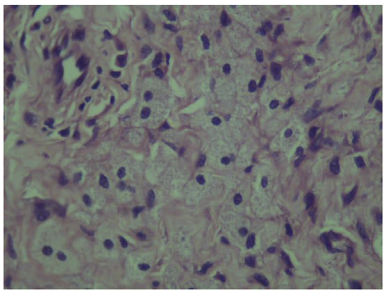

Fig. 9. Microscopic examination.

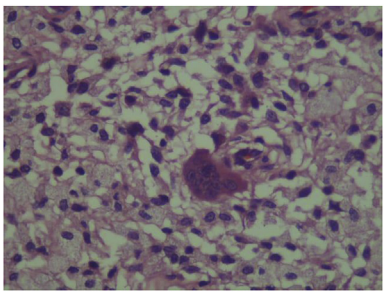

Fig. 10. Microscopic examination.

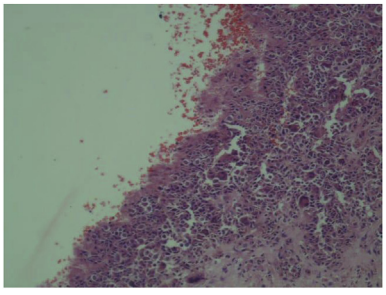

Fig. 11. Microscopic examination.

Discussion

The etiology of giant cell tumour remains uncertain, however it has been postulated that it may be due to a disturbance in lipid metabolism, a benign neoplastic process, a reaction to an unknown stimulus, and/or a response to repeated episodes of trauma or hemarthrosis.[1,4] The clinical manifestations include pain, effusion, limitation of motion, and may also mimic that of a meniscal lesion.[4,3,1] MRI is the investigation of choice in these cases [4] and the diagnosis is confirmed with histopathology. Arthroscopic resection has been recommended to be the treatment of choice in the past.[1,3,4,5] The advantages of arthroscopy include faster rehabilitation and the avoidance of an arthrotomy, while the disadvantages include the potential for intra-articular spread of the disease, difficulty accessing the posterior and extra-articular locations, and difficulty in removing thickened synovial tissue.[5] However, due to the large size of the mass and its adherent nature, we opted for an open excision procedure after an initial arthroscopic evaluation of the knee joint. The advantages of an open excision include the ability to perform a marginal excision, and a total synovectomy, while the only disadvantage is the possibility of post-operative adhesions.[5] Our patient at 4 weeks post-op is recovering well with no complications and an improvement in Lysholm knee score from pre-operative levels.

Conclusion

Synovial GCT is a rare disease with an incidence of 1 in 1.8 million individuals. We presented a rare case of a kidney shaped synovial GCT in the knee which was treated with a mini-open approach. We believe that even though past literature suggests that arthroscopic resection is the advised treatment of choice, if the size of the mass is large or if the mass is adherent, an open excision is a safe and viable option and allows for a clear margin to be achieved.

Ethical approval

The person presented in this case report is a known patient of a contributing author in this manuscript. Both his and the patient's approvals were taken before proceeding with this article. Approval of the hospital to retrieve the patient's file for use in this manuscript was obtained.

Consent

Written informed consent was obtained from the patient for publication of this case report and accompanying images.

Conflict of interest

The authors declare no conflict of interest regarding the publication of this article.

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Arthroscopic acromio-clavicular joint stabilization using a TightRope device

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ABSTRACT

Purpose/objectives: The purpose of the present study was to evaluate the outcome of arthroscopic stabilization of acute acromio-clavicular joint dislocation using a TightRope device.

Material and methods: Between june 2015 to march 2017, 12 patients (9 males and 3 females), aged 39.5 (23–64) years underwent arthroscopic stabilization using a double-button device for acute (2–4 days) acromio-clavicular joint injury, which included acromio-clavicular joint dislocation Rockwood Type III (n = 4), Type IV (n = 5) and Type V (n = 3). Data was collected retrospectively, and clinical assessment on follow-up included the Shoulder Constant Score and Visual Analogue Scale (VAS) for residual pain. Time of return to work was assessed and post-operative complications were recorded. Radiological examination consisted of antero-posterior (Zanca) view of the shoulder, and coraco-clavicular distance before and after surgery.

Results: The mean follow-up period was 28.75 (12–38) months, where the Constant Score at final follow-up was 90.4 ± 3.06 and Visual Analogue Scale score was 0.58 (0–1) on activity. The coraco-clavicular distance decreased from 20.18 ± 2.84 mm pre-operatively to 10.02 ± 0.39 mmat 6 months and 10.68 ± 0.55 mmat 1 year post-operatively. There were no failures. X-rays did not show acromio-clavicular joint arthritis or lysis around the endo-button. There was no tenderness and no evidence of vertical or horizontal instability at the acromio-clavicular joint, but 4 patients had tenderness at the endo-button insertion site. All the patients returned to work after an average of 2.6 (2–4) months.

Conclusion: Arthroscopic stabilization of acute acromio-clavicular joint dislocation using a TightRope device is a minimally invasive procedure with decreased post-operative morbidity. It allows early rehabilitation and consistently provides a satisfactory outcome when performed in the acute phase of injury.

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1. Introduction

Acromio-clavicular joint injuries are frequently diagnosed following an acute shoulder injury. Approximately 9% of shoulder girdle injuries involve damage to the acromio-clavicular joint. These injuries occur commonly in active young adults with a direct fall onto the top of the shoulder while the arm is adducted, or with a direct blow over the shoulder.[1]

Rockwood and Green classification is mainly used for classifying acromio-clavicular joint dislocations. It is based on the extent of damage to the acromio-clavicular and coraco-clavicular ligaments, as well as the displacement of the distal end of the clavicle.[2–5]

Type I and II are usually managed conservatively, whereas Type III, IV, V and VI are usually managed surgically.

The surgical treatment of acute Type III acromio-clavicular joint dislocation is still controversial where surgical management is preferable in active and high-demand patients.[6] Several open surgical techniques for fixation have been described, but most are associated with complications such as infection, loss of correction or implant migration.

Surgical options include open/closed reduction and Kirschner wire fixation,[7] hook plate fixation,[8,9] cannulated cancellous screw fixation,[10,11] anatomic coraco-clavicular joint reconstruction using a prosthetic ligament[12,13] and distal clavicular resection.[14,15]

Recently, arthroscopic techniques have been successfully

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proposed to treat acromio-clavicular joint instability. And for arthroscopic joint reconstruction, non-absorbable sutures,[16] semitendinosus graft with polydioxanone suture[17] and the TightRope device (Arthrex, Naples [FL], USA)[18–24] have been used. The TightRope comprises of two metallic buttons joined by a FiberWire loop. Originally designed for the reduction and stabilization of tibio-fibular syndesmosis, it similarly maintains the reduced acromio-clavicular joint to enable healing of disrupted acromio-clavicular and coraco-clavicular ligaments.[24]

Our study evaluated the outcome of arthroscopically fixed acute acromio-clavicular joint dislocations using the TightRope device.

2. Materials and methods

We retrospectively collected data of 12 patients (9 males and 3 females) aged 39.5 (23–64) years who underwent arthroscopic TightRope fixation for acute (2–4 Days) acromio-clavicular joint dislocation from June 2015 to March 2017 (see Table 1).

Four of the patients had Type III, 5 patients had Type IV and the remaining 3 patients had Rockwood Type V acromio-clavicular dislocation. All injuries occurred due to a direct fall on the affected shoulder with 8 injuries occurring in the left shoulder and the remaining 4 in the right shoulder. None of the patients had any concomitant gleno-humeral injuries, or injuries of the rotator cuff or lateral end clavicle.

We examined X-rays of the shoulder (Zanca View) before surgery, at 6 months and 1 year post-operatively for coraco-clavicular distance, acromio-clavicular joint congruency and arthritic changes if any (see Fig. 1). Clinically, the final outcome was assessed using the Shoulder Constant Score, and Visual Analogue Scale (VAS) was used for residual pain.

3. Surgical technique

Patients were positioned in the beach-chair position under general anaesthesia along with interscalene block. A 30° arthroscope was inserted into the gleno-humeral joint using a standard posterior portal and an antero-superior portal was made through the rotator interval using outside-in technique. An antero-inferior portal was created near the tip of the coracoid using the outside-in technique using a spinal needle and debridement of the rotator interval was started until the tip of the coracoid was exposed, following which the arthroscope was inserted through the superior portal to visualize the base of the coracoid.

A radio-frequency ablator and a 4.5 mm shaver was used to strip the bursa and periosteum to expose the base of the coracoid and view its under-surface. A drill guide set at 80° was inserted through the antero-inferior portal and positioned at the base of the coracoid under direct vision ascertaining that a sufficient bone bridge would remain around the 4 mm reamed tunnel. The top of the guide was positioned over the distal clavicle directly over the coracoid after making an incision in the skin. A 2.4 mm drill guide pin was inserted in the guide sleeve and advanced across the clavicle and coracoid. The position of the pin was checked in relation to the coracoid and the drill guide removed. A 4 mm cannulated drill was passed over the pin following which the guide pin was removed and the drill left in situ.

A Nitinol suture passing wire was passed down the drill and taken out through the antero-inferior portal leaving the suture loop superiorly and the drill was then carefully removed keeping the wire behind. The suture leader and needle were removed from the TightRope system following which the two white traction sutures from the oblong button were passed through the Nitinol suture passing wire and the button was flipped to enable the button to pass through the drill hole. The Nitinol suture passing wire was then drawn out of the antero-inferior portal. After the oval button was seen under the coracoid, the trailing suture was used to flip it and lock it under the bone and the clavicle was reduced by a surgical assistant; confirming it under fluoroscopy. After a satisfactory reduction was achieved, the sutures were tied over the top of the superior button and the incisions closed in layers.

Post-operatively, patients were placed in shoulder immobilizer for at least 4–6 weeks allowing elbow flexion-extension and gentle shoulder range of motion exercises. After discontinuing the shoulder immobilizer at 6 weeks, patients were allowed further strengthening exercises but were not allowed heavy resistance work for at least 3 months. Patients were allowed advancing their weight bearing activities in a gradual manner allowing full return to normal activities without restrictions at 6 months post-operatively.

4. Results

The mean follow-up period was 28.75 ± 6.34 months (12–38 months) and the mean time from injury to surgery was 2.58 days (2–4 days).

The mean post-operative Shoulder Constant Score was 90.42 ± 3.06 (Range – 86–95) and VAS was 0.58 (0–1) at final follow-up. All patients were satisfied with the outcome of the surgery and the cosmetic appearance.

Radiological review at 6 and 12 months post-operatively did not show loss of reduction or osteolysis around the endo-button site. The coraco-clavicular distance (CC) reduced from 20.18 ± 2.84 mm pre-operatively to 10.02 ± 0.39 mm at 6 months and 10.68 ± 0.55 mmat 12 months post-surgery. There were no failures.

There was no tenderness and no evidence of vertical or horizontal instability at the acromio-clavicular joint, but four patients had tenderness at the endo-button insertion site. All patients returned to work after an average of 2.6 months (2–4 months)

Table 1
Patient demographics and final outcome.

Name	Age	Sex	Time to Sx (Days)	Final Dx	Pre-Op CC(mm)	CC at 1 yr	Constant Score	VAS
H P	27	M	2	IV	19.5	10	92	1
S M	23	F	3	III	19	11	86	1
B P	30	M	3	V	21	12	94	0
A K	25	M	2	III	22	12	91	0
S S	37	M	2	IV	18.5	11	88	1
P S K	52	M	3	V	24.6	10	90	1
A D	64	F	3	III	18.5	11	93	1
I M	58	M	2	III	17.8	11	91	0
R K	60	M	3	IV	19	11	86	0
S C	29	M	2	V	26.5	10	92	1
G D	44	M	2	IV	17.5	11	95	1
E F	25	F	2	IV	18.2	11	87	0

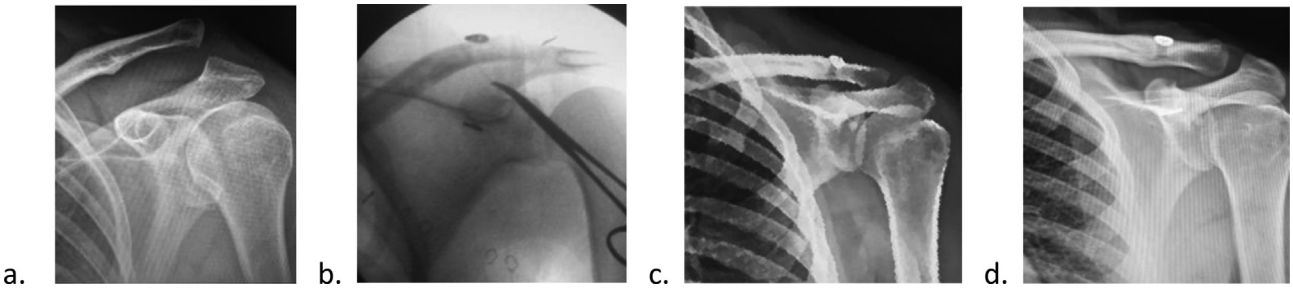

Fig. 1. Type IV acromio-clavicular dislocation. b) Intra-op C-arm image. c) 6 months post-op. d) At 1 year post-op.

following surgery.

5. Discussion

Acromio-clavicular joint injuries are commonly seen in general orthopaedic practice and many do not require surgical intervention. Acromio-clavicular joint stability depends on the acromio-clavicular and coraco-clavicular ligaments which get damaged in a sequential manner after a fall on the shoulder along with the joint capsule and delto-trapezial fascia.[1] The conoid part of coraco-clavicular ligament is the primary restraint to superior translation and the trapezoid ligament resists compression.

Rockwood Type I and II should be managed conservatively, however, patients with Type II injuries should be informed that a distal clavicle resection may be required in the future if symptomatic acromio-clavicular joint arthritis develops. Acute surgical intervention is recommended in Rockwood Type IV – VI. The management of Type III remains controversial. But if the joint is reduced in the acute phase and held reduced during the healing phase, the native ligaments will heal, restoring the stability of the joint. Surgery is recommended in young and active patients to maximize function.[5]

There are numerous surgical options for fixing acromio-clavicular dislocations, but they have their own set of drawbacks. Kirschner wire fixation has a risk of wire migration. Open techniques with screw and hook plate fixation requires hardware removal and has a high risk of infection, shoulder stiffness and osteolysis of the acromion. Cancellous screw fixation has a risk of screw cutout and dislocation. Surgilig fixation requires open reduction of the acromioclavicular joint. Compared to open repair, arthroscopic fixation using a TightRope has a lower risk of shoulder stiffness, infection and hardware prominence. It does not require implant removal and helps to simultaneously evaluate and manage intra-articular pathologies.

Arthroscopic surgery causes less trauma to the soft tissue envelope, but has a steeper learning curve compared to open techniques. The TightRope system has two metal endo-buttons, one circular and another oblong, joined by a continuous loop of FibreWire. Dissection around the coracoid tip present a risk of damage to the lateral cord of the brachial plexus and damage to the axillary nerve may occur while dissecting about the base of the coracoid, but safety of arthroscopic rotator interval release is increased by the fact that most of the work is done on the lateral aspect of the coracoid, which is further away from the neuro-vascular structures. This technique provides a simple and a reproducible, minimally invasive method of acute acromio-clavicular joint stabilization, that causes minimal scarring and enables a quick return to activity.

Failure may occur due to osteolysis around the clavicular button, which may result in subluxation of the joint during healing of the acromio-clavicular and coraco-clavicular ligaments. It may be related to the small size of the endobutton. Partial or complete loss of reduction may occur if the ligaments do not heal.

The TightRope system provides only supero-inferior stability, but in a cadaveric study it showed that when strengthened by a semi-tendinosus graft, it provided anterior and posterior stability as well, compared to modified Weaver-Dunn procedure. When two TightRope devices are used, it enables a stronger reconstruction than native coraco-acromial ligament,[23,24] but it decreases shoulder mobility along with increasing the risk of coracoid fracture. The commonest cause of failure is suture breakage.[18,22]

In our study we have used a single TightRope device and our results are comparable to other previous studies.[20-22,25] We performed the surgery within 2–4 days following injury. There were no failures, no loss of reduction and all our patients returned to work at an average of 2.6 months following surgery. There was no tenderness and no evidence of vertical or horizontal instability at the acromio-clavicular joint, although four of our patients complained of deep seated tenderness at the endo-button insertion site where the FibreWire knots were placed. No other soft tissue complications occurred, the surgical scars were acceptable by the patients and all were satisfied with the functional outcome of the surgery.

Limitations of this study include a relatively small sample size and a short follow-up period. The patient cohort were not matched for age and sex.

6. Conclusion

Arthroscopic stabilization of acute acromio-clavicular joint dislocation using a TightRope device is a minimally invasive procedure with decreased post-operative morbidity. It allows early rehabilitation and consistently provides a satisfactory outcome when performed in the acute phase of injury.

Conflicts of interest

This article is the author's original work and is not under consideration for publication elsewhere. There were no conflicts of interests declared by the authors

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Appendix A. Supplementary data

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MRI shoulder without contrast is unreliable method to explain prolonged morbidity after subacromial decompression

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ABSTRACT

Introduction: Subacromial decompression is a common surgical procedure in patients with subacromial impingement. The results are often good, although some patients develop prolonged morbidity with postoperative pain and stiffness. The main aim of the present study was to analyze the reaction of the joint capsule 3 months after subacromial decompression using MRI without contrast. We also wanted to study if there was a relation between the capsular reaction and the Constant score (CS) or the subjective shoulder value (SSV).

Materials and methods: Forty-eight patients with a mean age of fifty-six years underwent subacromial decompression. They were investigated with a standard x ray and MRI before surgery and at three months after surgery. The CS and SSV were measured preoperatively and at three months, six months, and two years postoperatively. Two musculoskeletal radiologists independently evaluated the MRI images and used a scoring system from 0 to 7 to evaluate capsular changes.

Results: The inter-rater reliability was fair. Spearman's correlation was calculated between CS scores at baseline, 3 months and 6 months with MRI score rater 1, MRI score rater 2. None of the relationships were significant. Spearman's correlation was also calculated for those with a CS score <60 and none were significant. The improvement in the CS from baseline to three- and six months postoperative was significant. The subjective shoulder value improved at three, six and 24 months after surgery.

Conclusions: The persistent pain and stiffness in some patients after subacromial decompression cannot be explained by the development of capsular changes shown by non-arthrographic MRI, which seems to be unreliable method due to high subjectivity in the assessment between the radiologists.

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1. Introduction

The shoulder joint is the only joint in the body that is affected by adhesive capsulitis. This condition restricts active and passive range of motion in all directions. Frozen shoulder was first described by Codman in 1934.[1] The name adhesive capsulitis was given by Neviaser in 1945 when he described synovial changes in the glenohumeral joint.[2] The disease is categorized into idiopathic or primary, and secondary adhesive capsulitis. The pathogenesis of the idiopathic form is not very clear. Some authors suggest endocrine, immunologic, inflammatory and biochemical changes as possible causes.[3]

The term secondary adhesive capsulitis is used when the cause is known. Possible causes include micro- and macrotrauma, surgical trauma or prolonged immobilization of the shoulder. Subacromial decompression and more extensive procedures like: open shoulder stabilization and rotator cuff repairs may cause adhesive capsulitis.[4]

Although adhesive capsulitis is a clinical diagnosis, several MRI findings of the capsule have been described, such as thickening of the axillary recess, thickening of the coracohumeral ligament and shortening of the rotator interval.[5–9]

Arthroscopic subacromial decompression is a common surgical procedure with good results. Nevertheless, in our experience some patients can have a prolonged postoperative morbidity due to pain

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and stiffness.

The aim of this investigation was to study if MRI is a good modality to demonstrate reactions of the shoulder joint capsule and the cause of persistent suffering of some patients following arthroscopic subacromial decompression. An additional aim was to correlate the MRI findings with the clinical assessments over time.

2. Materials and methods

2.1. Study population

2.1.1. Inclusion criteria

All Patients with impingement syndrome who underwent a subacromial decompression in our institute between December 2007 and October 2010 were included.

2.1.2. Exclusion criteria

Patients with other shoulder pathologies like rotator cuff injuries, patients with history of shoulder trauma, and patients with a history of a previous shoulder surgery were excluded from the study.

Standard X rays of the shoulder with an AP view in internal and external rotation, an AC-joint view and a supraspinatus outlet view were performed preoperatively.

An MRI of the affected shoulder was done preoperatively. Patients with cuff tears, osteoarthritis of the glenohumeral joint, labrum injuries, diabetes mellitus or rheumatoid arthritis were excluded from the study.

The inclusion and the surgery were performed by the author and another experienced shoulder surgeon, but the follow-ups were performed by the author only. The clinical assessments were done before the surgery, at approximately 3 months and 6 months after surgery. By telephone, an independent secretary did a follow-up interview of the SSV two years after the surgery.

2.1.3. Surgical technique

The operative procedure was a modification of the technique described by Ellman.[11] All procedures were performed in the beach chair position, under general anaesthesia or long acting scalene block, with the arm in forward traction. The passive range of motion was assessed prior to the procedure without any attempt for manipulation. The arthroscope was first introduced into the glenohumeral joint through a posterior portal, and when no other pathologies were detected, the subacromial space was inspected from the same posterior portal. An anterior acromioplasty was performed with a motorized resector. The adequacy of the decompression was judged by introducing a straight blunt probe through the posterior portal. This determined whether the undersurface of the acromion was flat and whether the anterior hook of the acromion had been eliminated. For those patients who had symptomatic arthritic changes of the AC joint, an arthroscopic resection of the outer end of the clavicle was performed through an anterior portal.

2.1.4. Postoperative rehabilitation

The training during the first three weeks postoperatively included passive training of range of motion and scapulae positioning training with relaxation of the shoulder girdle. From week four patients were allowed to move the joint freely and use it for activities of daily living. All patients continued on to follow-up under the care of a physiotherapist at the outpatient clinic.

2.1.5. Follow-up assessments

All patients underwent a preoperative and a 3-month postoperative MRI without contrast of the affected shoulder. The MRI was taken in a standard way by including an oblique coronal dual-echo T2-weighted, an oblique coronal inversion recovery, a sagittal dual-echo T2-weighed, an axial gradient-echo and an axial dual-echo T2-weighted image. All images were obtained using 4-mm section thickness with a 0.4-mm intersection gap. Capsule reaction was defined by using a scoring system, giving two points for edema of the axillary capsule, two points for thickening of the axillary capsule, two points for the pericapsular edema and one point for the rotator interval edema. A total score of seven points indicated a maximum value for adhesive capsulitis.[5–9]

Two musculoskeletal radiologists independently evaluated the images.

The clinical assessment included range of motion by goniometer, external rotation with the arm in 0º of abduction, Constant score (CS),[12] and the Subjective Shoulder Value (SSV).[13]

2.1.6. Statistics

The data were set up as longitudinal data with each visit corresponding to a visit on a timeline. The first visit was a baseline value taken before surgery or the day of the surgery, the second was at three months and the third at six months.

The intraclass-correlation coefficient ICC (with 95% CI) was used to evaluate the interobserver reliability. For ICC, the value of 0.00–0.20 was considered slight, 0.21–0.40 was considered fair, 0.41–0.60 was considered moderate, 0.61–0.80 was considered substantial and 0.81–1.00 was considered excellent.[17] The Constant scores were reported at baseline, three months and six months.

The correlations between the MRI scores and the CS at three months and six months for both raters were analyzed using Spearman's test.

Standard ANOVA methods were used to evaluate a possible difference in the mean values for the three Constant scores and the difference in each individual mean score with each other. The same analysis was done for the mean value for the subjective shoulder value (SSV) at each visit, although an additional time period at 2 years post-operative was included.

Simple linear regression was used to establish the relationship between the change in rotation at 0° and the MRI score at three months. A baseline adjustment was used in the regression.

3. Results

Forty-eight consecutive patients (18 men and 30 women) with a mean age of 56 years (range 33–77) were included in the study. All had a subacromial impingement with or without concomitant AC joint arthritis.

The diagnosis was established according to the criteria described by Neer.[10] All patients had a positive Hawkins sign, painful arch and a positive Neer test. There were no clinical signs of rotator cuff tear or adhesive capsulitis. Twenty-two patients had painful AC joint with a positive compression sign. The dominant side was affected in 26 patients. There were no complications.

The intraclass-correlation coefficient ICC for the two MRI raters was fair as 0.3, (95% CI 0.30–0.69).

Spearman's correlation was calculated between CS scores at baseline, 3 months and 6 months with MRI score rater 1, MRI score rater 2. None of the relationships were significant. Spearman's correlation was also calculated for those with a CS score <60 and none were significant.

The study population shows a significant improvement in constant score both at three months and at six months visit (Table 1). No patients have developed sever capsulitis according to MRI staging (Table 2).

The average score for SSV was 50 (95% CI 45–55) (out of 100) at baseline, 69(95% CI 63–75) at three months, 76(95% CI 70–82) at

Table 1
Constant score (CS) of the study population preoperative, at 3 months and 6 months respectively. The difference between the baseline visit and the 3- and 6-month visit were significant. ***CS:*** constant score, ***CI:*** confidence interval.

CS preoperative	CS 3 months	CS 6 months	Difference (preoperative-3m)	Difference (preoperative-6m)
46 (95% CI 41–51)	70 (95% CI 66–74)	77 (95% CI 73–81)	P < 0.05 (95% CI 19–29)	P < 0.05 (95% CI 26–36)

Table 2
Distribution of severity of postoperative capsule changes in the study population.

MRI staging	No. of patients (total:48)
0	1
1	9
2	18
3	16
4	4
5	0
6	0
7	0

six months, and 97 at two years (95% CI 96–99). The differences between the average SSV between the individual visits were all significant.

The changes in external rotation at 0° abduction and passive range of motion and the change in MRI score as the outcome variable were used in the regression with each rater evaluated separately. No relationship was found between ROM and the MRI score with the fitted regression.

4. Discussion

Few studies have focused on capsular reactions after shoulder arthroscopy. In this study, we examined how the joint capsule reacts after arthroscopic subacromial decompression with or without concomitant resection of the outer end of the clavicle. In our earlier experience, some patients suffer from pain and stiffness postoperatively despite the fact that both procedures are extra-articular to the glenohumeral joint.

In our study, we found no relationship between the CS and MRI score after surgery for either of the radiological raters. The poor reliability between the raters after surgery indicates that it is difficult to achieve an exact measurement of the edema and thickness of the joint capsule. It may even be difficult to define an appropriate anatomy using the non arthrographic MRI. These limitations were also seen in a study by Emig.[6]

Emig[6] measured the capsular thickness in the axillary fold. A measurement greater than 4 mm on MR images suggests a diagnosis of adhesive capsulitis. Since different areas other than glenohumeral capsule involvement might be involved, such as the rotator interval, the axillary recess or the subacromial space, we chose to score different kinds of pathologies. We measured edema or thickening of the capsule in the axillary recess, middle glenohumeral ligament, rotator interval, and thickening of the axillary capsule), in an attempt to include other areas that might be affected by capsulitis.

A decrease in external rotation is one of the signs that will be noted in the early phase of adhesive capsulitis. None of our patients had developed a fulminant capsulitis, but 12 patients had decreased, and five had more than 20° reduction in external rotation, indicating a milder form of capsulitis. We sought after a correlation between the change in external rotation and the changes in MRI score for both raters, but no clear relationships were found.

Evans JP et al. studied 200 patients who underwent either ASD or ASD in combination with arthroscopic acromioclavicular joint (ACJ) excision, to establish the incidence of frozen shoulder postoperatively. The study showed that simple arthroscopic shoulder surgery carries a risk for developing frozen shoulder of just over 5% with no increased risk if the ACJ is also excised.[14]

Previous research has concentrated on the incidence of stiffness of the shoulder, severe enough to warrant further surgery, in arthroscopic rotator cuff repair, rather than isolated ASD. A review of the literature shows the risk of postoperative stiffness after rotator cuff repair to range from 0 to 14%.[15,16] The results from Huberty et al. showed that one of the risk factors associated with an increased incidence of stiffness after cuff surgery was adhesive capsulitis (15%).[18]

Warner and Greis reviewed rotator cuff repair studies that occurred over 2 decades. The techniques of repair were highly varied (open, mini-open, and arthroscopic-assisted), as were the rehabilitation protocols. In their review, Warner and Greis showed that 21 out of 500 patients (4%) had a painful loss of motion that was thought to be caused by postoperative adhesions.[19] Cameron et al. reported a 32% incidence of significant persistent postoperative stiffness after mini-open rotator cuff repair.[20] Severud et al. reported a comparative outcome analysis between their arthroscopic and mini-open rotator cuff repairs.[16] Despite using the same early motion protocols, they found a 14% incidence of postoperative adhesions and stiffness in the mini-open group and a 0% incidence in the arthroscopic group. A multicenter study from France with 576 arthroscopic rotator cuff repair cases found persistent postoperative stiffness in 3.1% of patients.[15]

In the last two decades, many RCT studies published in order to understand the cause of the shoulder pain. These studies have helped us to importance of intrinsic mechanisms as a possible underlying cause of shoulder pain. Hence, shoulder pain is not necessarily caused by the contact between the acromion and the cuff, but originates from the rotator cuff tendons and is mediated by the free nerve endings in the bursa.[21]

The literature reveals that outcomes after arthroscopic subacromial decompression have not been uniformly successful. The reported success rate ranges from 66 to 92%.[22–24] The factors that influence the results might be patient occupation, dominance of the affected shoulder, duration of preoperative symptoms, response to the impingement test, extent of the damage to the cuff, and the experience of the surgeon.[25]

We found a good result after subacromial decompression with or without AC-joint resection, which is the same as reported in the literature. The average CS preoperatively was 50, and it increased to 77 at 6 months. This increase is considered significant.

The mean SSV increased from 50 preoperatively to 69, 76 and 97 at three, six months and two years, respectively, after surgery.[13] The preoperative average was significant compared to all postoperative averages, but not between the three and six-month averages. This indicates that most patient satisfaction occurs directly after the intervention and it continues to improve over time thereafter.

One limitation of our study is that we did not have the possibility to do MR arthrography, which has gained increasing popularity as a diagnostic tool in assessing intraarticular derangements.[26,27] With MR arthrography the capsule edges would be defined more clearly, leading to a more exact measurement of the thickness. According to Emig et al. joint capsule and synovial thickness >4 mm was a useful

MR criterion for diagnosing adhesive capsulitis, with a sensitivity of 70% and specificity of 95% on T2-weighted coronal images.[6] Jung et al., using MR arthrography, showed a capsule and synovial thickness >3 mm, gave a reasonable diagnostic accuracy using the same images mentioned before.[7]

As mentioned before, we included all parts of the joint capsule in our scoring of MR images, because capsulitis generally involves a large part or the entire capsule. One part included in this process is the rotator interval in which there is controversy about the effectiveness or clinical relevance of this measurement. In the study of Emig et al. there were no significant differences between the study and the control groups.[6] This was applied to MR arthrography by Lee et al., and they found no differences in the rotator interval width between the groups in his study.[8] In contrast, Connell et al.,[5] Mengiardi et al.[9] and Jung et al.[7] found a significant difference of abnormal signal within the rotator interval between the groups in their studies. However, there was a rather low specificity.

Another limitation of our study was the absence of a control group with a confirmed diagnosis of adhesive capsulitis both clinically and by MRI. That might have shown a greater difference in the MRI changes between the two groups.

In conclusion, MRI assessment seems to be very subjective, and it has a low reliability between radiologists. Therefore, it will be difficult to rely on MRI for the diagnosis of capsular reactions. Magnetic Resonance Arthrography (MRA) with intra-articular injection of a gadolinium contrast agent could be a better tool for evaluating shoulder disorders postoperatively. MRA can clearly visualize the rotator interval, containing the coracohumeal ligament (CHL), by expanding the joint capsule. With MRA, postoperative inflammation and scarring may be distinguished from recurrent partial articular-side tears, a distinction not easily made by non-contrast fluid-sensitive sequences.

Compliance with ethical standards

The local ethical committee at Uppsala University Hospital approved the study.

Disclosures

The authors declare that they have no conflict of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jajs.2019.05.004.

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Case report

Reverse Hill-Sachs lesion with a greater and lesser tuberosity fracture of the humerus due to posterior shoulder dislocation: A case report

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ABSTRACT

Reverse Hill-Sachs lesions are occasional complication of posterior shoulder dislocation. However, Isolated fractures of the lesser tuberosity humerus are rare, occurring in only 0.46 persons per 100,000. A lesser tuberosity fracture with a reverse Hill-Sachs lesion on the humeral head is an extremely rare case presentation. We present a case of a greater tuberosity fracture of the humeral head by posterior dislocation in addition to a lesser tuberosity fracture with a reverse Hill-Sachs lesion. To our knowledge, this is the first case report of a reverse Hill-Sachs lesion with a greater and lesser tuberosity fracture of the humeral head due to posterior shoulder dislocation.
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Posterior shoulder dislocation occurs infrequently, accounting for 2–5% of all shoulder dislocations. It occurs when extreme muscle contractions, such as seizures, electrical shocks, or trauma injury, accompany shoulder flexion, adduction, and internal rotation.[1] Typical clinical features of posterior shoulder dislocation include posterior protrusion of the humeral head with a flattened anterior shoulder contour and a limited range of motion in shoulder external rotation, internal rotation, and forward elevation.[1] However, unlike that in anterior shoulder dislocation, minimal definite deformity of the shoulder girdle may occur. Thus, posterior shoulder dislocation cannot be detected on primary physical examination.[2]

Reverse Hill-Sachs lesions are occasional complications of posterior shoulder dislocation.[1,2] However, isolated fractures of the lesser tuberosity of the humerus are rare, occurring in only 0.46 persons per 100,000.[3] A lesser tuberosity fracture with a reverse Hill-Sachs lesion of the humeral head is an extremely rare case. In addition to this scenario, our case was accompanied by a greater tuberosity fracture of the humeral head by posterior dislocation. To our knowledge, this is the first case to report a Reverse Hill-Sachs lesion with greater and lesser tuberosity fractures of the humeral head due to posterior shoulder dislocation.

1. Case report

A 57-year-old man visited the emergency room with left shoulder pain that developed after falling down. The mechanism of injury included the arm in a position with the shoulder flexed, in adduction and internal rotation. Physical examination revealed general tenderness in the left shoulder, and other tests, including a test for the range of motion (ROM), were not performed because of shoulder pain. Plain radiographs of the left shoulder showed displaced lesser tuberosity fragments in the anterior-posterior view and axial view (Fig. 1-A,B), However, the other fractures were not clear in the plain radiography. Computed tomography revealed articular fractures that impacted the humeral head and displaced fractures of the greater and lesser tuberosities (Fig. 1-C). Magnetic resonance imaging showed a posterior labral tear and articular impaction of the humeral head (Fig. 1-D). From the imaging datas, a reverse Hill-Sachs lesion and greater and lesser tuberosity avulsion fractures due to posterior shoulder dislocation was assumed. One day after the trauma, we decided to perform surgical treatment because the displacement of the lesser tuberosity of the humerus was more than 10mm, and an articular impaction of more than 5mm was observed. The patient was placed in a beach chair position, and the fracture site was exposed using the deltopectoral approach. Severe comminuted fractures and impacted fractures of

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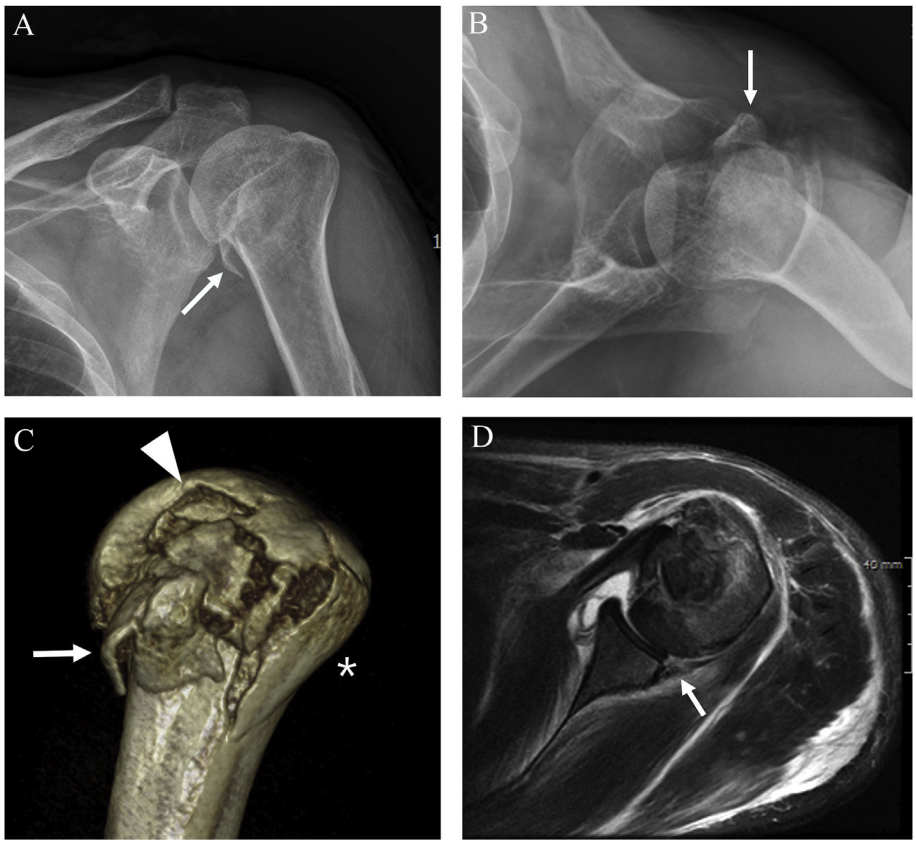

Fig. 1. Pre-operative plain radiograph of shoulder (A) Anterior-posterior view (B) Axial view. Avulsion fracture of lesser tuberosity of the humeral head (Arrow) (C) Pre-operative 3 dimensional Computed Tomography of shoulder showed impacted articular fractures of humeral head (arrowhead), the greater (asterisk) and lesser tuberosity fractures (arrow) (D) Pre-Operative T2-weighted axial magnetic sesonance imaging showed posterior labral tear.

humeral head, greater tuberosity fracture, and lesser tuberosity avulsion fracture were observed in the left proximal humerus. The articular fragments were so tiny that they could not be fixed with screws. Therefore, intra-articular fragments were reduced and temporarily fixed with K-wire. Thereafter, transosseous sutures using Polydioxanone 2-0 suture (PDS II, Ethicon, Johnson and Johnson Ltd., India) (Fig. 2-B) were placed. The greater tuberosity fragment was reduced and fixed with screw fixation using a 4.0-mm short-thread cancellous screw. Subsequently, lesser tuberosity fragments were reduced and fixed with a suture anchor using the suture bridge technique with two Y-Knot (ConMed, New York, New York) anchors and two poplok (ConMed, New York, New York) (Fig. 2-C).

2. Post-operative rehabilitation

The patient wore a shoulder immobilizer (Ultrasling ER; Donjoy, Vista, CA) that kept the shoulder at 30° of external rotation for 6 weeks postoperatively. Only pendulum exercises and scapular retraction were accepted during the period when a shoulder immobilizer was used. For the next six weeks after the immobilization period, the patient was allowed to progressively increase the range of motion and perform pain-free strength exercises. In 12–16 weeks, a more intensive strengthening exercise regimen was allowed, and the patient was able to return to work.

3. Clinical outcomes

The patient showed remarkable progress through his postoperative recovery and rehabilitation. He recovered well for 6 months after discharge and returned to daily life and work without pain. The pseudoparalysis, external rotation lag sign, and horn-blower's sign were all negative, and the visual analogue scale score at the last follow-up was 2 of 10. In the 12 months after surgery, the patient achieved full range of motiong of the shoulder (Fig. 3) and bony union was observed via plain radiography (Fig. 4). Moreover, the American Shoulder and Elbow Surgeon score was 96.7 of 100 and the Korean shoulder scoring system was 97 of 100, both of which represented the patient's excellent prognosis.

4. Discussion

Posterior dislocation of the shoulder is a rare injury and can result in complications such as reverse-hill sacs lesions.[1] Posterior shoulder dislocation is known to occur with extreme muscle contraction such as seizures, electrical shocks, or trauma injury with shoulder flexion, adduction, and internal rotation. Avulsion fractures to the lesser tuberosity of the humerus occur infrequently[3] and, isolated avulsion fractures of the lesser tuberosity of the humerus are known to occur due to traction of the subscapularis muscle by acute abduction and external rotation force in the upper arm. In addition, when an axial load is applied to the long axis of the humerus, in the position of upper arm extension and external rotation, a fracture can develop because of the increased tension of the subscapularis muscle and the superior glenohumeral ligament.[4] However, Liu et al. [5] reported that a lesser tuberosity fracture occurred with posterior shoulder dislocation. A reverse Hill Sachs lesion and lesser tuberosity fracture of the humerus with

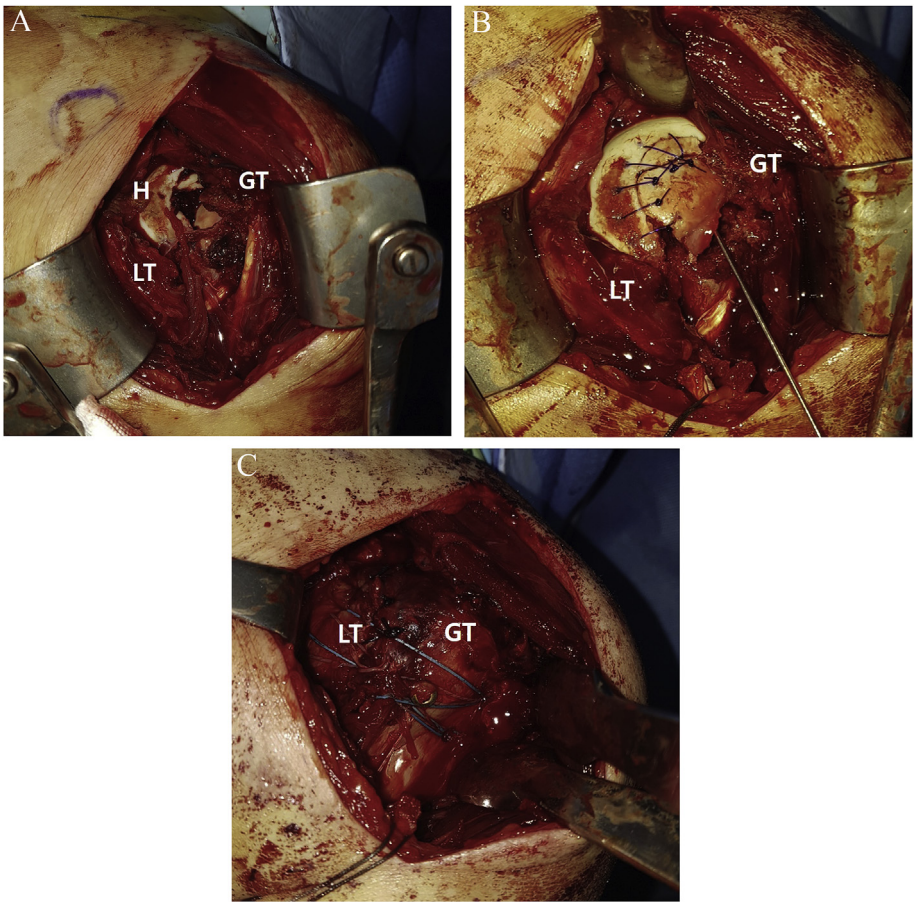

Fig. 2. Intraoperative findings. (A) Severe comminuted and impacted fracture of humeral head, greater tuberosity fracture and lesser tuberosity avulsion fracture were observed. (B) Intra-articular fragments were reduced and temporarily fixed with K-wire. Thereafter, those were fixed using the transosseous suture with Polydioxanone 2-0 suture (C) Lesser tuberosity fragment was reduced and fixed with suture anchor by the suture bridge technique. H: Humerus, GT: Greater tuberosity, LT: Lesser tuberosity.

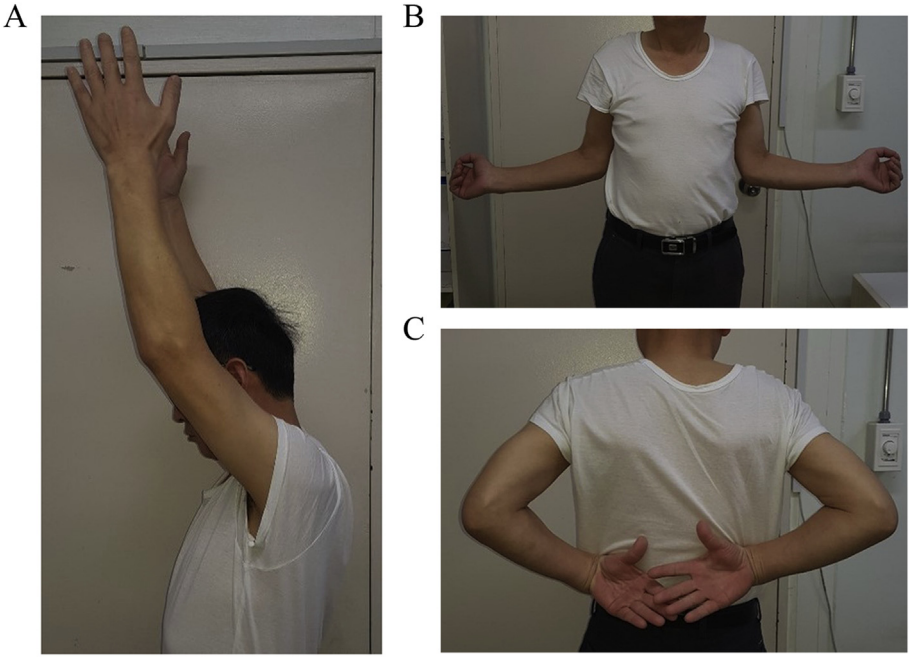

Fig. 3. Range of motion of the shoulder joint was measured in the 12 months after surgery. Full ranges were observed in forward elevation, external rotation, internal rotation of both shoulder joints.

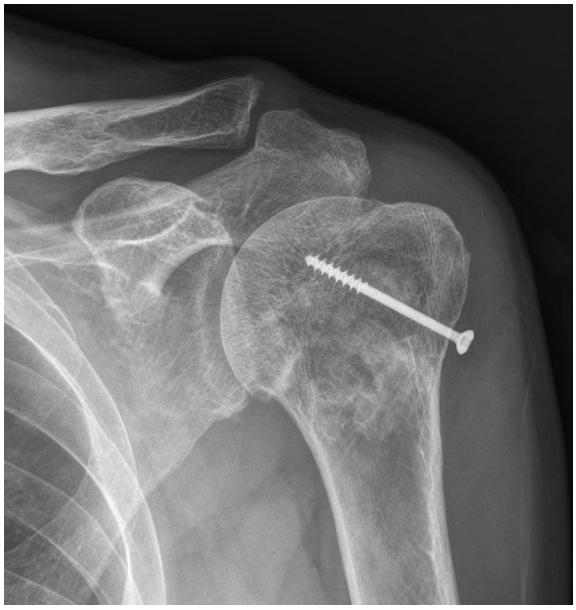

Fig. 4. Plain radiograph in 12 months after surgery showed bony union of fracture site.

simultaneous posterior dislocation is an extremely rare case. Furthermore, a fracture of the greater tuberosity of the humerus also existed in our case. However, the diagnosis of a reverse Hill-Sachs lesion can be missed, because it is not often seen on plain radiography.[6] Recently, Computed tomography could be helpful for evaluation the exact state of fracture pattern. Furthermore, Magnetic resonance imaging is useful to figure out the accompanied the tendons and ligamentous injuries, especially in the lesser tuberosity avulsion fracture. [3,5,7] Taking these into account, if there are fractures in the greater and lesser tuberosity of the humeral head, it is important to not only classify the fracture pattern, but also to evaluate and understand the injury mechanism.

The treatment of a reverse Hill-Sachs lesion and lesser tuberosity fracture is controversial. Pace et al. [8] treated small lesser tuberosity fractures with minimal displacement by conservative management using a collar for 12 weeks. In the other studies, reattachment of the lesser tuberosity with rotator cuff repair has been advised for displaced fractures. [6,8] For reduction of the articular bone fragment, we detached lesser tuberosity fragments and then reattached them, similar to the technique followed of Demirel et al. [9] For the reverse Hill-Sachs lesion with posterior shoulder dislocation, Guehring et al. [10] proposed a treatment algorithm that depended on the defect size and time interval between the trauma and surgery. A neglected articular fracture is associated with poor outcomes because the risk of malunion is relatively high. Therefore, precise understanding of the injury mechanism and further evaluation are needed. In our case, surgical management was determined because the impacted articular fracture was multi-fragmented, and displacement of the lesser tuberosity was more than 10 mm. Although there were other options for fixation of the small intra-articular fracture fragments, such as headless screw fixation, percutaneous pin fixation, we used transosseous suture fixation because the fracture was severe comminuted and impacted. In the case of small fragmented intra-articular fractures that can not be fixed by screws, we use the transosseous suture fixation technique, which showed good progress with satisfactory reduction and union of fractures.

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Improved perioperative outcomes with direct anterior approach total hip arthroplasty in a Veteran's Affairs patient population

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ABSTRACT

Background: A trend toward improved perioperative outcomes with direct anterior approach total hip arthroplasty (DAA THA) in comparison to posterior approach THA has been described. The benefits of the DAA THA have not been examined in the Veteran's Affairs (VA), a health system unique in its highly comorbid patient demographic and federally subsidized budget. Optimizing outcomes in this population could help reduce costs, readmissions, and complications. This study sought to compare the perioperative and radiographic outcomes of veterans who underwent a DAA THA versus a posterior approach THA.

Methods: We retrospectively reviewed the records of 110 primary posterior approach THAs and 93 primary DAA THAs performed for primary osteoarthritis by a single surgeon at a VA hospital between 2012 and 2018. We compared mean surgical duration, intraoperative blood loss, perioperative blood transfusion requirements, discharge disposition, hospital length of stay, as well as acetabular component inclination, femoral offset discrepancy, and leg length discrepancy using postoperative anteroposterior pelvis radiographs.

Results: The DAA group demonstrated significantly lower perioperative blood transfusion rates (5% vs. 20%), increased likelihood of discharge prior to postoperative day three (OR 2.12; 95% CI 1.02–4.44), and higher rate of discharge to home (65% vs. 40%). Acceptable acetabular inclination rate was higher in the DAA group (83% vs. 37%).

Conclusion: Among veterans undergoing primary THA at a VA hospital, patients undergoing DAA THA had better perioperative outcomes than patients treated with the posterior approach despite similar demographics, American Society of Anesthesiologists score, and the DAA learning curve.

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1. Introduction

The direct anterior approach (DAA) to the hip is rising in popularity for performing total hip arthroplasty (THA).[1] The approach uses the internervous plane between the sartorius and tensor fascia lata in the superficial layer and the plane between the gluteus medius and rectus femoris in the deep layer.[1] Several recent studies have demonstrated its benefits compared to the lateral and posterior approaches, including reduced need for narcotic pain medications, improved preservation of the soft tissues, decreased length of hospitalization, quicker postoperative recovery, improved gait kinematics, and decreased risk of dislocation.[2–6] Some concerns have been raised regarding increased operative time, blood loss, wound healing complications, lateral femoral cutaneous nerve injury, and decreased surgical exposure during femoral and acetabular component implantation.[7–13] However, these observed complications may be associated with the considerable learning curve for adopting this technique.[14]

The direct anterior approach requires supine positioning of the patient, facilitating the use of fluoroscopy for intraoperative assessment of implant positioning.[15] The approach is associated with improved rates of acceptable acetabular angle, and equivalent rates of acceptable acetabular anteversion, leg length, and femoral

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offset compared to the posterior approach.[16] Optimal component positioning is associated with lower postoperative instability, improved range of motion, and decrease risk of polyethylene wear, which translates to improved long term outcomes and longevity of a total hip replacement.[17–19] While trends toward shorter hospital stays, quicker recoveries, and improved component positioning have been noted with the DAA THA, the evidence is still insufficient to conclude the DAA is superior to the other approaches.[20,21]

The VA represents a uniquely integrated healthcare system that is different from the private sector in its highly comorbid patient population, budget regulation, and provision of care.[22] For example, obesity rates are higher among veterans who use the VA for health care compared with veterans who do not use the VA. This has important implications from an outcomes perspective, as obesity is an independent risk factor for infection, readmission, and component malpositioning.[16] To our knowledge, no study has examined the benefits of the DAA THA in the veteran's affairs (VA) arthroplasty population. Further studies are needed to examine if there is a benefit in this population, both to improve implant longevity in an at-risk population and reduce utilization of hospital resources funded by a federally constrained budget. The purpose of this study is to compare the perioperative clinical and radiographic outcomes of veterans who underwent a total hip arthroplasty (THA) via a direct anterior approach (DAA) versus those who underwent a posterior approach at a VA healthcare facility.

2. Materials and Methods

This study was approved by the institutional review board. We retrospectively identified from the operative logs consecutive cohorts of 121 primary posterior THAs performed between January 10, 2012 and May 12, 2015, and 93 primary DAA THAs performed between May 19, 2015 and January 16, 2018. All procedures were performed by a fellowship trained arthroplasty surgeon at a single VA hospital. The indication for surgery was primary hip osteoarthritis in all cases. One patient from the posterior THA group had Paget's disease. Exclusion criteria included acetabular dysplasia, avascular necrosis, and revision arthroplasty cases. We excluded from the study 11 patients in the posterior THA group with restricted medical records, reducing the total number of posterior THA cases included in the analysis to 110. Among the 93 DAA and 110 posterior surgeries, 11 patients (6 posterior and 5 DAA) were removed from radiographic analysis for having radiographs that were not amenable to technical review, yielding 192 (104 posterior and 88 DAA) radiographs available for analysis.

Data on pre-operative patient factors and intra-operative surgical factors were collected, including age, body mass index (BMI), gender, laterality, American Society of Anaesthesiology (ASA) score, operative time, and intraoperative blood loss. There were no differences between approaches with regards to BMI, patient age, gender, laterality and ASA score.

Data on postoperative outcomes were extracted through a chart analysis. These parameters included hospital LOS (in days), number of packed red blood cell units transfused, discharge disposition, and ICU admission. Discharge disposition was a binary outcome, documented as either “home” or “other” (including inpatient rehabilitation or skilled nursing facility).

2.1. Surgical technique

Posterior Approach: The patient was placed into the lateral decubitus position with the operative side up. A pre-incisional intravenous 1 g dose of tranexamic acid was administered to all patients. An incision beginning 5 cm distal to the greater trochanter, centered on the femoral diaphysis, was continued proximal to the greater trochanter. At that point, the incision was curved toward the posterior superior iliac spine for 6 cm. Iliotibial band was incised and the gluteus maximus was split. Piriformis tendon was detached at its femoral insertion and tagged, as were the external rotators and the capsular flaps following posterior capsulotomy. Placement of the acetabular cup was performed using straight inserter handles. Implant orientation was confirmed largely by evaluating the relationship between the inserter handle and the orientation of the pelvis. At the time of closure, the posterior hip capsule was repaired and the external rotators were reattached.

Anterior Approach: A regular OR table was used for all DAA surgeries. A pre-incisional intravenous 1 g dose of tranexamic acid was administered to all patients. An incision starting 2 cm lateral and 2 cm distal to the anterior superior iliac spine and proceeding 8 cm distally toward the fibular head was made. The tensor fascia lata (TFL) fascia was split, and the TFL was mobilized and retracted laterally. The interval between rectus femoris and gluteus medius was employed to access the anterior hip capsule. Intraoperative fluoroscopy was utilized during acetabular preparation and insertion of the shell. Intraoperatively, acetabular inclination and version were judged based on an intraoperative anteroposterior pelvis view. Straight inserter handles were used for acetabular cup positioning and confirmation of component alignment.

Implants: A Zimmer Biomet G7 acetabular component and Zimmer Biomet Echo femoral stem were used for all procedures except in rare cases.

2.2. Radiographic review

Two independent reviewers - a senior orthopaedic resident and a fellowship trained arthroplasty surgeon - were blinded to each patient's surgical cohort and clinical course, but given a spreadsheet with the patient's pre-assigned study identification number, laterality, and size of implanted acetabular cup. The reviewers measured acetabular cup inclination angle, LLD, and femoral offset for the 203 patients with available radiographs. Eleven patients without acceptable images were excluded from the radiographic analysis, yielding 192 total radiographs for inclusion for radiographic review. Reasons for exclusion were inappropriately rotated pelvic films, ischial tuberosities not visible in radiograph, or inadequate proximal femur visualized to obtain offset measurements.

The most immediate postoperative anteroposterior (AP) pelvis radiograph available for each patient was used for measurement assessment (Figs. 1 and 2). The methods used are demonstrated in Fig. 3, as adopted from a prior radiographic analysis performed by Lin et al.[16] All measurements were made using OrthoView digital software (Materialise, Leuven, Belgium). The implanted acetabular cup diameter was used to calibrate each image to produce accurate measurements for LLD and offset.

2.3. Measurement of acetabular inclination

The acetabular inclination angle was measured using the angle between a line tangential to the ischial tuberosities and a line through the axis of the major diameter of the acetabular component. We defined the range of acceptable acetabular inclination angle 30–50°, inclusive, based on the “safe zone” as described by Lewinnek *et al.*[17]

2.4. Measurement of LLD

LLD was measured by first creating a horizontal line tangential to the ischial tuberosities. The distance from the most medially prominent aspect of the lesser trochanter to the horizontal was

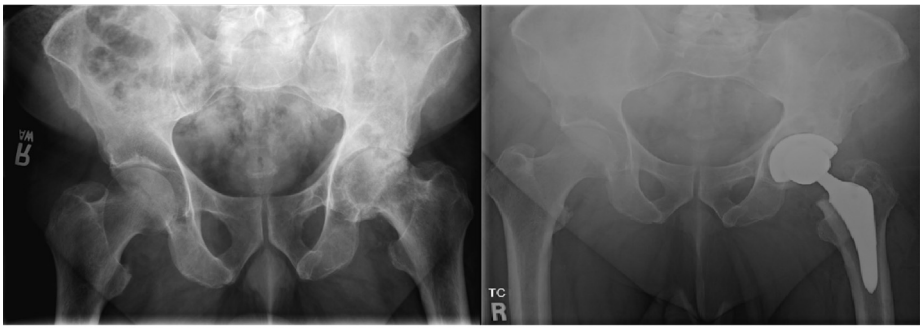

Fig. 1. Preoperative (left) and postoperative (right) AP pelvis radiograph of a patient who underwent left DAA THA.

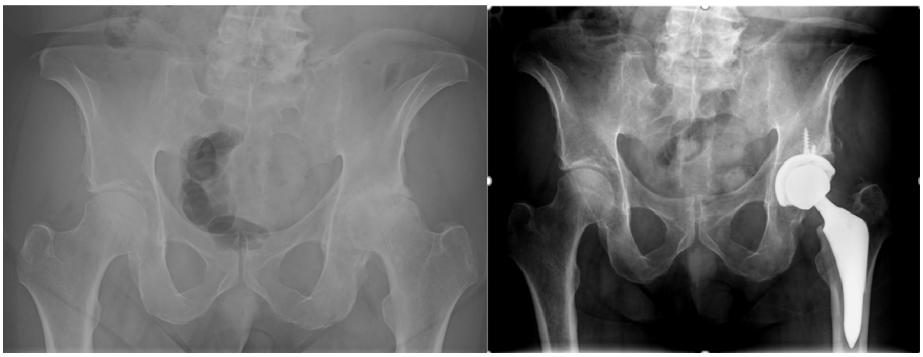

Fig. 2. Preoperative (left) and postoperative (right) AP pelvis radiograph of a patient who underwent a left posterior approach THA.

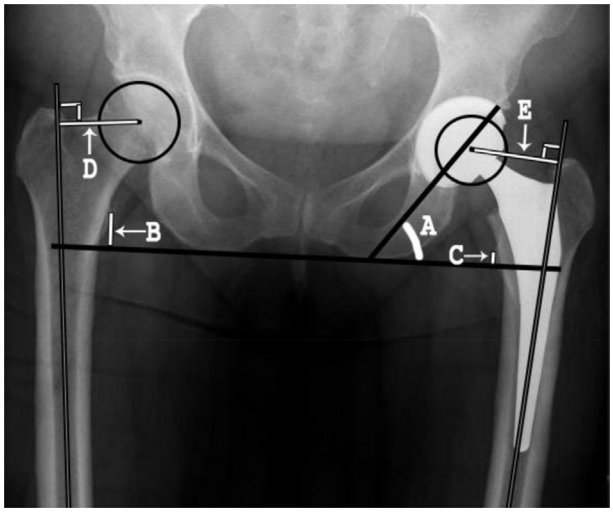

Fig. 3. Figure as adapted from Lin et al.[16] describing method for measuring acetabular inclination (angle A), offset (measurements D and E), and LLD (difference between measurements B and C) on a postoperative AP pelvis radiograph.

measured. This was compared to the distance on the contralateral side from the symmetric point on the lesser trochanter. For cases where the lesser trochanter was either dysmorphic or not visible in the radiograph, distance from the tip of the greater trochanter on each side was used instead. While there is no universally accepted value for meaningful difference in LLD, Konyves et al. found that approximately 90% of patients with a perceived LLD twelve months after THA had a perioperative radiographic LLD greater than five mm.[23] Hence, we chose five mm for our cutoff as a significant difference, where greater than five mm difference was considered unacceptable. Negative values for LLD represented an operative side shorter than the nonoperative side, and positive values represented a longer operative extremity. Hence, LLD values between −5 mm and 5 mm were considered “acceptable”.

2.5. Measurement of femoral offset

Change in femoral offset was measured as described by Lecerf et al.[24] Lines were drawn to bisect the proximal femoral shafts on the operative and nonoperative sides. The perpendicular distance was measured from this line to the ipsilateral center of the femoral head. The change in femoral offset was the distance on the operative side minus the distance on the nonoperative side. A negative change in femoral offset denoted that the operative side offset was less than the nonoperative side. A value between -5mm and 5 mm was considered “acceptable”, as supported by prior literature suggesting poorer outcomes with greater than 5 mm change from native offset.[19,25]

2.6. Statistical analysis

We statistically compared patient characteristics, perioperative clinical, and radiographic outcomes between the DAA and posterior THA cohorts. Categorical variables were compared with the Fisher exact test. Continuous variables were compared using the independent sample *t*-test and the Wilcoxon rank-sum test for parametric and nonparametric data, respectively. We calculated the odds of discharge prior to the third post-operative day for the DAA cohort in comparison to the posterior THA cohort, and tested for statistical significance with the chi-squared test. We performed all analyses using SAS 9.4 (SAS Institute Inc., Cary, NC, USA).

3. Results

There were no significant differences between the DAA and posterior cohorts in terms of age, sex, BMI, surgical laterality, and

ASA score (Table 1). Both cohorts had a mean age of 66 years, were predominantly male (>97%), and had mean BMIs of 29.5. Less than 30% had ASA scores of I, most were ASA II, and less than 2% were ASA III in each cohort.

The DAA THA group had a shorter LOS (IQR 3–5 days vs 3–6 days), increased likelihood of target discharge prior to postoperative day 3 (OR 2.12; 95% CI 1.02–4.44), longer operating room time (162 vs 151 min), higher intraoperative blood loss (50 mL higher), and lower rate of blood transfusion (5% vs 20%) ($p < 0.05$; Table 2). The DAA was protective against blood transfusion, with patients being 4 times less likely to be transfused than the posterior group (OR = 0.23; 95% CI 0.08–0.64; $p < 0.01$). Among those transfused between the two groups, the number of units administered were not significantly different ($p = 0.3$).

Discharge to home was achieved for 65% of the DAA THA group compared with 40% of the posterior THA group ($p < 0.001$). Patients undergoing DAA were nearly three times more likely to be discharged home compared to the posterior group (OR = 2.78; 95% CI 1.56–5.00; $p < 0.001$).

The rate of early discharge, defined as discharge on postoperative day 2 or earlier, was higher in the DAA group (23.7% vs 12.7%). The DAA group had a lower percentage requiring postoperative surgical ICU admission (2% vs 5%). Neither of these differences achieved statistical significance.

There was a higher percentage of subjects in the DAA group that had an acceptable acetabular inclination angle compared to the posterior group (83% vs. 37%, $p < 0.0001$; Table 3). The DAA was protective against an unacceptable angle compared to the posterior approach (OR = 0.12, 95% CI 0.06–0.23; $p < 0.0001$). The mean leg length discrepancies for the DAA cohort (−0.3 mm) and the posterior cohort (3.7 mm) were significantly different, however the rate of acceptable leg length discrepancy in each cohort was not significantly different (52% vs 50%, $p = 0.77$). The majority of all subjects had acceptable (<5 mm difference compared to contralateral side) offset, with no difference by approach (59% posterior vs. 52% anterior, $p = 0.33$).

There were a higher number of in-hospital morbidities in the posterior THA group. Four patients were admitted to the surgical intensive care unit (SICU) postoperatively for management of postoperative hypotension or monitoring after high intraoperative blood loss. One patient developed a superior gluteal artery aneurysm that required embolization. Two patients were admitted to the medical intensive care unit, one for management of atrial fibrillation with rapid ventricular response, the other for management of pulmonary edema. Two patients were transferred postoperatively to the medicine service, one for management of a gastrointestinal bleed, the other for atrial flutter. There were no in-hospital mortalities in both groups.

Two patients in the DAA group sustained an intraoperative nondisplaced greater trochanter fracture. One case occurred during femoral elevation in the setting of an incomplete posteromedial capsular release, the other occurred during extraction of a femoral broach. Both patients were treated conservatively with abductor precautions and protected weight bearing in the perioperative period (approximately 4 weeks). Additionally, two patients were transferred to the SICU postoperatively for management of postoperative hypotension.

Table 1
Patient characteristics, DAA and posterior THA cohorts.

	DAA	Posterior	*P* value
Total number (% total cohort)	93 (45.8)	110 (54.2)	–
Mean age (SD)	66.4 (8.3)	65.9 (8.8)	0.65 *
Sex			0.63 §
Female	1 (1.1)	3 (2.7)	
Male	92 (98.9)	107 (97.3)	
Mean BMI (SD)	29.5 (4.3)	29.4 (5.3)	0.86 *
Laterality			0.26 §
Left	47 (50.5)	46 (41.8)	
Right	46 (49.5)	64 (58.2)	
ASA score			0.77 §
ASA I	26 (28)	30 (27.3)	
ASA II	65 (70)	79 (71.8)	
ASA III	2 (2.1)	1 (0.9)	

Percentage of cohort is in parentheses, unless otherwise indicated. Comparison between groups by (*) independent sample *t*-test, (§) Fisher's exact test.

4. Discussion

The increased adoption of the DAA THA at arthroplasty centers nationwide has garnered attention in recent literature. Proponents of the DAA cite improved implant positioning, shorter hospital LOS, less postoperative pain, reduced blood transfusion rates and increased likelihood of discharge home in comparison to the posterior approach.[16,26,27] To our knowledge, no study has examined the benefits of the DAA for THA in the VA patient population. In our study of veterans undergoing primary THA at a VA hospital, patients undergoing DAA THA demonstrated better perioperative outcomes than patients undergoing the posterior approach despite similar demographics, ASA score, and the DAA learning curve.

Applying available arthroplasty outcome data from the private sector to the VA patient population may be fraught with biases. The VA manages a unique patient population that is different from the private sector patient population. Veterans who use the VA for health care have the highest rates of obesity compared with veterans who do not use the VA, and obese veterans who utilize the VA for services have higher rates of comorbidities, particularly diabetes.[28,29] This has important implications from a THA perspective, as obesity is an independent risk factor for infection, readmission, and acetabular component malposition.[16,30,31] The latter, in turn, is a risk factor for postoperative dislocation and implant wear.[17,32] Furthermore, the VA cares for a higher percentage of minorities who, as a group, often encounter barriers to care in community settings, socioeconomic burdens, and poor social support systems. Such access issues may translate to discharge barriers and prolonged hospital lengths of stay; poor social support may decrease the chances of a patient being discharged home.[22]

We found that the DAA THA was associated with a significantly lower perioperative blood transfusion rate, increased discharge to home rate, shorter LOS, and increased likelihood of discharge prior to postoperative day three when compared to the posterior approach. This is concordant with comparative studies performed in the non-VA population. Ponzio et al. found similarly improved perioperative parameters with the DAA at a large volume arthroplasty center, despite including the learning curve for DAA.[26] The finding of lower perioperative transfusion rates despite longer operating time and higher blood loss in the DAA group may be attributed to differences in postoperative hidden blood loss (HBL) between the two approaches. The posterior approach is associated with more soft tissue dissection and a considerably longer surgical incision, which are known influential factors of HBL in THA.[33] These factors are also implicated in the DAA 's known association with expedited postoperative mobilization, which was apparent in our study. At our institution, clearance for home discharge is determined by the patient's ability to mobilize independently, navigate stairs, and tolerate activities of daily living without significant discomfort. This accounted for the higher rate of home discharge clearances by our physical therapy department for the DAA cohort. Lastly, the higher likelihood of later discharge in the posterior cohort may be explained by several factors, such as the cohort's higher rate of medical morbidity (ie., anemia requiring transfusion)

Table 2
Perioperative outcome measures, DAA and posterior THA cohorts.

	DAA	Posterior	*P* value
Mean surgery duration (min; SD)	162 (33)	151 (23)	0.009 *
Estimated blood loss, median (ml; IQR)	300 (200–570)	250 (200–400)	0.007 **
Number transfused	5 (5)	22 (20)	0.003 §
Median units transfused (IQR)	1 (1–2)	2 (1–4)	0.14 **
Number admitted to SICU	2 (2)	6 (5)	0.30 §
Number discharged prior to POD3	22 (24%)	14 (13%)	
Odds of discharge prior to POD3 (95% CI)	2.12 (1.02–4.44)	–	0.042
Number discharged to rehab	32 (35)	66 (60)	<0.001 §

Percentage of cohort is in parentheses, unless otherwise indicated. Median units transfused reported for those patients in each cohort who received a transfusion. Comparison between groups by (*) independent sample *t*-test, (**) Wilcoxon rank sum test, (§) Fisher's exact test. Odds of discharge prior to POD3 reported for DAA compared to posterior cohort; p-value reported from chi-squared test.

Table 3
Radiographic outcome measures, DAA and posterior THA cohorts.

	DAA	Posterior	*P* value
Total number	88	104	
Mean acetabular inclination (degrees; SD)	36.8 (6.5)	51.9 (5.3)	<0.0001 *
Number acceptable (30°–50°)	75 (83)	37 (37)	<0.0001 §
Mean leg length discrepancy (mm; SD)	−0.3 (8.6)	3.7 (6.8)	0.0005 *
Number acceptable (-5 mm – 5 mm)	46 (52)	50 (50)	0.77 §
Mean femoral offset (mm; SD)	−0.8 (6.4)	−0.4 (6.8)	0.66 *
Number acceptable (-5 mm – 5 mm)	46 (52)	60 (59)	0.31 §

Percentage of cohort is in parentheses, unless otherwise indicated. Comparison between groups by (*) independent sample *t*-test, (**) Wilcoxon rank sum test, (§) Fisher's exact test.

and increased rate of rehabilitation referrals. Awaiting the resolution of postoperative anemia and acceptance at a local rehabilitation center can be lengthy processes that would delay discharge.

The aforementioned findings have important clinical and financial implications. Longer index LOS, discharge after postoperative day three, discharge disposition to a nursing facility, and blood transfusion requirements are independent risk factors for 30-day readmission and complication after THA.[34] Perioperative blood transfusion has been independently linked with an increased risk of surgical site infection after THA.[35] Sutton et al. found discharge prior to postoperative day 2 to be an independent predictor against major postoperative complications.[36] Lastly, there is a significant difference in episode of care costs according to discharge disposition after THA, with discharge to home being the least costly.[37] The adoption of the DAA in the VA patient population has the potential to control future costs, rehospitalizations, and complications in an already economically burdened VA health care system.

A longer surgical duration and marginal increase in intraoperative blood loss was noted for the DAA THA group. We attribute these findings to the learning curve of the DAA, as well as the complexity of the DAA procedure, which requires greater skill in various steps. Not surprisingly, these findings are consistent with prior studies that similarly included the learning curve for the DAA.[38,39] The authors believe that this difference in surgical duration would not persist if this study were performed outside of the senior author's DAA learning curve.

Acetabular component inclination is an important modifiable risk factor for postoperative instability, bearing surface wear, periprosthetic osteolysis, and component impingement in THA.[32,40,41] The DAA cohort demonstrated an increased rate of achieving target acetabular component inclinations within the safe zone as defined by Lewinnek, matching prior trends demonstrated in the literature.[5,16,42] We do not attribute these findings to the use of fluoroscopy but rather to the nature of the DAA itself. The supine positioning facilitates anatomic comprehension and pelvic landmark identification, which is helpful when external alignment guides are utilized to gauge acetabular component positioning. Pelvic tilt and rotation have been found to be highly variable in the lateral decubitus position, leading to inconsistent and inaccurate orientation of the acetabular component despite intraoperative use of fluoroscopy.[43] Furthermore, Grammatopoulos et al. reported a significantly higher risk of acetabular component malposition and significantly greater discordance between intraoperative and postoperative radiographic component positioning with posterior THA, despite the use of intraoperative fluoroscopy in both cohorts.[44] Lastly, obscurity of pelvic landmarks and unpredictability of pelvic orientation in the lateral decubitus position, particularly in centrally obese patients, impedes accurate component positioning.[43] This is especially true when external alignment guides are used to gauge version and inclination of the acetabular cup, as was the case in this study.[43] We believe a combination of these factors explains the high percentage of acetabular component malposition seen in our posterior approach cohort.

Our study has several limitations. First, our data are observational and non-randomized, which may introduce selection bias and decrease the generalizability of our results. We compared surgeries performed by a single surgeon at a single VA site to optimize consistency and confer control to this comparative trial. Second, all cases in this study were performed by a fellowship-trained arthroplasty surgeon at a high-volume VA hospital consistently rated highly by the VA Strategic Analytics for Improvement and Learning (SAIL) quality improvement system.[45] Our results may not be applicable to VA centers with a dissimilar practice profile. Third, the surgeon used the posterior approach exclusively for approximately 6 years in his practice prior to adopting the DAA. The findings may be related to the surgeon continuing to refine and improve surgical skills over time. Fourth, we did not examine patient-reported or long-term outcomes in this study. While the perioperative findings we report have been associated with long-term clinical outcomes, we were unable to independently demonstrate this association in our patient population. The clinical superiority of the DAA THA in the VA population remains to be examined prospectively in future studies. Lastly, whether the perioperative benefits of the DAA offset the shortcomings of the procedure, including the cost of fluoroscopy and radiation exposure to the surgeon and the patient, are aspects to consider as well.

We found that despite the learning curve associated with surgeon adoption, DAA THA resulted in improved perioperative outcomes compared to the posterior approach in a VA patient cohort. Additionally, the DAA was associated with improved acetabular inclination angles compared to the posterior approach, and showed no difference in rates of unacceptable LLD or offset. While perioperative outcomes after THA are only one aspect of a patient's outcome, there is mounting evidence to suggest that longer term outcomes, including decreased post-discharge costs, readmission

rates, and implant failures, are associated with the perioperative parameters examined in this study. We therefore advocate for increased adoption of the DAA THA technique for patients in the VA or similar health systems.

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Research paper

Periarticular regional analgesia in total knee arthroplasty – Efficacy and outcome of single posterior capsular vs multiple site injections

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ABSTRACT

Objective: Total knee arthroplasty (TKA) is a frequently performed elective orthopedic intervention for painful arthritic knee with the purpose to improve postoperative quality of life. However, TKA is followed by intense pain in postoperative period. Postoperative pain after total knee arthroplasty (TKA) is a well-known clinical problem and prevents patients from sleeping, ambulating and participation in physical therapy. The infiltration of a cocktail in knee joint is a simple procedure performed by surgeon in soft tissue before component implantation. However, the technique and site of periarticular infiltration is still evolving, recent studies suggest that the proper technique of periarticular injection includes drug administration at eight sites around the knee. The purpose of this study was to compare the efficacy and outcome of single posterior capsule vs multiple site infiltration.

Methods: This was a prospective randomized control study. A total of forty patients were randomly assigned into two groups of twenty each. Group A was given a single periarticular injection of a fixed cocktail just before implantation of components while group B was given same cocktail at eight pre-determined sites around knee. Post operatively pain status was assessed by means of visual analogue scale.

Results: Comparison of the pain scores of the two group were not statistically significant.

Conclusion: The results of the study indicates that periarticular infiltration is a safe and effective means of postoperative pain control and that single posterior capsular infiltration is as effective as multiple infiltration.

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Introduction

Total knee arthroplasty (TKA) is a frequently performed elective orthopedic intervention for painful arthritic knee with the purpose to improve postoperative quality of life[1,2]. However, TKA is followed by intense pain in postoperative period. Postoperative pain after TKA is a well-known clinical problem and prevents patients from sleeping, ambulating and participation in physical therapy.Early mobilization post TKA can prevent knee stiffness, lessens hospital stay and improves overall patient satisfaction and outcome of TKA[3]. Besides, early knee mobilization is associated with decreased risk of deep vein thrombosis and good long-term functional outcomes[4,5]. Adequate pain relief following TKA may facilitate early mobilization and thus the overall outcomes.

Multi-modal analgesic regimes are used to relieve pain in patients who have undergone TKA. Conventional postoperative analgesia is provided by either intravenous patient-controlled analgesia (PCA) or epidural analgesia. Recently several studies reported an upsurge in peripheral nerve block (PNB) use for Orthopedic patients[6,7]. Moreover, analgesic efficacy and surgical outcomes of PNB are comparable to PCA or epidural analgesia without the associated side-effects[7,8]. However, one of the challenges of treating post-operative pain after TKA with regional anesthetic techniques is to provide sufficient analgesia with preserved muscle function and minimal side effects.

Femoral nerve block (FNB) is often considered as the gold standard for pain alleviation after TKA[6,9–13]. However, FNB reduces quadriceps muscle strength thereby potentially compromising postoperative mobilization[14–18]. Furthermore, the FNB is associated with higher risks of fall due to quadriceps weakness

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following block[19–21]. Therefore, alternative analgesic techniques for effective pain treatment with preserved muscle function need to be evaluated.

With the aim to spare quadriceps motor function providing analgesia, periarticular infiltration (PAI) of a high volume of local anesthetic during TKA is gaining interest. In the late 1990s, Kerr and Kohan used ropivacaine, ketorolac, and adrenaline as a local infiltration after TKA, and the results have been promising, although not fully scientifically evaluated. Various papers have described the use of periarticular injections of anesthetic concoctions to relieve pain. These drug cocktails commonly include combinations of nonsteroidal anti-inflammatory drugs (NSAIDs), local anaesthetics and opioids such as morphine.

The infiltration of local anesthetic in knee joint is a simple procedure performed by surgeon in soft tissue before component implantation. Previous study demonstrated a low impact of PAI on quadriceps function during TKA[22], although several PAI methods have been proposed with different results depending on type of the solutions used; a classical PAI solution included high volume of local anesthetic, opioids (theoretically with low adverse-effects than systemic administration), and epinephrine to prolong analgesia.

However, the technique and site of periarticular infiltration is still evolving, recent studies suggest that the proper technique of periarticular injection includes drug administration at eight sites around the knee[23] We are not aware of any study comparing the efficacy and outcome of technique of periarticular analgesia.The purpose of this study was to compare the efficacy and outcome of single posterior capsule vs multiple site infiltration.

Methods

Study design and subjects

This study was a prospective randomized control study. After obtaining institutional ethics committee approval, we assessed all 40 consecutive patients scheduled for unilateral primary TKA aged 50–80 years, from July 2017 to December 2017 for inclusion into the study. Written informed consent was obtained from all subjects prior to enrolment.

Eligibility criteria were.

Inclusion criteria:

- Primary, unilateral TKA under spinal anesthesia,
- American Society of Anesthesiologists physical status classification of I–III.

Exclusion criteria:

- Renal insufficiency,
- Contraindications to adductor canal block,
- History of arrhythmia or seizures,
- History of chronic pain unrelated to the knee,
- requiring treatment with long acting opioids,
- Alcohol or drug abuse,
- Allergy to either the components of the periarticular injection and
- Difficulties in comprehending visual analogue scale (VAS) pain scores.

40 patients were enrolled for the study and randomized into two groups (A-single or B-multiple injections), using computer generated randomization table. The patients and a clinical investigator who prospectively collected all clinical information were unaware of the group identities until the final data analysis. There were no significant differences in the demographic data, preoperative status and operative time among the two groups.

Anesthesia technique

Spinal anesthesia was induced with 3.0 ml 0.5% hyperbaric bupivacaine at the L3/4 interspaces (alternatively at the L2/3 or L4/5 interspaces).

Administration of adductor canal block(ACB)

In all patients, ACB was performed immediately postoperatively. All blocks were performed by the same senior anesthesiologist, with considerable experience in US-guided nerve blocks.All patients were given a single shot loading dose of 30 cc inj. Ropivacaine 0.75% followed by repeated boluses of inj. Ropivacaine 0.25%, 30 cc at an interval of 4 h till 8:00 am on the morning of the second day after surgery.

Surgical procedure and perioperative management

All surgeries were performed by the senior surgeon by the same approach and technique. Tourniquet was used in all of the patients, and the standard median parapatellar approach was used in all the cases. Posterior stabilised implants were used in all cases and patella was resurfaced in selected group of patients. After the bone cuts were taken and before cementing, 25 cc of single injection cocktail was delivered into the posteromedial capsule of the knee joint using a 21 gauge needle in group A and at eight standard sites (approx 2 cc cc each) in group B. The sites included.

1. Suprapatellar pouch and quadriceps tendon
2. Medial retinaculum
3. Patellar tendon and fat pad
4. Medial collateral ligament and medial meniscus capsular attachment
5. Posterior cruciate ligament tibial attachment
6. Anterior cruciate ligament femoral attachment
7. Lateral collateral ligament and lateral meniscus capsular attachment and,
8. Lateral retinaculum.

The cocktail contained a combination of ropivacaine (0.75%) 10 cc, cefuroxime 750 mg (5 cc), fentanyl (50mcg/ml) 2 cc and triamcinolone 40 mg (5 cc).

Patients were observed for side effects of Ropivacaine (i.e., perioral paraesthesia, visual disturbances, hearing problems, dizziness, uncontrolled muscle contraction, convulsion, hypertension, bradycardia, or headache every fifteen minutes in the recovery room, and every four hours for 48 h postoperatively.Side effects of narcotics were also noted in the chart (i.e.,nausea, vomiting, confusion, constipation, urinary retention, dizziness, sedation, respiratory depression or pruritus).

Below knee TED stockings for both lower limbs were utilized. Aspirin 75 mg OD for 6 weeks was used as a chemical prophylaxis for DVT. Perioperative intravenous antibiotics were given to all patients on first postoperative day. Additional analgesics consisted of oral acetaminophen 500 mg administered at 6 h intervals starting 6 h postoperatively. Ondansetron 4 mg i.v. was administered in case of moderate to severe nausea or vomiting, if needed. The adductor canal catheter was removed at 8:00 am on postoperative day (POD) 2 and site was inspected daily for signs of localized infection.

Patient's criteria for discharge were VAS $\leq$2, no signs of symptoms of surgical wound infection and adequate mobility around

with or without aids.

Outcome assessment

At the time of admission, patients were explained about the Visual Analogue pain scale and oxford knee scores. Patients were assessed for pain at 6, 12 and 24 h postoperatively at rest, pain after mobilization on POD1 and POD2. Secondary measures included Oxford Knee Score and length of stay. Oxford Knee Scores were calculated preoperatively and 6 weeks postoperatively.

Pain was evaluated on a VAS with 0 = no pain, and 10 = worst imaginable pain(Table 1).

Statistical analysis

Statistical analyses were performed using SPSS® for Windows® (version 20.0, IBM, Chicago, IL, USA). A P value of less than 0.05 was considered statistically significant, for all comparisons.

Results

Demographics

There was no significant difference in the demographic profile of the two groups (Table 2). The mean average age of patients included in the study was 67.4 years. Female preponderance was seen with a total of twenty three female patients (57.5%).

Pain scores

The pain scores were observed to be high in the immediate post operative period and then declined gradually over next forty eight hours. Same trend was observed in both the groups.The difference in pain scores in both the groups were not significant (Table 3).

Length of stay

The average length of stay in both the groups was more than three days (Table 4).

Oxford scores

At six weeks follow up both the groups reported almost identical increase in oxford scores (Table 5).

Discussion

Total knee arthroplasty can be associated with severe, early post-operative pain. Thus, optimal analgesia after surgery is prerequisite to facilitate early rehabilitation and mobilization, enhance functional recovery and to minimize post-operative morbidity.

Femoral nerve blocks are commonly used to decrease preoperative pain from total knee arthroplasty, despite the 1–2.5% incidence of femoral motor blockade with quadriceps weakness, nerve damage, and infection[24–28]. Furthermore, 15% of femoral nerve blocks are unsuccessful[29] and do not provide any analgesia to the posterior portion of the knee supplied by the sciatic nerve.

Introducing an analgesic into the site of surgical trauma modifies the nervous system in 2 ways: (1) peripheral sensitization occurs by reducing the threshold for afferent nociceptive neurons, and (2) central sensitization occurs by increasing the excitability of spinal neurons.

LIA allows for pain control at the source, maximizes muscle control, facilitates rehabilitation, and prevents venous stasis.We injected a combination of ropivacaine, fentanyl, triamcinolone and cefuroxime. Ropivacaine has a pharmacokinetic profile similar to bupivacaine with a longer half-life and lower cardiac and systemic toxicity; patients can therefore tolerate a higher dose.The techniques for LIA and in particular the target tissues vary in the literature. It is still unclear which tissues are responsible for generating pain in the setting of total knee arthroplasty. Periarticular infiltration techniques target the joint capsule, deep tissues surrounding the collateral ligaments, and the subcutaneous tissues and wound edges[30].

Anderson et al[31] found that ropivacaine infiltrated into the subcutaneous tissues intraoperatively was a key component in postoperative pain control. It has been observed in the literature[31–35] that periarticular infiltration is effective in reducing opioid consumption postoperatively. This would suggest that the tissues responsible for generating pain in the setting of total knee arthroplasty may be better targeted by a periarticular technique. The authors of a systematic review of the literature in 2012[36] advocated delivery by systematic infiltration of all exposed tissues, including the posterior capsule.

Intraoperative cocktail injection of analgesia facilitates direct visualization and precise placement of the needle into the

Table 1
Visual analogue scale.

1	Mild pain that you are aware of but not bothered by
2	Moderate pain that you can tolerate without medication
3	Moderate pain that is discomforting and requires medication
4–5	More severe and you began to feel anti social
6	severe pain
7–9	Intensely severe pain
10	Most severe pain, you might contemplate suicide over it

Table 2
Demographic variables between the study group.

	Group A	Group B	Total
No. of patients (n)	20	20	40
Gender (M/F)	9/11	8/12	17/23
Avg. age (years)	68.6	66.2	67.4
Body mass index	26.3	25.7	26

Table 3
VAS pain scores.

	Group A	Group B	P value
Preoperative	3.00	3.53	.10
6 h	5.51	5.00	.21
12 h	4.42	5.32	.11
24 h	3.56	3.30	.32
48 h	3.37	3.24	.09

Table 4
Length of stay.

	Group A	Group B	P value
Avg. LOS(days)	3.30	3.44	.21

Table 5
Oxford knee scores and ROM.

	Group A	Group B	P value
Oxford (pre)	22.9	24.2	.16
Oxford (6 weeks post)	40.9	41.3	.22

traumatized tissues and nerve endings. The local concentration of the cocktail agents within the soft tissue improved and prolonged the analgesic blockade and decreased the seepage from the wound.Also injection of the cocktail into different sites compared to a single site was equally effective in pain control.

Conclusion

The results of the current study successfully demonstrate that intraoperative cocktail injection safely provides excellent post-operative pain control and can be substituted for conventional pain control alternatives and also that single posterior capsule injection is as effective as multiple site injections.

Limitations

Several limitations of the study should be noted. First, regarding the study patient population, 57.5% (23/40) of our patients were females. Furthermore, our patients tended to be elderly (mean age >66 years old). Moreover, because factors, such as, age, gender, and ethnicity probably influence pain perception, these cohort-related characteristics should be considered before foreseeing our findings to patient populations in different part of the world.

Small sample size and short follow-up period limit the generalization of the findings. Owing to low risk rate we have used spinal anesthesia for TKR; authors speculated that it could mask the pain score in postoperative period.

Conflicts of interests

None.

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Research paper

Influence of femoral head diameter on intraoperative range of motion in total hip arthroplasty

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ABSTRACT

Purpose: To investigate the intraoperative change of range of motion (ROM) using different femoral ball head diameters in the same patient using a navigation system and to compare the postoperative ROM speculated by 3D computer simulation software and the actual intraoperative ROM.
Materials and methods: Fourteen patients (12 female and 2 male patients) who underwent one-sided primary total hip arthroplasty for hip osteoarthritis caused by developmental dysplasia of the hip from January 2016 to November 2017 were included. Dislocation was defined as the center of femoral head moved by 5 mm. After placing the cup and stem via the posterolateral approach, measurement of the ROM with 28-, 32-, and 36-mm-diameter femoral ball heads was carried out using the navigation system. Postoperative computed tomography (CT) was performed, and the ROM simulation of the same movement was measured intraoperatively using a small-sized ball head (ZedHip).
Results: The intraoperative ROM was approximately closed to the preoperative ROM, and it tended to be in the following order: preoperative<28-mm head<32-mm head. As the diameter of the femoral head increased, the abduction increased significantly ($p < 0.05$). None reached 80% of the ROM simulated by ZedHip, and the movements that obtained 50% or more in the simulated ROM were flexion, abduction, and the angle until the dislocation.
Conclusions: ROM expansion due to the increase in femoral ball head diameter can be obtained even in vivo, but it was suggested that there is a limitation to the effect because of the interference of bone and soft tissue.
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1. Introduction

Improvement of function aimed at the expansion of range of motion (ROM) of the hip joint and prevention of dislocation after surgery are still important challenges in total hip arthroplasty (THA), which are influenced by operative approaches, position/angle of the placed implants, existence of osteophytes, soft tissue balance, preoperative ROM, pelvic inclinations, and implant design.[1] Additionally, in the actual clinical practice, several other factors complexly affect the operative results.

Accompanying the advancement of polyethylene materials, such as crosslink and vitamin E-containing polyethylene, and the reinforcement of the resistance to oxidation and abrasion enable the polyethylene to be thinner to maintain its mechanical strength; thus, variation of the femoral head diameters is increased, because the use of a larger diameter head makes the polyethylene liner thinner when the same cup size is used. However, in the elderly with remarkable posterior pelvic inclination, not requiring long durability, it is expected to be one of the effective methods.

A large diameter ball head increases with oscillation angle and jumping distance; thus, it is an important option for operators to achieve maximal ROM and prevent dislocation during surgery. The previous simulation studies show good results, with increased oscillation angle, head-neck ratio, and jumping distance. However, it is unknown whether the results of these studies are also applicable in vivo, involving soft tissues and anatomical bony prominences. In the clinical reports, the assessments were mostly carried

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out by determining the rate of dislocation or visual ROM; thus, the reliability of the accuracy is not high. Although the postoperative ROM is one of the most important clinical factors, its exact evaluation was often underestimated because of contraction of soft tissues and fear of dislocation from the evaluator's previous examination. Thus, to investigate the actual effect of the large ball head diameter, it is necessary to assess the difference of intraoperative ROM in the same patient.

The navigation system is a surgical assistive device that guides accurate placement of artificial implants. Additionally, this device can also measure the ROM up to the dislocation by ensuring the distance of the center of the cup and ball head is set with the registration of the pelvis and the femur. Three-dimensional (3D) computer simulation software also helps in improving the view of osteophytes in the surgical field and the projected image of the monitor as well as in improving the accuracy of preoperative planning. In addition, its performance made it possible to simulate the postoperative ROM without involving soft tissues.

The aim of this study was to investigate the intraoperative change of ROM due to the difference in femoral head diameters in the same patient using a navigation system. Moreover, we also aimed to clarify the difference between the postoperative ROM speculated by 3D computer simulation software and the actual intraoperative ROM.

2. Materials and methods

2.1. Patients and ethical statements

A total of 14 patients (12 female and 2 male patients) who underwent one-sided primary THA for hip osteoarthritis caused by developmental dysplasia of the hip (DDH) in our hospital from January 2011 to November 2012 were included. Patients' mean age during the surgery was 61.3 years (37–78 years), the mean height was 154.1 cm (141–173 cm), and the mean weight was 57.4 kg (45–81 kg). There were a total of 14 joints, with 5 right and 9 left hip joints (Supplementary Table 1). The study was approved by the Ethics Committee of XXX University (XXX, 15th September 2016) and was performed in accordance with the ethical standards of the 1964 Declaration of Helsinki and its later amendments. All patients were informed of the possible risks of surgery and provided written consent before the procedure.

2.2. Surgical procedures and devices implanted

All patients underwent a CT scan of their hip joint from the iliac crest to the knee joint and through the distal femoral condyles using a 320-row multi-detector helical CT scanner (Aquilion ONE; Toshiba Medical Healthcare, Tochigi, Japan) (detector configuration 80×0.5, beam collimation $= 40$ mm) with reconstructed slice widths of 1 mm and slice intervals of 1 mm.

Prior to surgery, the objective angle was set at 40° and 15° of radiographic inclination and anteversion, respectively. Vector Vision Hip (Vector Vision Compact Hip CT version 3.5.2; Brain Lab, Munich, Germany) was used as the navigation system. After placing the antenna at the iliac crest, two fluoroscopic images with an angular difference of 20° or more, capturing the pubic symphysis and obturator foramen of the surgical side, were taken. The fluoromatch registration was conducted by pointing the anterior superior iliac spine and iliac crest of the surgical side and was compared with the preoperative CT. In the femoral side, the antenna was placed distally from the femur, two fluoroscopic images containing the femoral head, greater trochanter, and proximal femoral shaft with an angular difference of 20° or more were taken, and the fluoromatch registration was carried out in a similar manner to the pelvic side by pointing the medial and lateral condyle. The center of rotation of the hip joint was determined by moving the femur. The divergence in all cases was within 2 mm. The preoperative ROM was measured by placing the patients in a complete lateral decubitus position. Surgery was performed under general anesthesia, and the posterior lateral approach was used, detaching the short external rotator muscles and joint capsule from the trochanteric fossa and intertrochanteric crest. On the stem side, broaching was conducted with reference to the visual lower thigh axis. AMS cup (Japan-Kyocera, Shiga, Japan), Aqala AMS polyethylene liner (Japan-Kyocera, Shiga, Japan), Wright Medical Profemur TL (MicroPort Orthopedics Inc, Arlington, Tennessee, USA), and BIOLOX® delta ball head (MicroPort Orthopedics Inc, Arlington, Tennessee, USA) were used.

2.3. Intraoperative evaluation

After placing the cup and the stem, 28- and 32-mm trial liners were set up. In a cup with a size of 52 mm or more, a 36-mm trial liner was used. All trial liners used were flat. Taking into consideration the leg length difference and the offset, the trial neck selected was either short or long. The trial heads with a neck length ±0 of 28 mm and 32 mm were used. In this study, dislocation was defined as the movement of the femoral head center by 5 mm, which is the limit of the navigation system. The hip joint angle was recorded when the movement of 5 mm or more occurred. The measured items were hip flexion at a 90° knee joint flexion position, hip extension/abduction/inside/outside rotation at a knee joint extension position, and internal rotation at a 90° knee joint flexion position and 60° hip joint flexion position. Finally, the cups used were 48–52 mm in size, the ball head diameters were 28 mm–36 mm, and the stems were 1–5. Eight joints had short necks, whereas six joints had long necks. The capsule and short external rotator muscles were repaired in all cases.

2.4. Postoperative evaluation

After undergoing a CT scan post-surgery, the imaging data were processed using the Digital Imaging and Communications in Medicine format (DICOM; National Electrical Manufacturers Association, Rosslyn, VA, USA) and were transferred into CT-based simulation software (ZedHip Lexi Co., Ltd., Tokyo, Japan), which included the implant database with computer-aided 3D design models provided by the implant manufacturer. With ZedHip, the cup inclination, cup anteversion, and stem anteversion were measured after the implants were set at the same position and angle as the postoperative CT. The actual ball head used was also elected, and we calculated the simulated ROM that was performed intraoperatively.

2.5. Statistical analysis

For the statistical analysis, preoperative ROM, intraoperative ROM of each ball head diameter, and postoperative simulated ROM were compared using the Wilcoxon-signed rank test ($p < 0.05$) using EZ-R.

3. Results

The mean cup inclination was 35.64° (range: 31–43°), the mean cup anteversion was 18.50° (15–26°), and the mean combined anteversion was 50.21° (43–59°) (Table 1). As shown in Table 2, the ROM was generally increased in the following order: preoperative<28-mm diameter<32-mm diameter. Internal rotation was remarkably increased intraoperatively compared to that

Table 1
Preoperative range of motion (ROM) and the ROM with 28-mm or 32-mm femoral ball head.
Approximately close to the preoperative ROM, the ROM expands in the following order: preoperative<28 mm < 32 mm. The internal rotation increased remarkably intraoperatively than preoperatively because of the posterolateral approach.

(Degree)	Preoperative ROM	Head size	
		Φ28 mm	Φ32 mm
Flexion	73.36 ± 17.30	74.00 ± 11.93	75.36 ± 11.41
Extension	11.71 ± 5.87	11.50 ± 7.62	13.14 ± 8.10
Abduction	24.71 ± 10.33	28.21 ± 9.62	31.21 ± 10.65
Internal rotation	18.00 ± 12.64	47.07 ± 15.89	45.21 ± 14.91
External	15.14 ± 7.23	19.64 ± 12.34	22.21 ± 14.72
Internal rotation with 60° flexion	–	54.07 ± 12.50	54.71 ± 11.30

Table 2
The comparison of the 36-mm femoral ball head with 28-mm and 32-mm femoral ball heads.
Seven joints are inserted with 36-mm femoral ball heads. The flexion angle and internal rotation until dislocation with flexion of 90° increased by the use of a 36-mm femoral ball head than with the use of a 32-mm femoral ball head. However, it was equal or lower for the ROM in other directions.

(Degree)	Head size		
	Φ28 mm	Φ32 mm	Φ36 mm
Flexion	78.71 ± 8.10	79.14 ± 9.61	81.29 ± 9.62
Extension	12.57 ± 8.50	16.86 ± 5.96	13.71 ± 6.84
Abduction	31.00 ± 9.09	36.14 ± 10.47	28.71 ± 9.33
Internal rotation	39.57 ± 12.37	37.71 ± 13.20	36.14 ± 13.35
External rotation	23.14 ± 13.34	29.57 ± 14.69	20.29 ± 10.36
Internal rotation with 60° flexion	47.14 ± 12.57	49.14 ± 13.13	53.29 ± 8.36

preoperatively because of the posterolateral approach in the 28-, 32-, and 36-mm heads.

A cup with a size of 52 mm or more and a femoral head with a diameter of up to 36 mm were used in 7 joints. The 36-mm-diameter femoral head increased the internal rotation angle until dislocation at 90° hip flexion compared to the 32-mm-diameter femoral head. However, in other directions, the ROM of the 36-mm-diameter femoral head was equal or lower than that of the 32-mm-diameter femoral head (Table 2). A significant increase in the ROM ($p = 0.005$) was found due to the increase in the femoral ball head diameter at the internal rotation and abduction angle (Supplementary Table 2). There was no significant difference in the dislocation position of hip flexion and internal rotation. None reached 80% of the simulated ROM with the ZedHip, whereas the flexion and abduction reached up the 50% or more of the simulated ROM (Table 3). There was a tendency that the difference between the simulated ROM and the intraoperative ROM was small, whereas the difference between the final ROM after device implantation and the preoperative ROM was large (Fig. 1).

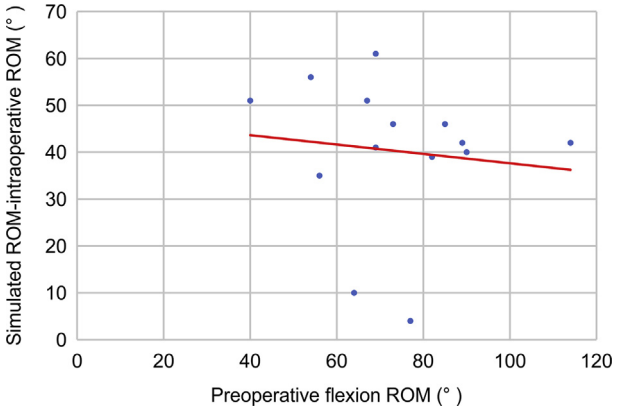

Fig. 1. The ROM simulated by ZedHip and preoperative ROM. Correlation coefficient is −0.244. Given that the preoperative ROM is better, the difference between the simulated ROM and the ROM measured during surgery tended to decrease.

4. Discussion

The ROM and dislocation after THA are affected by patient's factor, surgical technique, and instrument, such as patient's age, sex, original disease, preoperative ROM, pelvic tilt, joint laxity, dementia, surgical approach, instrument placement position/angle, implant size, offset, osteophyte, soft tissue balance, leg length, and so on. However, perpendicular dislocation of the femoral head occurs less frequently in clinical setting in most cases; the impingement of the femur including the stem and the pelvis is expected as

Table 3
The comparison between the intraoperative ROM and the postoperative ROM simulated by ZedHip. As the soft tissue, such as short external rotator muscle, is cut off by the posterolateral approach, the flexion and internal rotation angles are closest to the simulated ROM; however, these did not reach 80%.

(14 joints)	Intraoperative ROM (°)	Simulated ROM (°)	Intraoperative ROM/simulated ROM (%)
Flexion	76.21 ± 11.47	116.50 ± 16.80	65.4
Extension	13.07 ± 6.32	58.29 ± 22.22	22.4
Abduction	29.29 ± 10.78	55.64 ± 14.97	52.6
Internal rotation	44.50 ± 14.08	93.64 ± 15.62	47.5
External rotation	18.93 ± 10.85	53.79 ± 26.37	35.2
Internal rotation with 60° flexion	52.00 ± 10.13	63.79 ± 24.52	76.7

the major cause of this dislocation. Implants, bones, and soft tissues are considered as interference factors during impingement.

The merit of using femoral heads with a large diameter is that it prevents dislocation due to the enlarged oscillation angle and jumping distance. However, it could increase friction torque and wear, has thinner liner, and may result in neck corrosion, which should be taken into consideration in clinical settings. In addition, dislocation may also occur due to the interference factors caused by bone and soft tissues; thus, its true effect should be verified before its clinical use.

Regarding the dislocation tolerance, Cuckler et al. reported no dislocation with the use of large diameter femoral heads until 3 months postoperatively, as compared with using a 28-mm ball head, with demonstrated a dislocation rate of 2.5%.[2] Amilie et al. also reported a lower dislocation rate when using a 32-mm than a 28-mm-diameter femoral head in patients who underwent the procedure with the posterolateral approach, regardless of gender, age, and source disease.[3] Bistoli et al. also reported that the dislocation rate was 3.9% and 0.5% in 28- and 36-mm-diameter femoral heads.[4] In other studies, there was no significant difference in the dislocation rate among the 28-mm, 32-mm, and 38-mm femoral heads; however, the dislocation rate was as low as 0.4% in patients with more than 38-mm-diameter femoral heads.[5,6] On the other hand, Lu al. reported that the dislocation rate of 32-mm or less femoral head was similar to that of 36-mm femoral head in THA using ceramicon ceramic.[7] However, in clinical practice, the efficacy of a large diameter head in preventing dislocation is still controversial.

The effect on the oscillation angle and the ROM due to the increase in size of the femoral head diameter was reported in a cadaveric and computer simulation study. Klingenstein showed that the large femoral head increased the oscillation angle in their three-dimensional model study.[8] Cinotti et al. reported the effectiveness of the large diameter head, but the effect became small when 32-mm or more was used in their mathematical model study.[9] In addition, even if the femoral head diameter increases, it is possible that osseous impingement reduces its effect. A study using a 3D computer model showed that the effect of the large diameter head on ROM was limited, because it likely caused osseous impingement.[10] In a computer simulation study, stability was improved by using a large head when the cup inclination was large.[11] Moreover, a cadaveric study showed that implant-to-implant impingement occurred in a 22-mm-diameter femoral head, but in a 32-mm-diameter femoral head, osseous impingement between the femur and pelvis occurred.[12] These studies suggested that the ROM depends on the bony factor if the cup and the stem are placed with proper alignment, thereby the use of the large diameter head may not change the actual ROM.

In a clinical study, Matsushita et al. reported that postoperative flexion and abduction angles of 32-mm femoral heads were significantly larger than those of 26-mm-diameter femoral heads.[13] Another study comparing the 28- and 40-mm femoral heads showed that the flexion, extension, abduction, and internal rotation were significantly larger in patients with 40-mm femoral heads.[14] Lu et al. also reported that femoral heads with a diameter of 36 mm or more have increased flexion angle compared to 32-mm femoral heads in patients who underwent ceramicon-ceramic THA.[6] On the other hand, no difference in postoperative ROM was shown between the various head diameters in a case-control study.[15]

In this study, the conditions, except for the diameter of the femoral ball head, are the same to accurately examine the effect of the femoral ball head diameter. Only the flexion ROM tended to expand due to the increase in femoral ball head diameter, but the difference was not significantly different. Given that there is a wider space for flexion, which makes the patient less susceptible to the influence of bony protrusion and soft tissue intervention compared to the other movements, it seemed that the effect of increasing the oscillation angle owing to the increase in femoral ball head diameter directly reflects the intraoperative range of motion. The posterior approach was needed to detach the posterior support of the hip joint, which led to the removal of posterior strain and increase in flexion and internal rotation ROM due to the large diameter femoral ball head. Hip abduction ROM increased significantly from 28 mm to 32 mm, but a significant decrease was observed between 32-mm and 36-mm femoral ball heads. It is expected that abduction is more likely to be affected by soft tissue and osseous impingement between the tip of the great trochanter and acetabulum, because the distance of anatomical bony protuberance is short. As the preoperative ROM was better, the difference between the simulative ROM and the intraoperative ROM surgery tended to decrease. This result suggests that flexibility of the soft tissue around the hip joint before operation is important. This study showed that there is a limit to the effect on increasing the ROM by the head diameter due to influence of bone and soft tissue.

The fact that there was a difference between the simulated ROM in ZedHip using CT and the intraoperative ROM proves that existing soft tissue is an important factor in ROM. Although it seems that the surgical approach also influenced this discrepancy, the simulation test evaluating bones only may become the barometer, but it cannot predict the actual postoperative ROM correctly.

This study has several limitations. First, as the dislocation in this study was defined as the range of motion until the center of the femoral ball head moves by 5 mm from the original position, there is a possibility that the range of motion could not be contained completely until the final true dislocation. Second, given that the patients were under anesthesia during the procedure, pain, bathyesthesia, and muscle resistance are eliminated; thus, the ROM until dislocation in awake patients may not necessarily show the same results. Third, the sample size is small. If the sample size was larger, the ROM of flexion and flexion-internal rotation would be increased with a significant difference; however, clinically, it is difficult to conclude that there is a remarkable increase of the ROM that can be calculated mathematically.

5. Conclusion

The expansion of the ROM due to the increase in femoral ball head diameter can be obtained even in vivo, but it was suggested that there is a limitation on the effect because of the interference of bone and soft tissue. It is shown that the presence of soft tissue influences the discrepancy between the ROM of 3D simulation and the intraoperative ROM. It is recommended that surgeons should provide comprehensive management for patients who underwent one-sided primary THA for hip osteoarthritis to obtain a wider ROM and resistance to dislocation without relying solely on the size of the ball head, because the ROM in vivo is dependent on multiple factors, such as skeletal anatomy, interventions of bone and soft tissue, or soft tissue tension.

Author contributions

Nobuhiro Kaku was involved in Study design, concept and writing the manuscript. Hiroya Akase and Shouhei Noda were involved in data acquisition and analysis. Hiroaki Tagomori and Masashi Kataoka were involved in Interpretation. Hiroshi Tsumura was involved in supervision of research.

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Declarations of interest

None.

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None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jajs.2019.05.001.

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Changes of the serum creatine phosphokinase in total hip arthroplasty in Vietnamese patients

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ABSTRACT

Background: We analyzed biochemical markers of muscle damage in patients treated with total hip arthroplasty with minimally invasive and standard posterolateral approach to providing objective evidence of the local soft-tissue injury at the time of arthroplasty.

Methods: Sixty-one patients in group one treated with minimally invasive total hip arthroplasty through an approach less 9 cm length and fifty-three patients in group two treated with the same procedure through an approach more than 9 cm length. Serum creatine phosphokinase (CPK) levels were measured preoperatively and on postoperative days 1, day 2 and 5.

Results: The levels of the markers of muscle damage were increased in both group. The rise in the CPK level on postoperative day 1 in both group was 2.5–3 times higher than preoperative CPK and were slightly decreased on the next few days. There were no significant differences between the two cohorts of changes of CPK level.

Conclusions: The objective measurement of muscle damage marker provides an unbiased way of determining the immediate effects of surgical intervention in patients treated with total hip arthroplasty.

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1. Introduction

Total hip arthroplasty is a standard procedure in the world and Vietnam. Beside the development of implants material and surgical instrument for better mobility and longevity of artificial hip joint, the minimally invasive total hip arthroplasty also been improved. Minimally invasive total hip arthroplasty requires the proper instrument, appropriate surgery approach with an experienced surgeon. Minimally invasive total hip arthroplasty is to cause less trauma to soft tissue and is not the same as smaller incision. The smaller incision is one of the criteria in minimally invasive total hip replacement but with smaller incision may cause poor exposure, challenging to manipulate instrument and implants, damage surrounding soft tissue such as muscle, nerve, artery and poor implant position. What one of the challenge surgeons have to face is to evaluate the efficiency and result of minimally invasive total hip replacement. If only based on pain and range of motion before and after surgery, the study is not accurate and objectively because pain is somewhat subjectively and affected by pain medicine and patient's pain tolerance. Hip range of motion also affected by hip pathology, hip contracture condition before surgery and challenging to address the relationship between soft tissue trauma after surgery with the range of motion. A smaller incision but cause more trauma to soft tissue is not less invasive than a bigger incision with less trauma. Using laboratory data in serum to measure muscle damage provide an objective method to evaluate the invasiveness between different surgical techniques and approaches. Creatine phosphokinase (CPK) also known as creatine kinase is an enzyme which catalyzes the conversion of creatine and utilizes adenosine triphosphate (ATP) to create phosphocreatine (PCr) and adenosine diphosphate (ADP). CPK plays a vital role in monitoring energy to different cells, especially muscle cell. CPK is an enzyme found primely in cardiac muscle, skeletal muscle, and brain tissue. CPK is classified using chromatography into three distinctive isoenzymes: CPK BB is expressed in the brain cell and smooth muscle in lungs;

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CPK MB is expressed in cardiac muscle; CPK MM is expressed in skeletal muscle. In normal condition, human serum contains mostly CPK MM. CPK MB is 5% of total CPK, and CPK BB is insignificant. CPK level test is a valuable test in diagnostic skeletal muscle pathology. So because of that, this study is to evaluate CPK level in non-cemented total hip replacement.

2. Patients and methods

1 **Patients**: 114 patients with non-cemented total hip arthroplasty in Bach Mai Hospital from July 2014 to July 2016.
   i **Patient selected criteria**: primarily non-cemented total hip arthroplasty with randomly selected either minimally invasive approach or standard posterolateral approach, patient's information and laboratory test as required for the study.
   ii **Patient excluded criteria**: not obtain full patient's information, laboratory test, cemented total hip replacement or hybrid total hip replacement, hip hemiarthroplasty. Patient with history of prior injury or surgery in the hip, dermatomyositis, renal failure, heart failure, patient on medicine affecting skeletal muscle such as anticoagulant, muscle relaxation, diuretic. The patient does not agree to involve in the study.

2 Methods:
   i **Cross sectional study**
   - The patient selected with total hip arthroplasty indication and meet the criteria.
   - Pre-op laboratory test including CPK level.
   - Non-cemented total hip arthroplasty with one surgeon using a minimally invasive approach or standard posterolateral approach.

   ii **Surgery technique:**
   - All patients are going on spinal anesthesia, lateral decubitus on the contralateral hip. The posterolateral hip approach is chosen.
   - With a minimally invasive incision less than 9 cm, we split through the fiber of gluteus maximus muscle, take down the insertion of the external rotators: piriformis, gemellus superior and inferior, obturator internus.
   - With a standard posterolateral longer than 9 cm, we take down a superior portion of the quadratus insertion. Open the hip capsule, dislocate the hip posteriorly.
   - Cut the femoral neck as pre-op templating, reaming the acetabulum and place the trial component. We are then broaching the femoral canal to the proper size. Reduce the hip joint using trial components and check for stability, the range of motion. Replace the hip with implants size accordingly. Restore capsule and external rotators attachment. We do use drainage and close the wound in standard fashion.
   - Patients are taken post-op, first day and fifth-day laboratory test including complete blood count, prothrombin time, partial thromboplastin time, INR, renal and liver function test, CPK level tests.

3. Results

- A total of 114 patients met the study's criteria, 94 male (81.6%) and 21 female (18.4%).
- Patients' average age was 52.72 ± 14.44 (range, 18–82)
- The minimally invasive approach used in 61 patients (53.51%), the standard posterolateral approach used in 53 patients (46.49%).

Table 1
The correlation between incision length and BMI.

Incision length	BMI			Total
	N			
	<18.5	18.5–22.9	>23	
≤ 9 cm	27	29	5	61
> 9 cm	5	27	21	53
Total	32	56	26	114

Comment: Different incision length between BMI groups. Higher BMI tends to have longer incision ($p < 0.05$).

- The average length of the minimally invasive incision is 8.39 ± 0.56 cm (range, 7–9 cm). The average length of standard posterolateral approach is 12.09 ± 2.26 cm (range, 10–18 cm).
- The average BMI is 20.64 ± 3.31 (range, 13.6–33.5) separate into 3 BMI groups:
  - Group 1: BMI < 18.5 with 32 patients
  - Group 2: BMI from 18.5 to 22.9 with 56 patients
  - Group 3: BMI > 23 with 26 patients

4. Discussion

Minimally invasive total hip arthroplasty is may be advantageous for both patient and surgeon. Smaller incision and less invasive dissection could lead to less post-op pain and faster recovery. Surgeons who are encouraging minimally invasive suggest that hip replacement may be done without cutting through any muscles or ligaments. Various cadaveric studies carefully verify this idea, and it showed total hip arthroplasty may not always be done without injuring soft tissues.[1]

Mardones R. et al. study was to quantify the extent and the location of damage to the abductor and external rotator muscles and tendons after two-incision and mini-posterior total hip arthroplasty. Ten cadavers (20 hips) were studied. In each cadaver, one hip randomly was assigned to the two-incision group, and the contralateral hip was assigned to the mini-posterior group. After inserting the total hip arthroplasty components, the muscle damage was assessed using a technique described previously. Damage to the muscle of the gluteus medius and gluteus minimus was substantially more significant with the two-incision technique than with the mini-posterior technique. Every two-incision total hip replacement caused measurable damage to the abductors, the external rotators, or both. Every mini-posterior hip replacement caused the external rotators to detach during the exposure and had additional measurable damage to the abductor muscles and tendon. The author suggested that a two-incision total hip arthroplasty cannot be done without cutting or damaging the gluteus medius or gluteus minimus muscle or external rotators.[2]

In non-cement hip arthroplasty, we split the maximus gluteus and use a Charnley extractor, and the external rotators are partially cut to expose the capsule. The minimus and medius gluteus could be extracted without cutting, but prolong surgery is still damaging the tissue because the CPK level increased 2.5 to 3 times post-op (Table 2). Apple FS. et al., the study was assessed in 35 women and 34 men runners after a 42.2-km race using a method developed for estimation of myocardial infarct size. Results indicate that greater skeletal muscle damage occurred in men vs. women runners after a marathon.[3] In the study of Larsson K. et al., the CPK activity of the serum of 33 male and 24 female patients with tibial shaft fractures has been assessed. In 40 of the 57 patients, the CPK level surpassed the maximal standard limit of 1.7/1. Patients with fractures due to direct force had significantly higher levels than

Table 2
The correlation between CPK level and incision length.

Incision length	CPK level			
	Pre-op	Post-op		
		Day 1	Day 2	Day 5
≤ 9 cm	96.48 ± 69.27	231.46 ± 153.24	202.52 ± 147.26	182.94 ± 143.53
> 9 cm	91.92 ± 66.44	281.42 ± 202.68	249.36 ± 191.11	238.33 ± 201.21

Comment: The CPK level increase 2.5 to 3 times postoperatively and gradually decreased in the following days. No differences in CPK level between the longer and shorter incision ($p > 0.05$).

Table 3
The correlation between CPK level and gender.

Gender	CPK level			
	Pre-op	Post-op		
		Day 1	Day 2	Day 5
Male	98.95 ± 69.16	265.82 ± 189.81	235.07 ± 180.14	218.07 ± 184.93
Female	73.52 ± 66.44	205.38 ± 109.27	176.62 ± 104.50	159.70 ± 90.69

Comment: No differences in CPK level between gender group ($p > 0.05$).

Table 4
The correlation between CPK level and BMI.

BMI	CPK level			
	Pre-op	Post-op		
		Day 1	Day 2	Day 5
< 18.5	93.09 ± 71.17	225.84 ± 144.67	197.28 ± 137.80	177.67 ± 136.78
18.5–22.9	95.75 ± 68.29	245.79 ± 154.63	215.79 ± 147.72	188.38 ± 133.24
> 23	92.50 ± 63.74	309.35 ± 248.46	302.19 ± 267.37	275.89 ± 234.69

Comment: No differences in CPK level between BMI groups ($p > 0.05$).

those with fractures due to indirect force. When the fracture was displaced, the CPK level was more often abnormal than when there was no displacement. Patients with extensive swelling of the injured leg had significantly higher levels than patients with minor or no swelling.[4]

In our study, CPK level increased in male and female group post-op and gradually decreased in the following post-op days and no difference in both groups (Table 3). The same result in different BMI groups, this might be the same in soft tissue damaged with the same muscle mass (Table 4). Gender and BMI are not representing the muscle mass, and soft tissue damage, and only reflect the over-weight or under-weight condition of the patients. However, BMI might be the critical factor affecting the incision length, and the higher BMI might lead to longer incision for adequate exposure for proper reaming and place hip components (Table 1).

The smaller incision might affect the vision, difficult for placing instrument and hip components and may require more extended extractor and causing soft tissue damaged. Moreover, prolong surgery time might lead to ischemia of the soft tissue under tension, and higher CPK level as a result. Meneghini RM. et al., compared muscle damage during minimally invasive total hip arthroplasty: Smith-Petersen versus posterior approach. The study was performed in six human cadavers (12 hips), one hip was assigned to the Smith-Petersen approach and the contralateral hip to the posterior approach. Muscle damage was graded with a technique of visual inspection to calculate a proportion of surface area damage. Less damage occurred in the gluteus minimus muscles and minimus tendon with the Smith-Petersen approach. A mean of 8% of the minimus muscle was damaged via the Smith-Petersen approach, compared to 18% via the posterior approach. The tensor fascia lata muscle was damaged (mean of 31%), as well as the head of the rectus femoris (mean 12%) during the Smith-Petersen approach. The piriformis or conjoined tendon was transected in 50% of the anterior approaches to mobilize the femur. The different hip approach leads to different muscle damaged.[5]

In our study, we used mini posterolateral and standard posterolateral approach with a similar technique. The CPK levels increased in both groups with no difference (Table 2). So, through a smaller incision, we could still avoid muscle damaged, provided a faster recovery and better cosmetic, less pain. Suzuki K. et al., study with 94 patients (8 male and 86 female), a total of 100 total hip arthroplasty procedures separate into two groups: minimally invasive and standard incision. The CPK level is measured pre-op and day one post-op and showed 4.7 times increased in the standard incision, 3.6 times increased in the minimally invasive incision, but not statistically different between groups. Our study result has a comparable outcome as Suzuki K et al.[6]

5. Conclusions

CPK level is a practical and objective test to evaluate the soft tissue damage in total hip arthroplasty. We believe this test is an important step in evaluating different total hip arthroplasty technique in term of less invasive. More study should be done to further develop technique and surgical instrument.

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