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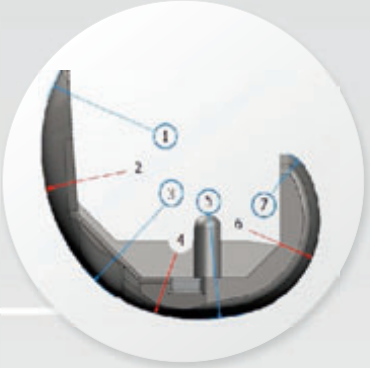

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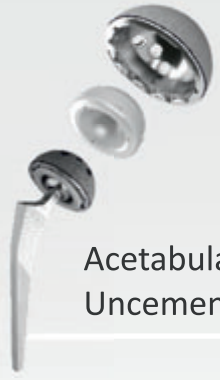

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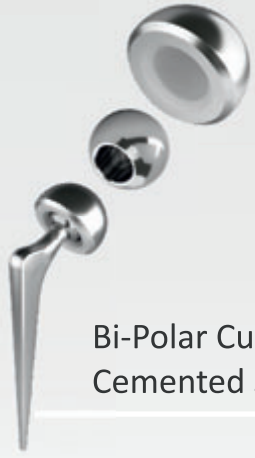

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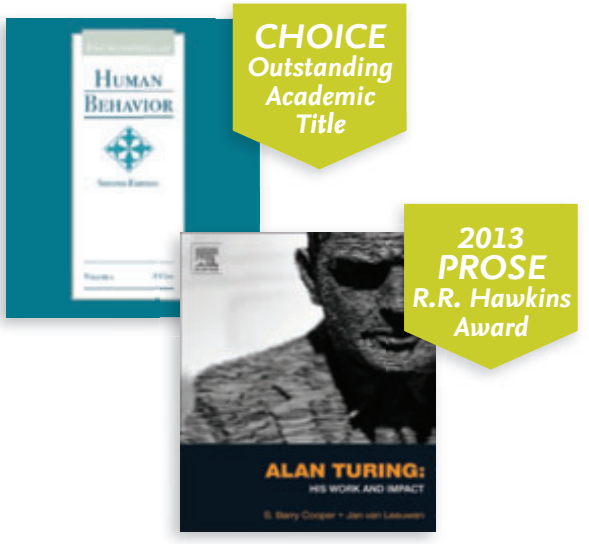

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Aims and Scope

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

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Review article

The Promise of Silicon: bone regeneration and increased bone density

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ABSTRACT

Historically, silicon has been accorded low importance as a trace element. Its role has generally been regulated to that of minor influence on bone and connective tissue development. However, in vitro and in vivo studies have shown that these assumptions are incorrect. Silicon plays a key role in bone biology, improving bone regeneration and increasing bone mineral density. The aim of this review is to provide an understanding of the role of silicon in bone biology and its clinical application.

Contents

1. Introduction

Historically, silicon has been accorded low importance as a trace element. Nielsen proclaimed that silicon was an inert universal element, a "fortuitous reminder of our geochemical origin or an indicator of environmental exposure".[1] However, animal studies in the 1970's showed that dietary silicon deficiency produces defects in connective and skeletal tissues,[2,3] and that silicon is concentrated at the mineralization front of growing bone.[3] Over the past few decades we have improved our understanding of the essential role of silicon in bone biology, with renewed interest recently for its application as a potential treatment for osteoporosis and other forms of bone loss. The aim of this review is to provide an understanding of the role of silicon in bone biology and its clinical application.

2. Silicon – the important trace element

Silicon (Si) is a non-metallic trace element, with a distribution in the body of 1–2 g (the third most abundant element after iron and zinc).[4]Dietary intake of Si is between 20–50 mg Si/day for most Western populations,[5] more than two fold higher than the typical intake of iron and zinc. In China and India, plant based societies, the intake is higher (140–204 mg/day).[6,7] In children, the major source is from cereals (68% of total dietary intake), whereas beer ingestion

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forms the major source in adults (44% of total dietary intake).[5] Other source of Si include drinking water, plant foods (cereals, rice, barley, oats etc), some vegetables (beans, spinach and root vegetables), seafood (mussels) and supplements.

In vivo, silicon is widely distributed throughout the body with a strong predilection for bone and connective tissue.[4] Within bone, silicon appears to be extensively bound to gylycosaminoglycans, key component of the extracellular matrix (ECM) in addition to collagen and proteoglycans. This suggests that silicon plays an important role in bone structure and formation. Silicon depravation studies have showed the detrimental effects on bone and connective tissue.

On the contrary, silicon is rarely toxic when taken orally.[8] Humans have used magnesium trisiclate, a gastric antacid, for more than 40 years without adverse reaction.

3. In vitro and in vivo studies

The Carlisle in vivo studies of the 1980's found that silicon increased bone matrix synthesis in chick tibias and that Si had a dose dependent increase in prolyl hydroxylase activity, the enzyme involved in collagen synthesis.[4] This suggests that silicon is involved in bone matrix synthesis, through the upregulation of enzymes.

Recent studies with human osteoblast cell lines showed increased osteoblast proliferation, ECM synthesis, ALP activity and osteocalcin synthesis.[9] Feng et al (2007) and Zou et al (2009) also found that silica containing nanospheres have a significant effect on proliferation of osteoblast cell lines in vivo and in vitro, in a dose dependent manner.[10,11]

Recently, Martinez et al (2015) and Ghanaati et al (2010) have found that a when silicon is converted into a gel scaffold, it promotes osteoblast differentiation and vasculogenesis, and may also aid in drug delivery.[12,13]

Thus silicon has been shown both in vivo and in vitro to have significant effects in promoting bone formation, bone regeneration and vasculogenesis.

4. Silicon in bone implants and cement

Silicon containing implants and ceramics such as Si-substituted hydroxyapatite and Bioglass have been shown to bond better to bone that their non-Si containing counterparts due to the spontaneous formation of a biologically active apatite-like layer on their surface, with an additional positive effect of vascularized soft tissue regeneration.[14] Silica is postulated to undergo partial dissolution on these materials to form an amorphous Si layer and the dissolved Si has been implicated in the in vivo efficacy. Further, the addition of Si to hydroxyapatite leads to faster bone remodeling at the bone-HA interface.[15]

Coathup et al. conducted an in vivo study on female sheep of a silicate-subsituted calcium phosphate ectopic implant in the paraspinal muscles.[16] After twelve weeks, they found that Si had a significant effect on the formation of bone both within the implant and on the implant bearing surface versus a non-Si calcium phosphate control group.

Thus, silicon based implants promote bone formation and vasculogenesis.

5. Silicon and bone mineral density (BMD)

The Farmingham Offspring cohort study found that higher intake of dietary silicon was significantly associated with more positive BMD at the hip in men and pre-menopausal women, but not in post-menopausal women.[17] These findings were also reported in the APOSS (Aberdeen Prospective Osteoporosis Screening Study) cohort, a women only cohort, where dietary silicon intake was positively associated with BMD at the hip and spine in pre-menopausal women. Similar findings were seen in post-menopausal women who were on concurrent HRT.

There have been no silicon depravation studies conducted in humans till date. In chicks, silicon depravation leads to thinner and more flexible legs with increased fracture risk.[18] In rats, defects to the skull are prevalent in the silicon deprived.[2]

In osteoporotic subjects, silicon supplementation leads to increased bone volume[19] and increased femoral and lumbar spine BMD.[20] Interestingly, Eisinger and Clairet found that silicon is more effective than Etridonate and sodium fluoride in increasing BMD. A recent study by Spector also found that silicon increased both BMD and bone formation markers (pro-collagen type 1 N-terminal propeptide) in osteopenic and osteoporotic subjects, with a dose dependent relationship between the marker and increasing choline-stabilized orthosilicic acid dose (ch-OSA). Similarly, in ovariectomized rats, chicks and horses, supplementation with Si or ch-OSA reduced bone resorption and bone loss and increased bone formation and BMD.[21–24] In a recent review,[25] Price et al. found overwhelming evidence for further research into silicon as an important component of osteoporosis treatment.

Thus silicon works has a compounded effect to increase bone mineral density and should be an essential part of the diet of osteoporotic patients.

6. Mechanism of action

The mechanism of action of silicon is poorly understood at present. In Fig. 1 we present our proposed mechanism of action. It is postulated to be involved in bone formation through the synthesis and/or stabilization of collagen and ECM. It is also implicated in gene transcription of the type 1 collagen gene, a cofactor for prolyl hydroxylase the enzyme of collagen synthesis, promoting the absorption of essential elements needed for bone synthesis such as copper, calcium and magnesium, and in the scavenging of toxic aluminium.[4] Carlisle postulated that silicon probably acts by making the bone matrix more calcifiable.[3]

Fig. 1. Proposed mechanism of action of silicon.

7. Conclusion

Silicon has a key role to play in bone biology. Although poorly understood, its mechanism of action is likely related to the synthesis and stabilization of collagen in bone matrix. In vivo and in vitro studies have demonstrated its importance in improving bone regeneration and increasing bone mineral density. Clearly, this forgotten element holds much promise for the future of orthopaedics.

Conflict of interest

None.

Acknowledgement

None.

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Research paper

Surgical outcomes of arthroscopic lateral clavicle excision for osteolysis

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ABSTRACT

Background: Lateral clavicle osteolysis has been attributed to repetitive stress; particularly in activities requiring excessive overhead motions such as weightlifting or rugby. Arthroscopic lateral clavicle excision is recommended for symptomatic acromioclavicular joint that has failed conservative treatment.
Aim: The present study aims to assess patient-reported outcomes of arthroscopic lateral clavicle excision for osteolysis.
Methods: Sixteen patients with a mean age of 33.56 ± 12.2 (range 18–59) underwent lateral clavicle excision over a 24 month period, by one senior shoulder surgeon. All patients participated in sport and professional athletes accounted for 56% of the patient cohort. Constant (CS) and QuickDASH (QD) outcome scores were obtained by questionnaire at a mean 21 months following surgery (range 3–40).
Results: A significant improvement in CS ($p < 0.001$) and QD ($p = 0.012$) was noted. Patient satisfaction increased from 3.7 ± 1.7 to 8.8 ± 2.5 on a 10-point visual analogue scale ($p = 0.0024$). 87% of patients were able to return to their former level of sporting activity. The average time to return to sport was 6.3 ± 4.8 months, ranging from 2–18 months.
Conclusions: Acromioclavicular joint excision for lateral clavicle osteolysis is associated with significant improvements in post-operative shoulder outcome scores, while providing adequate pain relief and improving the range of motion of the affected shoulder.
Level of Evidence: IV Case Series

1. Introduction

Osteolysis of the acromioclavicular (AC) joint has been regarded as an increasing cause of shoulder pain.[1] Traumatic lateral clavicle osteolysis was first described by Dupas et al. in 1936,[2] followed by atraumatic lateral clavicle osteolysis two decades later.[3] Recent work has reported similar findings on radiographic and magnetic resonance imaging (MRI) in both traumatic and atraumatic lateral clavicle osteolysis.[4]

Controversy surrounds the pathogenesis of lateral clavicle osteolysis, where Cahill proposed that the osteolytic process was induced by the presence of microfractures in the subchondral bone, caused by a repetitive stress.[5,6] He postulated that repetitive microtrauma activates an inadequate repair and remodeling process, which favours bone resorption over formation. Ultimately, Cahill's pathogenic theory still has a traumatic element, albeit in a more chronic and subacute manner. Numerous case reports have suggested alternative pathogeneses of lateral clavicle osteolysis, including autonomic dysfunction, hypertrophic synovial tissue, ischemic necrosis, and reactive hyperemia.[7–12] However, due of lack of sufficient evidence, Cahill's theory of osteolysis induced by microfractures in the subchondral bone still remains the most accepted.[5]

Lateral clavicle osteolysis, as described above, has been attributed to repetitive stress; particularly in activities requiring excessive overhead motions, reducing the ability of the bone to heal after loading. Therefore, lateral clavicle osteolysis most likely presents in strength and power athletes, such as weightlifters or rugby players, and jobs requiring heavy overhead lifting, such as builders or plasterers.[13] Cahill et al.[5] noted that 98% of radiographs indicating lateral clavicle osteolysis belonged to weightlifters, in which 50% had microfractures in the subchondral bone, and was the first case series detailing this occurrence. Since then, more than one hundred cases have been reported in male weightlifters[13];

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highlighting the association between weight training amongst athletes and lateral clavicle osteolysis. Additionally, the increased number of women in weight lifting and sports involving overhead throwing, coincides with an increase of females presenting with lateral clavicle osteolysis.[14]

Early management of lateral clavicle osteolysis consists of rest and activity modification. The use of non-steroidal anti-inflammatory drugs (NSAIDs) are recommended to reduce inflammation, however it has been debated that NSAIDs may reduce bone healing.[15] Additionally, intra-articular corticosteroid injections may temporarily relieve the pain. Worcester et al.[16] have argued that temporary relief of pain provided by a steroid injection may second as a diagnostic tool indicating that the pain is localised to the AC joint; patients who experienced only temporary relief of their symptoms after two injections, were candidates for surgery and noted full relief of their symptoms post-operatively.[16] Surgical intervention is recommended for a symptomatic AC joint that has failed conservative treatment. Typically there is point tenderness of the AC joint, combined with abnormalities on radiographs. The excision of the lateral clavicle has become the mainstay of surgical treatment.

The present study evaluates the outcome of lateral clavicle excision in patients with lateral clavicle osteolysis. The success of the procedure was evaluated based on pre- and post-operative shoulder outcome scores. Other epidemiological factors were also assessed with regards to their effect on surgical outcomes.

2. Materials and methods

2.1. Patient demographics

Data was extracted over a 24 month period from patients who required a lateral clavicle excision due to osteolysis. All patients were in the care of one senior shoulder surgeon and procedures carried out at one day-case unit. Nineteen patients were identified as eligible for the study, with a minimum follow up period of 3 months. Three patients could not be contacted to evaluate their post-operative outcomes and were subsequently excluded from the present study. As a result, 16 patients were included in this study; where 15 patients had unilateral surgery and one patient, bilateral.

The patient cohort consisted of two females and fourteen males, with a mean age of 33.56 ± 12.17 (range 18–59). Professional athletes accounted for 56% of the patient population (n = 9); where 50% of patients were professional rugby players (n = 8). Additionally, the current series included one professional water polo player and a semi-professional rugby player. The remaining patients participated in sports at a recreational level; ranging from weight lifting, triathlons and football. The diagnosis of osteolysis was made on MRI in 87.5% of cases and plain radiography alone in the remainder.

2.2. Surgical technique

Surgery was performed under general anaesthesia, with an interscalene brachial plexus block. The patient was placed in a beach chair position.[17] Following arthroscopic examination of the glenohumeral joint, the subacromial bursa was entered and the AC joint exposed inferiorly. Instruments were inserted into the AC joint via direct anterosuperior and posterosuperior portals to deride the lateral end of clavicle. Bony resection was kept to minimum due to the osteolysis of the lateral clavicle, in order to avoid any ligament damage and instability. The anterior, superior and posterior capsule and AC ligaments were not breached. After resection, the joint was then examined arthroscopically from both the anterior and posterior portals, to check for any loose bone fragments and the lateral clavicle was stressed to assess for any excess mobility after resection.[13]

2.3. Outcome measures

To investigate the efficacy of lateral clavicle excision for osteolysis, shoulder outcome scores were utilised both pre- and post-intervention. The present study employed Constant Shoulder Score[18] and QuickDASH[19] scoring instruments. Additionally, all patients were asked to rate their satisfaction with their affected shoulder. This was carried out using a visual analogue scale (1–10) both pre- and post-operatively.

2.4. Statistical analysis

Statistical analysis was conducted using IBM SPSS software version 20. Nonparametric statistics were used in the present study. Wilcoxon matched pairs tests were performed to assess the pre and postoperative difference between outcome scores and patient satisfaction. When $p < 0.05$ data is deemed as significant and highlighted with an asterix (*).

3. Results

In the present study, 81% of patients present with lateral clavicle osteolysis as a result of a sport (n = 13); 50% rugby, 12.5% lifting weights (n = 2), while 1 injury was related to cricket, water polo and cycling respectively (Fig. 1).

Prior to lateral clavicle excision surgery, 87.5% of patients received an AC joint corticosteroid injection (n = 14). Of those who had injections, 36% noted slight improvement (n = 5), 29% reported a significant improvement (n = 4), while 14% of patients reported no improvement at all (n = 2) (Table 1). The effect of the injections on a further 3 patients (21%) was not recorded.

The mean time taken from symptoms to surgery was 9 months (1–36 months). All patients were reassessed for shoulder outcome scores at mean follow-up time of 21.38 ± 10.69 months (range 3–40). A significant improvement in the Constant Shoulder Scores was noted, as depicted in Fig. 2A. The mean pre-operatively score improved from 52.3 ± 12.1 to 87.3 ± 17.8 post-operatively ($p < 0.001$), with a 95% confidence interval (CI) of 23.41 to 46.6. Improvement in QuickDASH scores were noted following lateral clavicle excision as depicted in Fig. 2B, from 30.5 ± 6.4 to 6.8 ± 1.2 ($p = 0.012$), with 95% CI of 39.97 to 7.51. The work module of the QuickDASH score averaged 25.0 pre-operatively and 0.0 post-operatively. Despite the decrease of 25.0 points, this improvement

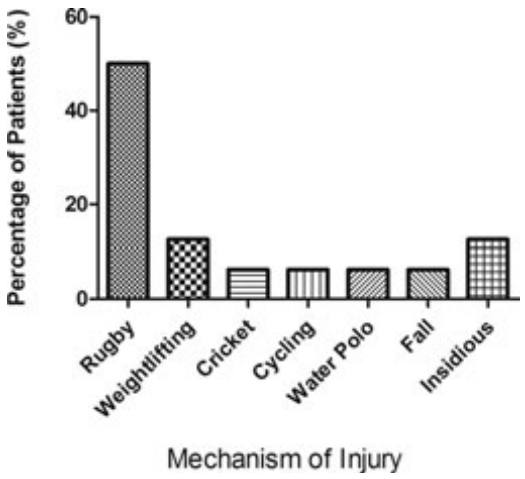

Fig. 1. Aetiology for lateral clavicle Osteolysis.

Table 1
Effect of corticosteroid injection for lateral clavicle osteolysis.

Effect of Steroid Injection	Number of Patients	Percentage
No Injection	2	12.5%
Injection	14	87.5%
No Improvement	2	14%
Slight Improvement	5	36%
Significant Improvement	4	29%
Effect not recorded	3	21%

was not shown to be statistically significant, where $p = 0.106$. The sport module of the QuickDASH score significantly improved from 69.7 to 13.4 post-operatively ($p = 0.001$). The time taken for patients to return to their previous level of sport was also noted, where 87% of patients were able to return to their former level of sporting activity. Of these patients, the average time it took to return to full sports was 6.3 ± 4.75 months, with a range of 2–18 months. Thirteen percent of patients could not return to their former level of sport after surgery. No significant difference was observed dependent on age ($p = 0.631$) or time to surgery ($p = 0.364$). There were no complications in this case series. As depicted in Fig. 2C, patient satisfaction significantly increased from 3.7 ± 1.7 to 8.8 ± 2.5 on a visual analogue 10-point scale, where ten is "most satisfied" ($p = 0.0024$).

4. Discussion

The current paper evaluated clinical outcomes of arthroscopic lateral clavicle excision to treat osteolysis and has shown significant improvements in post-operative shoulder outcome scores, while providing adequate pain relief. No complications were noted in patients who had undergone lateral clavicle excision.

It is well-recognised that lateral clavicle osteolysis occurs in weightlifting and power athletes. The present study supports this, accounting for 75% of all patients ($n = 12$). Furthermore, 81% ($n = 13$) of all injuries were attributed to sports. This data correlates well with early work from Cahill, who noted that 98% of radiographs indicating lateral clavicle osteolysis belonged to weightlifters.[5] However, it has been claimed that this figure is an overrepresentation, where Scavneius and Iversen report a much lower 27% incidence in weightlifters.[20]

Response to pre-operative steroid injections were shown to have no effect on the post-operative outcome. A mere 4 point difference in Constant Scores was observed between groups of patients who did not have an injection pre-operatively (31.5 points) and those who did (35.5 points). It should be noted that the current data cannot draw any conclusion on the efficacy of steroid injections in the non-operative cohort.

Arthroscopic resection of the clavicle has been reported to provide pain relief and allow a return to function comparable to open techniques.[21] Outcomes of arthroscopic lateral clavicle excision were described in 2000, however the study merely described 54% shoulders had excellent results, 39% had good results, and 7% were failures.[21] The current study aimed to explore the outcomes further, aided with shoulder outcome scores, satisfaction and return to sport.

A significant increase in Constant scores, 21 months following surgery, is indicative of improvement in range of motion and pain. Additionally, a significant improvement in QuickDASH scores highlights an enhancement in the quality of life of the patient following surgery. We have no knowledge of any other study utilising shoulder outcome scores as a measure of improvement following lateral clavicle excision. Patient satisfaction increased from 37% to 88% following lateral clavicle excision, in the present study. Petersson reported that 72.5% of patients were "pleased" following their procedure.[22]

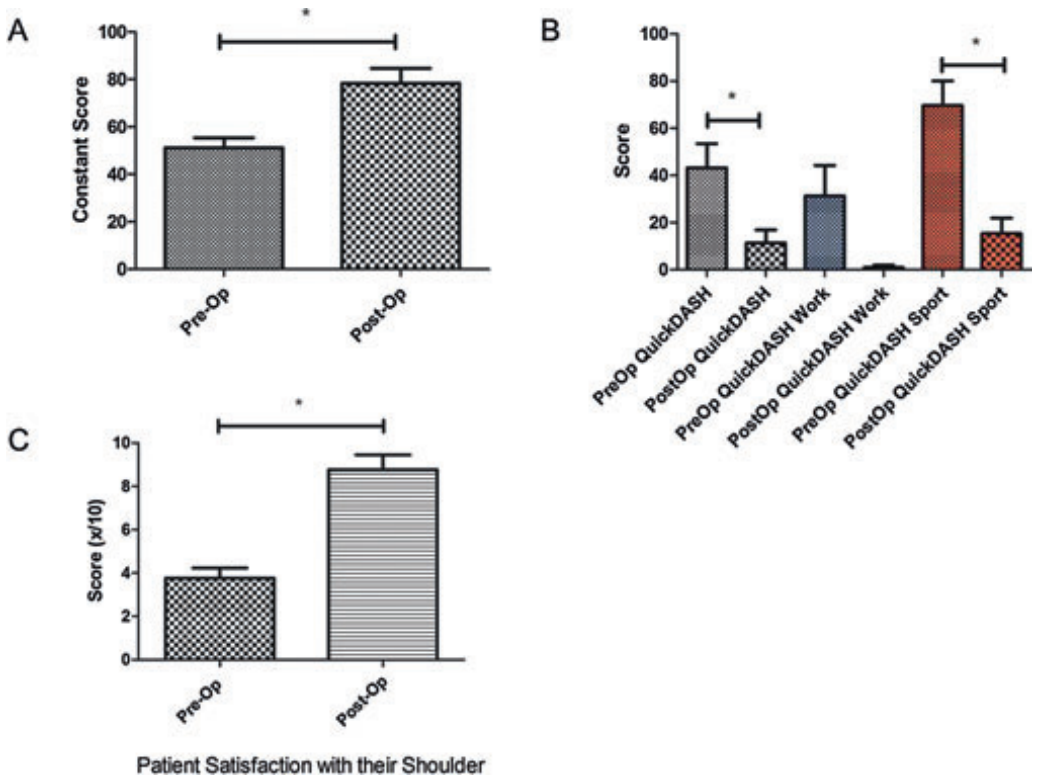

Fig. 2. A) Improvement in Constant score following lateral clavicle excision. B) Improvement in QuickDASH scores following lateral clavicle excision. C) Improvement in patient satisfaction following lateral clavicle excision.

One advantage of the current study is that all procedures were conducted by the same surgeon. This reduces the variability in surgical results between different surgeons, and as such the results obtained can be standardised to rule out any differences between differing surgical techniques. The limitations of this study were directly linked to the inherent problems of a level IV study. As such, there was no control group available to compare the results of this lateral clavicle excision surgery against.

Arthroscopic lateral clavicle excision is associated with significant improvements in post-operative shoulder outcome scores, while providing adequate pain relief and improving the range of motion of the affected shoulder, with a high rate of return to sport.

Conflict of interest

This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

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Research paper

Midterm results of surface replacement of the shoulder

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ABSTRACT

Purpose: This study was undertaken to determine the midterm results of resurfacing hemiarthroplasty of the shoulder, evaluate the inclination of prosthesis and correlate the effect of valgus or varus positioning on clinical outcomes.
Methods: Between 2007 and 2014, fifty-seven humeral head surface replacements were performed in our hospital for the osteoarthritis of shoulder. One patient expired and 6 shoulders were lost to follow-up. Forty-seven patients with 3 patients having bilateral humeral head replacements, were assessed thoroughly at the mean period of 4.4 + 2.3 years (Range 2–9 years). All fifty shoulders were evaluated using the VAS, ASES and Constant and Murley score.
Results: Humeral head surface replacement produced satisfactory results in 96% of the patients at a mean follow-up of 4.4 years. We found that the difference in mean postoperative ASES, Constant and VAS score in normal and valgus inclination angle shoulders was not significant whereas the difference in normal and varus inclination angle shoulders was significant. Three patients had severe pain with VAS score (range 0 to 10) of 7, 5 and 4 postoperatively though in all 3 patient's inclination angle was normal. No revision surgery was performed till recent follow-up.
Conclusions: In conclusion mid-term outcomes of the uncemented Global C.A.P. resurfacing prosthesis are promising. Inclination of the implant has effect on functional outcome of patients.

1. Introduction

Shoulder resurfacing arthroplasty for glenohumeral arthritis has been in use for the past three decades. One of the attractions of surface replacement is simplicity of the procedure, as compared to a conventional stemmed shoulder arthroplasty. Surface replacement overcomes the need to remove the entire humeral head and the unnecessary invasion of the medullary canal. Keeping in mind that it may not be necessary to replace glenoid in all patients.[1] Another concern with stemmed device is version and off-set error. If the version of device is incorrect by just 15° a painful shoulder will be the result.[2] It is easier to replicate the version and offset of the humeral head when resurfacing.

Steffee and Moore reported first humeral resurfacing procedure in late 1970 with use of a resurfacing hip implant[3]. The radius of curvature of the prosthesis was customized to precisely fit the dimensions of the humeral head. This and other early prosthesis were made of stainless steel and had no central stem. They were fixed to the proximal aspect of the humerus with methyl methacrylate cement.[3,4] All the procedures were performed as hemiarthroplasties, with the glenoid not being resurfaced. Copeland introduced a cementless surface replacement during the same period.[5] The prosthesis that he developed had a central pegged humeral component that was secured by a screw through the lateral cortex combined with a polyethylene glenoid element that was secured by a peg. The humeral screw often loosened, and in vitro testing suggested that it was not contributing to fixation. The screw was discarded in a later version of this prosthesis, and a metal-backed glenoid component was added. In 1993, a hydroxyapatite coating was added to the humeral and glenoid components in an attempt to decrease the prevalence of loosening. All current designs have a central humeral stem, and these stems have variable shapes, diameters, and lengths. Copeland shoulder arthroplasty has proven to be a reliable procedure to relieve pain and improve function in patients with osteoarthritis.[1,6,7] In a recent report from the Danish Shoulder Arthroplasty Registry, in which the clinical outcome and short-term survival of 2137 primary arthroplasties were evaluated, 28% were resurfacing hemiarthroplasties.[8] The results published by Levy and Copeland[1] with the Mark 3 prosthesis are comparable, in terms of pain relief and range of

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motion, to those attained with stemmed implants.[9] Humeral resurfacing does have distinct advantages over conventional shoulder replacement, like no osteotomy is needed (and thus the head-shaft angle does not have to be addressed), minimal bone resection, short operative time, low chance of humeral periprosthetic fractures and if required easier revision to a conventional total shoulder replacement. The current prospective study, reports mid-term results of the uncemented resurfacing shoulder prosthesis in patients with arthritis of shoulder. This study also evaluates the inclination of prosthesis and the effect of valgus or varus positioning on clinical outcomes and the mis-term survival of implant.

2. Materials and method

This study was approved by the institutional review board and ethics committee of our hospital before commencement. Informed consent was taken from all patients to enroll in study.

2.1. Subjects

From 2007 to 2014 fifty-four patients with fifty-seven end stage symptomatic arthritic shoulder who met the inclusion criteria were treated with an uncemented resurfacing shoulder prosthesis, the Global Conservative Anatomic Prosthesis (C.A.P., DePuy, Johnson & Johnson Warsaw, Indiana). This implant has an apical flat undersurface and cruciate stem. Undersurface of the cap and the proximal portion of the central stem are surface-treated with DuoFixTM Hydroxyapatite for secure bone ingrowth fixation. Data for this study was compiled prospectively and patients were evaluated at mean period of 4.4 ± 2.3 years (Range 2–9 years).

2.2. Inclusion criteria

Radiological evidence of osteoarthritis of glenohumeral
Intact rotator cuff
Having not responded to 6 months of conservative treatment
Adequate bone stock of the humerus head (60% of bone stock) and glenoid type assessed on plain radiographs and CT scan as A1, A2 osteoarthritis (Walch classification[10])

2.3. Exclusion criteria

Type B2, C osteoarthritis (Walch classification) patients
Full thickness rotator cuff tears.
Inadequate bone stock (less than 60% of humeral head)
Previously operated shoulder for any reason.
Prior infection or neurologic injuries affecting the shoulder
Preoperative true anteroposterior and axillary radiographs were used to measure the humeral head diameter and cartilage wear. CT scans and MRI were performed in all cases. All the surgical procedures were performed by one senior shoulder surgeon. All patients received a cementless Global C.A.P humeral resurfacing implant. A first-generation cephalosporin was given intravenously one night prior to surgery and 30 minutes prior to incision and continued for 48 hours. Preoperative interscalene block was administered in all patients along with general anaesthesia. Patients were placed in the beach-chair position with the arm draped free. A deltopectoral approach was used and the subscapularis tendon was divided approximately 1 cm medial to its insertion along with the capsule. The humeral head was delivered out of the wound and all humeral osteophytes were removed. The head size was estimated using the jig provided. Care was taken in passing a threaded pin in the centre of the head through the jig, while ensuring anatomic alignment. Head was reamed over the guide wire, using the reamer of the selected size while maintaining the anatomic angle of inclination. In 2 cases, we had to switch intraoperatively to a stemmed hemiarthroplasty, due to very soft, osteoporotic humeral head. These two patients were not included in the study. Trial prosthesis was used to reconfirm final implant size and placement. The cannulated cruciform stem punch was used to create a path for the implant stem. Circumferential release of the glenohumeral joint capsule was accomplished and the glenoid osteophytes were trimmed. Multiple holes were drilled in the glenoid with a 2.5 mm drill. None of the glenoids were resurfaced. The appropriate-sized implant was placed thereby replicating the anatomic retroversion and inclination. Five head sizes of implant are available, and each size has 2 heights to match the anatomy of the shoulder. Tenodesis of the long head of the biceps was performed in all the cases. Supscapularis along with capsule was reattached. Deltopectoral interval was closed and skin was closed in layers. Radiographs were taken in recovery to verify implant positioning and seating. Dressing and drain removal was done after 24 hours and elbow, wrist and finger ROM started next day. Sling was kept for 4 weeks. Gentle passive exercises were started after 3 weeks, active assisted ROM exercises started after 6 weeks and strengthening exercises with elastic bands after 12 weeks.

2.4. Clinical and radiological assessment

Patients were routinely followed-up at 2 weeks, 6 weeks, 3 months, 6 months and then once every one year. All patients were encouraged to undergo follow-up with the senior surgeon. Telephone interviews were conducted for patients unable to visit, and the subjective portions of the assessment tools were obtained and their post-operative x-rays were received by post or email. Preoperative and postoperative evaluation was done using the VAS (Range 0–10), ASES and Constant and Murley score.[11] True AP view, AP view in 30° external rotation and axillary radiographs were obtained at all follow up. Inclination angle of the implant was calculated in AP view with 30° external rotation by method explained by P. Boileau and G. Walch.[7] According to them, the inclination angle is between the proximal metaphyseal (intramedullary) axis and the perpendicular to the articular margin plane. The normal inclination angle ranges from 123.3 to 135.8 degrees. The degree of glenoid erosion, the glenohumeral relationship, and the acromiohumeral relationship were also assessed on plain radiographs. Radiolucent lines and their evolution over time were also assessed.

2.5. Statistical analysis

The data were entered into Microsoft Excel 2007 and analyzed by use of SPSS software (version 16; IBM). For descriptive analysis for numerical data, various parameters are expressed as mean (standard deviation, range). Frequencies for categorical data are expressed as percentages.

Following statistical tests of significance were used as per distribution of data (Normal or non-normal). Paired t test for comparison of mean ASES, CONSTANT & VAS before & after surgery and un-paired t test for comparison of mean difference of ASES, CONSTANT & VAS between two groups. The P value less than 0.05 were taken as statistically significant.

3. Results

Fifty-seven humeral head surface replacement arthroplasties were performed in fifty-four patients (3 bilateral). One patient died due to heart attack after 3 years of operation unrelated to surgery and 6 patients (shoulders) were lost to follow up. Therefore, we had 50 shoulders with an average age of 67.9 ± 12.6 (37–95) years.

Thirty-one (62.0%) were males and 19(38.0%) were females. In all 47 (100.0%) patients the right side was dominant, however 28 (56.0%) affected shoulders were left and 22(44.0%) were right. Out of 50, 49(98.0%) shoulders had primary osteoarthritis and 1(2.0%) patient had rheumatoid arthritis. Duration of hospital stay was average 3.0 ± 0.1 days (3–4). The mean follow-up was for 4.4 ± 2.3 years (Range 2–9 years). Mean ASES score for all shoulders significantly improved from 15.0 ± 5.6 (range 5–25) preoperatively to 81.8 ± 12.9 (range 30–95) at follow-up with mean difference of 66.8. ($P < 0.001$). Mean Constant and Murley scores for all shoulders significantly improved from 32.2 ± 4.4 (range 24–44) preoperatively to 81.4 ± 10.5 (range 52–100) at follow-up with mean difference of 49.2 ($P < 0.001$). VAS score for all shoulders significantly improved from 8.4 ± 0.7 (range 7–9) preoperatively to 1.4 ± 1.5 (range 0–7) at follow-up with mean difference of 7.0 ($P < 0.001$). All components of range of motion improved significantly following resurfacing shoulder arthroplasty.

None of these patients showed loosening around the prosthesis till their latest follow up. The average angle of inclination of implant was 131.1 ± 9.4 (116–153). Of the 50 shoulders, 32(64.0%) were in normal range and 8(16.0%) were in varus and 10 (20.0%) were in valgus. Difference in mean postoperative ASES, Constant and VAS score in normal and valgus inclination implants (Table 1) was not statistically significant. However, the difference in normal and varus inclination (Table 2) was statistically significant.

One of the patient had osteolysis around the stem at 7th month, which resolved at 1.5 year (Fig. 1). One of the bilateral patient had developed capsulitis in right shoulder therefore having restriction of movement as well as pain. We did not encounter any perioperative complications, such as neurovascular injury, infection, humeral fracture, or gross malposition of the implant. No subsidence of the humeral prosthesis was found. No revision surgery was necessary till the latest follow-up.

4. Discussion

We studied the outcomes of cementless humeral head resurfacing arthroplasty in fifty shoulders operated between 2007 and 2014 and followed prospectively for mean period of 4.4 ± 2.3 years (Range 2–9 years). We found 96% patient satisfaction, a perceived return of function, and decreased pain with neither loosening nor progressive radiolucent lines around the humeral implant. Our results are similar to results with the Copeland Mark 3 prosthesis.[9] Our midterm results are slightly better compared with other results reported with stemmed implants.[12–15] An important finding in our study is that, the inclination of the prosthesis had an impact on functional outcome. The difference in mean postoperative ASES, Constant and VAS score in normal and varus inclination angle was statistically significant, indicating varus angle affects the functional outcome. In these patients with varus inclination, we were not able to identify any other reason for their poor functional outcome. Therefore, authors suggest that a jig to aid consistently accurate alignment of the prosthesis is desirable. Three patients had severe pain with VAS score of 7, 5 and 4 postoperatively, despite the angle of inclination being normal. The patient with 7 VAS score (which is a bilateral case) had developed capsulitis in right shoulder therefore having restriction of movement as well as pain. In the patient with 5 VAS score, we found obvious glenoid erosion (Fig. 2) at 8 years post-op, whereas, the patient with 4 VAS score did not comply with our rehabilitation protocol hence had stiffness and pain.

Although the current gold standard for the treatment of osteoarthritis of the shoulder is total shoulder arthroplasty, we believe there is a place for resurfacing hemiarthroplasty combined with glenoplasty, which includes release of capsule, removal of osteophytes and multiple drill holes in the glenoid. Long-term survival of glenoid replacement remains unpredictable. Glenoid loosening reported after unconstrained total shoulder arthroplasty is between 0% and 20% at mid-term follow-up and 39% at mid- to long-term follow-up[2,16–19] with more than a 5% rate of revision surgery at long-term follow-up. Several factors, such as rotator cuff tears, component malposition, and instability, can contribute to glenoid failure.[2,20,21] In the current series, we have not done glenoid replacement and had only one patient with symptomatic glenoid erosion. This implant has the advantage over stemmed implant especially in young patients particularly if it needs to be revised, because of preservation of bone stock. Besides removal of the humeral surface component is easily and speedily effected since no cement or stem has to be removed. In contrary, in cemented stemmed prosthesis there is risk of perforation and fracture of the humerus shaft along with loss of bone stock. Studies with follow-up ranging from eight months to seven years shows low complication rates with humeral resurfacing[1,9,10,17–19] Periprosthetic fractures, which have a reported prevalence of 3%, account for approximately 20% of all complications associated with total shoulder arthroplasty intra- and postoperatively. This can be avoided using this prosthesis.[14,22] To our knowledge, only one intraoperative periprosthetic fracture has been reported, and it was managed non-operatively. However, in current series periprosthetic fractures were not seen perhaps because of the absence of stress shielding with resurfacing implants.[15,23,24] Stemmed prosthesis creates a stress riser effect at the tip of the stem in the midshaft of the humerus[1] whereas there is no stress riser due to absence of stem in this implant. This is especially important with elderly patients, who have a greater tendency to fall. This situation can cause difficulties in the event of a humeral shaft fracture.[12,22] Subluxation and dislocation did not take place due to correct sizing and version of the humeral component since the implant was positioned on the natural humeral head.

The revision rate for resurfacing maybe slightly higher compared with stemmed implant as stated in recent papers, especially the Danish Joint Registry Study.[8] This could be due to selection bias because a surgeon facing a painful stemmed shoulder replacement will be reluctant to suggest revision shoulder replacement. However, when facing painful resurfacing

Table 1
Difference in mean postoperative ASES, Constant and VAS score in normal and valgus inclination angle shoulders.

Difference	Normal (n = 32)	Valgus (n = 10)	P value
ASES	68.1 ± 11.8	69.3 ± 12.0	0.781 (NS)
CONST	51.5 ± 8.6	51.8 ± 11.2	0.937 (NS)
VAS	7.1 ± 1.4	7.5 ± 1.2	0.451 (NS)

(Unpaired t test).
ASES: American Shoulder and Elbow Surgeons Shoulder score.
CONST: Constant and Murley Score.
VAS: Visual Analog Scale.
NS: Non-Significant.

Table 2
Difference in mean postoperative ASES, Constant and VAS score in normal and varus inclination angle shoulders.

Difference	Normal (n = 32)	Varus (n = 8)	P value
ASES	68.1 ± 11.8	58.4 ± 4.7	<0.030 (S)
CONST	51.5 ± 8.6	36.6 ± 6.9	<0.001 (S)
VAS	7.1 ± 1.4	5.6 ± 0.9	<0.007 (S)

(Unpaired t test).
ASES: American Shoulder and Elbow Surgeons Shoulder score.
CONST: Constant and Murley Score.
VAS: Visual Analog Scale.
S: Significant.

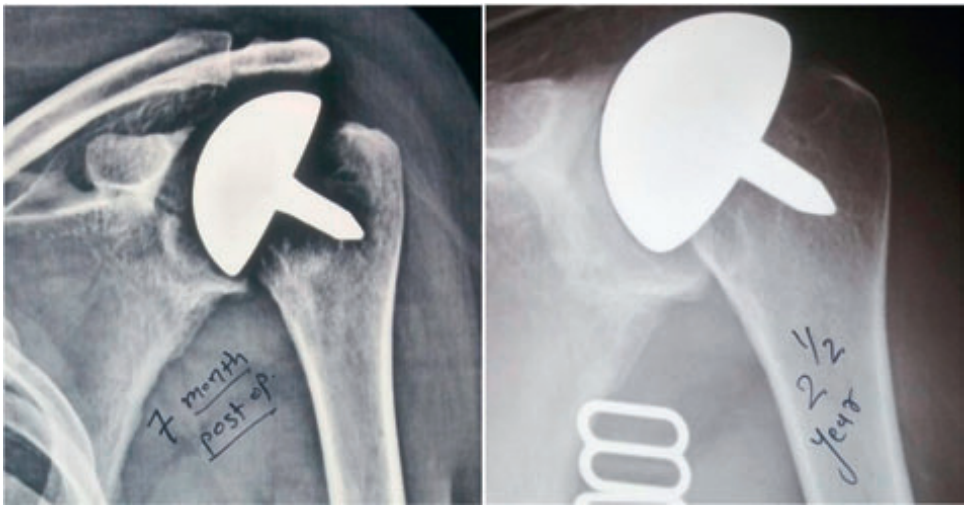

Fig. 1. X-Ray Left Shoulder AP view at 7th month showing osteolysis around the stem and X-Ray Left Shoulder AP view at 2.5 years showing resorption of osteolysis.

Fig. 2. X-Ray Left Shoulder AP view at 8th year showing erosion of glenoid.

prosthesis, it might be easier to suggest a revision. Hence, the higher revision rate of surface replacement is significantly biased. Compared with revision of a traditional stemmed component, removal of the humeral component may require less manipulation and may be associated with a smaller risk of complications. Reported indications for revision include loosening of the humeral and/or the glenoid component, glenoid erosion, infection, fracture, and improper implant size. In our study, we have not done any revision and the first patient, which we had operated, nine years ago is doing well till latest follow up. Authors agree with Cofield[25] that revision rate alone is not sensitive to a failed procedure. He suggests that it should be used in combination with pain and satisfaction as assessed by patients, with those reporting pain equal to or worse than that preoperatively, be considered a failure.[1]

This study has some limitations. One, there was no control group treated with a stemmed implant. Second, the population reported is small, yet comparable with other published studies of shoulder resurfacing.[1,12,19] Nevertheless, small case numbers suggest caution in interpreting the incidence of uncommon complications. Despite the promising mid-term follow-up with good pain relief and function, the incidence of symptomatic glenoid erosion and survival of the implant in the long term remains to be seen.

5. Conclusion

The authors report the clinical and radiologic outcome of uncemented shoulder resurfacing prosthesis for the treatment of primary osteoarthritis with 4.4 ± 2.3 years (range 2–9 years) follow up. The authors conclude that mid-term follow-up of the uncemented Global C.A.P. resurfacing prosthesis is encouraging and comparable with modular stemmed hemiarthroplasty and the Copeland Mark 3 resurfacing prosthesis. Inclination of the implant has effect on functional outcome of patients. No patients required revision surgery. Long-term follow-up is necessary to evaluate whether these results will endure.

Conflict of interest

None of the authors has any conflict of interest.

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Research paper

Functional outcomes and survival-ship of total hip replacement in patients with Ankylosing Spondylitis: A systematic review

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ABSTRACT

Background: Aim of this systematic review was to study the current literature regarding total hip replacement (THR) in patients suffering from ankylosing spondylitis to answer following questions: (1) Is there functional improvement in these patients after THR (2) Is there a higher risk of hetrotopic bone formation or loss of range of motion in long term follow up, and (3) What are the survival rates of THR in AS?

Methods: Literature search was carried out in electronic databases PubMed, EMBASE, Google Scholar and Cochrane Library. Search was done using a pre-designed search strategy. Data on functional outcomes, survival-ship and hetero-topic ossification was collected.

Results: Based on inclusion criteria 13 studies were included in the systematic review. Total of 917 arthroplasties were carried out in 585 patients. Swignificant improvement in hip function was seen in all studies. Failure defined as the need for revision THR was seen in 90 hips (11.9%). Clinically significant (class III or IV) heterotopic ossification was seen in only 40 (4.5%) patients and only 6 cases of reankylosis or reduced range of motion were reported.

Conclusion: The outcomes and survival-ship of total hip replacement in patients with ankylosing spondylitis are as good as those done for other indications. Heterotopic ossification and re-ankylosis after THR is not a common phenomenon and routine prophylaxis are not recommended. But there is lack of high quality controlled studies comparing outcomes in patients undergoing total hip replacement for ankylosing spondylitis and osteoarthritis.

1. Introduction

Prevalence of ankylosing spondylitis (AS) in general population is estimated to be about 1%.[1,2] Axial skeleton including sacro-iliac joints is most commonly involved and hip is the most commonly involved peripheral joint. Hip may be involved in 30–50% of the patients with AS and in 50–90% of the patients this involvement is bilateral.[3–5] Younger age and juvenile onset is associated with greater incidence of hip joint involvement.[6] Total hip replacement (THR) is the treatment of choice for advanced destruction of hip joint in AS.

These patients are relatively young compared to patients undergoing THR for osteoarthritis. Bone is often soft due to regional or generalised osteoporosis. Unlike involvement of spine, hip involvement does not lead to formation of bridging syndesmophytes, but there are erosions leading to loss of joint space and bony or fibrous ankylosis of the hip joint. There may be bone loss on acetabular side resulting in a protrusio acetabuli.

There is lack of sufficient information on outcomes of hip arthroplasty in patients with AS. The aim of this systematic review was to study the current literature regarding THR in patients suffering from AS to answer following questions: (1) Is there functional improvement in these patients after THR (2) Is there a higher risk of hetrotopic bone formation or loss of range of motion in long term follow up, and (3) What are the survival rates of THR in AS?

2. Material and methods

Comprehensive search of literature was carried out using the online databases PubMed (http://www.ncbi.nlm.nih.gov/

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pubmed), EMBASE (http://www.elsevier.com/online-tools/embase), Google Scholar, and the Cochrane database (http://www.cochrane.org) for all studies published in the English language before 8th May 2015. Search terms used were- 'Ankylosing Spondylitis' OR 'Ankylosis' AND 'total hip replacement' OR 'hip arthroplasty' OR 'Hip Surgery'. Search was restricted to articles on human subjects in English language. References of the studies whose full texts were studied were also hand- searched for any other relevant studies.

Criteria for including the studies in review were- adult patients with diagnosis of ankylosing spondylitis undergoing total hip replacement, articles studying functional or radiological outcomes and survival of THR procedure, and articles published after year 1991 (last 25 years). Case reports were excluded. Studies including patients with other types of inflammatory arthritides were also excluded. Article primarily comparing outcomes with other type of arthroplasty (such as resurfacing) were also excluded.[7] Total number of cases available for follow up after accounting for losses during follow up were included in the review. Studies were considered retrospective unless it mentioned that the cases were enrolled before THR was carried out and were then prospectively followed up.

The systematic review was carried out by two authors who independently analysed the data. Any controversy was sorted out by mutual agreement. Data from full text articles was extracted into Microsoft Excel. Information was extracted on demographic details of patients, prosthesis and surgical approach used, preoperative and postoperative function, heterotopic bone formation and survival of the prosthesis.

3. Result

A total of 386 studies were identified in the search. Title and abstracts of all these articles were studied for potential inclusion in the review. After assessing the studies against inclusion criteria 13 studies were finally included in this review. A flow chart of literature search using the PRISMA format (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) is presented in Fig. 1. Twelve studies were retrospective in nature and one study was prospective (Table 1).

Total of 917 arthroplasties were carried out in 585 patients. There were 490 males and 95 females. Total 332 procedures were bilateral. Information on type of arthroplasty (cemented vs uncemented) was available in 12 studies (Table 1). There were total of 501 (56.6%) uncemented THR, 351 (39.7%) cemented THR and 33 (3.7%) hybrid THR. Data on surgical approach used was available in 751 patients. Most commonly used approach was posterior, which was used in 322 patients (42.9%), followed by lateral approach with trochanteric osteotomy in 237 patients (31.6%). Anterolateral approach was used in 160 (21.3%) patients and Hardinge's approach was used in 32 (4.2%) patients.

All studies graded heterotopic ossification using the system described by Brooker et al.[20] No prophylaxis against heterotopic ossification was used by five authors (Table 2). Modalities used by other authors for prophylaxis against heterotopic ossification are presented in Table 2. HO was seen in total 246 (27.73%) patients. Of these clinically significant (class III or IV) HO was seen in only 40 (4.5%) patients. Only 6 cases of reankylosis or reduced range of motion were reported.

Harris hip score was the most common scoring system used by 8 authors (Table 3). Other scores used were Merle d'Aubigné hip score, Japanese Orthopedic Association score and WOMAC score. Pre-operative and post-operative hip functions are mentioned in Table 3. This shows a significant improvement in hip function in all studies. Ten year survival rates were given in 5 studies and 15 year survival rates were given in 3 studies (Table 3). Failure defined as the need for secondary surgery such as a revision THR was seen in 90 hips (11.9%). Aseptic loosening was more common on the acetabular side (31 hips), compared to the femoral side (20 hips).

4. Discussion

Ankylosing spondyitits is a relatively rare indication for a hip replacement. Yet a significant number of patients of AS will have hip involvement and may need THR. Challenges of doing a THR in AS are different compared to osteoarthritis or avascular necrosis. This is the first systematic review of literature on THR in patients with AS. There is evidence from this review that these patients do as well as patients in which THR has been done for some other indication. Functional outcomes, survival-ship of the prosthesis, incidence of re-ankylosis and dislocation are similar.

Indications for surgery may be different in these younger and more active individuals with AS. Following ankylosis pain may be absent in many of these patients, but functional disabilities may be very marked due to stiffness and deformities as suggested by Bhan et al.[9] They also found that these patients with bony ankylosis may not have any hip pain initially but they may develop some pain in the hip joint after the surgery. But they remain overall satisfied functionally with the improved range of motion and quality of life. Soehart and Porter [18] also reported that patients with bony ankylosis may be free from pain. Though there will be shortening of the lower limb due to hip involvement, limb length discrepancy is infrequently seen. This is due to bilateral nature of the disease in majority of cases.[9]

Accurate positioning of the patient during surgery may be demanding in these patients because of associated pelvic tilt. This will have an impact on the positioning of the acetabular cup. Hyperextension of the pelvis may risk placement of cup in too much anteversion, thus increasing the risk of anterior instability.

Exposure of the hip joint for dislocation during the surgery may be difficult due to ankylosis or protrusio acetabulum. Bhan et al.[9] described in-situ osteotomy of the femoral neck as it may be difficult to dislocate the ankylosed hip joint. Remaining femoral head was removed from the acetabulum in a piece-meal fashion. Identification of femoral neck may be difficult in stiff hip, particularly if they are associated with protrusio and rotational deformities. Removal of a few millimeters of the posterior wall,[9,10] dissecting anterior to the greater trochanter or making a neck cut by a separate anterior incision of the two-incision minimally invasive technique.[9] Baba et al.[10] recommended excision the entire hip joint capsule considering it a pathological tissue in these patients.

Estimation of true centre of acetabulum during reamimg may be difficult in patients with ankylosis. Frequently the head has to be removed piecemeal in these cases. There is a risk of over-reaming the acetabulum [9] or creating a higher centre of the hip joint. Subchondral bone should be preserved as it provides support for fixation of acetabular component. Landmarks such as fovea, tranverse acetabular ligament and remnant of cartilage and subchondral bone on acetabular side may help to determine amount and direction of reaming.[13] Bhan et al.[9] suggested that the bone spike at superolateral part of the acetabulum serves as a guide to abduction of the acetabular component. This part of the acetabulum should be preserved during exposure of the femoral neck.

Flexion contracture in ipsilateral knee may be another surgical challenge in these patients. This may be secondary to long standing flexion deformity in the hip joint. Bhan et al.[9] described posterior soft tissue release of knee in 18 patients simultaneously to correct the flexion deformity of the knee joint. Another 3 patients needed wedging casts for correction of deformity.

Uncemented THR was the most common type of procedure and posterior approach was the most common surgical approach. This

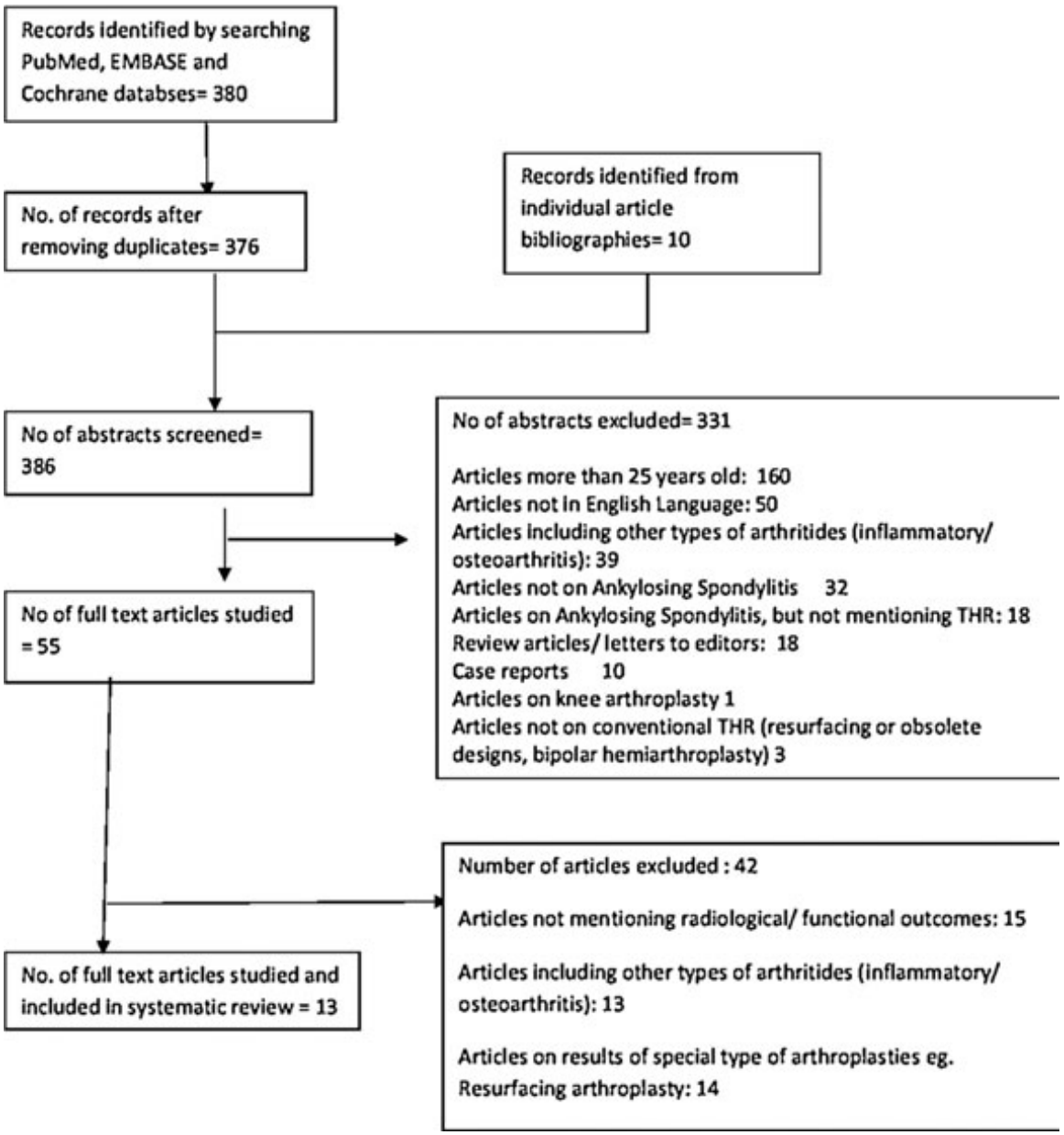

Fig. 1. Flow chart of literature search using the PRISMA format.

may reflect the general trends of surgeons shifting towards use of uncemented implants for all primary hip arthroplasties and posterior approach.

All studies reported significant improvement in hip function at follow up. Thus THR is an effective procedure in relieving pain and restoring function in patients with AS and this improvement is maintained at medium to long term follow up.

Benchmark for survival prosthesis used for THR is set at more than 90% at 10 years follow-up.[23] Four of the six studies reporting ten year survival had more than 90% survival rates at 10 years.[10,13,17,18] The reasons for poorer outcomes in other studies could be related to older cementing techniques [19] or earlier uncemented hip prosthesis.[9] Joshi et al.[19] had a ten year survival rate of 87.3% (79%–92%) in their 181 patients operated using cemented Charnley low-friction THR. Reported ten year survival rates of Charnleys low friction arthroplasty are in the range of 90–95%.[24,25] Shih et al on the other hand [19] found that 88% of their prosthesis that were loose was cemented. Rates of implant loosening were twenty-eight percent in cemented THR done for AS whereas it was only 13% for THR in OA.[19] They had used second generation cementing techniques and predominantly Muller prosthesis. Sochart and Porter had a 91% survival rate at 10 years using cemented prosthesis. Present literature cannot prove superiority of either cemented or uncemented prosthesis in these patients. The choice should depend upon other factors such as age and morphology of femoral canal.

Thus patients with inflammatory arthritides may not be at a higher risk of undergoing revision compared their counterparts undergoing THRs for other indications such as osteoarthritis. A recent metaanalysis by Ravi et al has not shown increased rates of revision of total hip or knee arthroplasty in patients with rheumatoid arthritis as compared to osteoarthritis.[22]

None of the authors recommend routine use of prophylaxis for HO. Clinically significant HO include Brooker's class III and IV and is uncommon in these patients after THR.[19] Brinker et al.[16] compared rates of HO in their 14 patients with AS not receiving any

Table 1
Demographic profile of patients in the studies included.

	Author, year of publication	Country	Duration of study	Number of patients	Number of THR	Male/ female	Mean age (Range)	Mean follow up (Range)	Approach	Type of THR
1.	Joshi et al. 2002 [8]	UK	NA	103	181	70/33	47 Y (17–77)	10.3 Y (2–27.2)	TT 166, Hardinge 15	Cemented
2.	Bhan et al. 2008 [9]	INDIA	1988–2004	54	92	42/12	25.5 Y (18–44)	8.5 Y (2–16)	Posterior	Uncemented
3.	Baba et al. 2010 [10]	Japan	1982–2007	20	31	16/4	39.5 Y (26–69)	12 Y (2–28)	Posterior	Uncemented
4.	Ye et al. 2014 [11]	China	NA	15	30	14/1	37.2 Y (28–52)	29.3 mo (15–40)	Posterior	Uncemented
5.	Zhang et al. 2014 [12]	China	NA	100	167	81/19	36.4 Y (17–69)	54.8 mo (32–129)	NA	134 uncemente 33 hybrid
6.	Wang et al. 2014 [13]	China	2000–2008	13	26	11/2	33.7 Y (22–57)	128.4 mo	Posterior	Uncemented
7.	Weng et al. 2015 [14]	Taiwan	2004–2012	91	129	84/7	Gp I 43.9 Y ± 14.1 (SD), Gp II 39.5 Y ± 14.2 (SD)	Gp I 6.7 Y, Gp II 8.1 Y	Anterolateral	Uncemented
8.	Goodman et al. 2014 [15]	USA	2007–2010	30	32	24/6	52.7 Y ±16.2 (SD)	2Y	NA	NA
9.	Brinker et al. 1996 [16]	USA	1983–1990	12	20	12/0	35 Y (23–53)	75 mO (27–121)	Hardinge 17 Posterior 3	Uncemented
10.	Tang and Chiu. 2000 [17]	Hong King	NA	58	95	56/2	38.9 Y (19.2–78.8)	11.2 Y (24.4–331.2 mo)	Posterior	Cemented 46 Uncemented 49
11.	Sochart and Porter. 1997 [18]	UK	1966–1978	24	43	17/7	28.8 Y (19–39)	22.7 Y (1mo-30.3y)	TT	Cemented
12.	Shih et al. 1995 [8]	Taiwan	1979–1990	46	74	46/0	36 Y (20–75)	100 mo (37–174)	Anterolateral 31 Posterior 25 TT 18	Cemented 52, Uncemented 22
13.	Walker and Sledge. 1991 [19]	USA	1972–1985	19	29	17/2	53.4 Y (20–74)	55.9 mo(24–168)	TT 10 Posterior 20	cemented

NA – information not available
mo – months
Y – years
SD – standard deviation
TT – lateral trans-trochanteric approach

prophylaxis with another group of 49 patients undegoing primary uncemented THR for other indications. These groups included patients of similar age groups operated by same surgeons using predominantly Hardinge's approach. Interestingly, there was a significantly lower rate of HO in the AS group (6 out of 14 patients) as compared to the other group (43 out of 49 patients).

Weng et al.[14] compared 58 hip who did not receive any prophylaxis with another group of 78 hips who received postoperative single-fraction radiotherapy of 500 cGy. There was no difference in HO in the two groups. Baba et al.[10] had heterotopic ossification in 11 out of 31 THRs (36.6%) which was Brooker class I or II in 9 patients with HO. There was no difference in the final range of motion in the patients developing HO at follow up and those not developing HO. Thus current data does not suggest that these patients are at a higher risk of development of HO and use of prophylaxis for HO cannot be recommended. Rates of HO have not been shown to vary with surgical approach used.[19]

Patients with AS undergoing THR are not at a higher risk of dislocation (Table 3). A total of 19 (2.6%) dislocations were seen in the studies included in this review (Table 3). Majority of these dislocations occurred within few weeks of surgery [10,11] and were treated with closed reduction.[9,19] Tang et al.[17] found that the pelvis

Table 2
Detail on prophylaxis and development of heterotopic ossification.

	Author (year of publication)	Prophylaxis HO	Heterotopic ossification					Decreased ROM at follow up
			Class I	Class II	Class III	Class IV	Total	
1.	Joshi et al. 2002 [8]	No	19	2	0	0	21	0
2.	Bhan et al. 2008 [9]	Indomethacin 25 mg 3 times/day 14 days	8	3	1	0	12	2
3.	Baba et al. 2010 [10]	No	7	2	2	0	11	0
4.	Ye et al. 2014 [11]	Indomethacin	NA	NA	NA	NA	NA	NA
5.	Zhang et al. 2014 [12]	No	29	9	4	0	42	NA
6.	Wang et al. 2014 [13]	Celebrax	6		0	0	6	
7.	Weng et al. 2015 [14]	Radiotherapy in 53 pts (500cGy)	41		0	0	41	
8.	Goodman et al. 2014 [15]	NA	3	0	0	2	5	NA
9.	Brinker et al. 1996 [16]	Radiotherapy 2 Indomethacin 4 No prophylaxis 14	3	3	0	0	6	0
10.	Tang and Chiu. 2000 [17]	No	37	13	16	4	70	NA
11.	Sochart and Porter. 1997 [18]	No	3	3	0	0	6	NA
12.	Shih et al. 1995 [8]	Indomethacin 39 radiation 8 No prophylaxis 27	31	11	5	0	47	1 reankylosis
13.	Walker and Sledge. 1991 [19]	11 patients (details NA)	13	1	3	3	20	3 reankylosis
	Total		206		40		246 (27.73%)	6

NA- information not available

Table 3
Functional outcomes at follow up and survival rates.

	Author (year of publication)	Clinical grading	pre operative grading	post operative grading	Total number of revisions	Aseptic loosening	10 year survival	15 year survival	Dislocations (direction)
1.	Joshi et al, 2002 [8]	MP	NA	173 hips (96%) had an	25	17 (femur or acetabulum not specified)	87.3% (79%–92%)	81.4% (70–88)	4 (NA)
2.	Bhan et al, 2008 [9]	HHS	49.5 (44–65)	excellent (low) pain score, and 53 hips had a normal or near-normal function score	13	Femoral 9 Acetabular 2 Both 2	8.5 years follow-up was 85.9%		4 (anterior)
3.	Baba et al. 2010 [10]	JOA	26.4 ± 10.3 SD	−29.20%	4	Acetabular 4	100.00%	63.50%	3 (posterior)
4.	Ye et al. 2014 [11]	HHS	24.8 ± 7.42 SD	83.8 ± 4.61	0	0	NA	NA	1 (NA)
5.	Zhang et al. 2014 [12]	HHS	14.0 (9.0–23.0)	89.0 (83.0–95.0)	0	0	NA	NA	2 (1 ant other not mentioned)
6.	Wang et al. 2014 [13]	HHS	22.1 (10–38)	91.7(75–98)	7	Acetabulum 1 Both 4	92.30%	73.1% at 13 years	0
7.	Weng et al. 2015 [14]	HHS	Gp I 51.3 to 93.4, Gp II 51.6 to 93.1		NA	NA	NA	NA	NA
8.	Goodman et al. 2014 [15]	WOMAC	70.0 (10.0–100.0) and 64.7 (4.4–100.0)	100.0 (40.0–100.0) and 91.2 (35.3–100.0)	NA	NA	NA	NA	NA
9.	Brinker et al. 1996 [16]	HHS	48.4 (27–72)	89.1 (69–99)	0	Femoral 2 Acetabular 4	NA	NA	0
10.	Tang and Chiu. 2000 [17]	HHS	27.4(18–50.3)	88.8 (68.6–91)	19	Acetabulum 7 Both 6	96.8	66.3	3 (2 were ant)
11.	Sochart and Porter. 1997 [18]	MP	3.7,2.8, 2.3	5.8,5.3,5	11	Acetabular 8 Both 2	91	73 at 20 y	0
12.	Shih et al. 1995 [8]	HHS	14 ± 13 SD, 23 ± 10 SD	75(22), 85(17)	11	Acetabular 13 Femur 9	78%	NA	2 (NA)
13.	Walker and Sledge. 1991 [19]	NA	Pain in 100% Independently mobile- 15.75	Pain in 3% Independently mobile- 53%	0	0	NA	NA	NA
	Total Number (%)				90 (11.9%)	Femoral 20 Acetabular 31 Both 14 Not specified 17 Total 68 (9%)			19 (2.6%)

NA – information not available.
MP – Merle d'Aubigne and Postel score.
HHS – Harris Hip Score.
JOA – Japanese Orthopedic Association hip score.
WOMAC – Western Ontario and McMaster Universities Arthritis Index.

in patients with AS is hyper-extended. This occurs as compensation to kyphotic deformity in thoracic spine and loss of lumbar lordosis. Thus if the cup is placed aligned to the normal anatomical landmarks, it comes into a position of exaggerated anteversion and abduction. This could explain the higher prevalence of anterior dislocation in these patients.

Total number of deep infections noted was 21 (2.3%). Sciatic nerve injury was seen in 9 (1%) patients. Brinker et al.[18] reported a higher rate (15%) of peroneal nerve palsy in their series of 20 patients, which was not supported by other studies. Pulmonary embolism was seen in only 1 patient.

Anaesthesia in these patients also poses unique challenges. Intubation may be difficult due to involvement of cervical spine and temporo-mandibular joint. Access to spinal and epidural anaesthesia may be difficult due to fibrosis of ligaments and new bone formation around vertebrae. In cases with associated spinal and thoracic cage deformities the lung capacity may be low. Discussion on these complications is out of scope of this review.

One limitation of this review is that different studies used different outcome scores, so the result could not be combined for further analysis. Since studies had included both unilateral and bilateral cases and separate comparison was not carried out, such analysis also couldnot be done in this review. Ankylosing spondylitis is a systemic disease and may involve multiple joints. Overall disability may not be only because of the hip but also other joint involvement. Since the included studies focussed on hip joint involvement, such details could not be included in this article.

5. Conclusion

THR in patients with ankylosing spondylitis is more challenging as compared to other indications. But results of the surgery are rewarding and survival-ship may be as good as THR done for other indications. Heterotopic ossification and re-ankylosis after THR is not a common phenomenon and routine prophylaxis is not recommended. There is lack of good case-control studies comparing outcomes in patients undergoing THR for AS and other indications. There is a need for such studies for a high quality of evidence on this topic.

Conflict of interest

The authors have none to declare.

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Further reading

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Research paper

Templating digital radiographs using acetate templates in Total Hip Arthroplasty

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ABSTRACT

Introduction & objective: Preoperative templating in Total Hip Arthroplasty (THA) has traditionally been done with conventional radiographs. With conventional films being replaced by digital films, it has become difficult for surgeons to template the hip preoperatively, as digital templating involves special software, carries an additional cost and is not freely available. We describe a hybrid technique that involves the use of standard acetate templates, used over digital radiographs on a LCD monitor.
Materials and methods: Preoperative digital radiographs of the pelvis were taken with a 30 mm diameter spherical metal ball taped onto the greater trochanter. Viewing the digital radiographs on a flat screen LCD monitor, the metal ball on the image was magnified to 30 mm as per the scale on the acetate template. The size of the acetabular cup and the femoral stem were then directly read using standard techniques with the acetate templates. To assess accuracy, digital films of 54 hips were retrospectively templated and the estimated size of the implant was compared with the actual size used at surgery. Reliability of the method was tested with Intraclass Correlation Coefficient (ICC).
Results: Using this technique, it was possible to accurately predict the acetabular cup size in 38/54 (70%) of the hips and to within 1 size in 96% of the hips. The femoral component size was accurately predicted in 24/54 (44%) of the hips and to within 1 size in 82% of the hips. When assessed by two independent observers, there was good intraobserver reliability (ICC value = 0.96) and interobserver reliability (ICC value = 0.93) for the acetabular templating as well as for the femur (ICC value of 0.93 for intraobserver reliability and ICC value of 0.88 for interobserver reliability).
Conclusion: It was possible to accurately and reliably predict the size of the acetabular cup and the femoral stem, using standard acetate onlay templates on digital radiographs, without the use of digital templating software.

1. Introduction & objective

Total Hip Replacement (THR) surgery has an excellent track record in providing pain relief and restoring hip function. Preoperative templating helps in planning for the surgery and in implanting prostheses of the appropriate size. During surgery, the acetabulum is serially reamed till the subchondral bone is exposed, and an uncemented acetabular cup is then inserted to get a "press fit". The femoral medullary canal is also broached using sequentially larger broaches till a good fit is obtained and the corresponding size uncemented femoral stem is then impacted into the femur. It is essential that the implants have a "good fit", as loose implants affect the survival of the prostheses.

Traditionally, templating has been done using conventional Antero-Posterior (AP) radiographs of the pelvis that are performed with the x-ray tube at a standardized distance from the x-ray table. Acetate templates provided by the implant manufacturing companies are used on these "conventional radiographs" to determine the size of the acetabular cup and the femoral stem that is likely to be implanted. These templates are usually magnified to 110–120%, which is also the magnification produced by most conventional x-ray machines. However, magnification of radiographs are proportional to the distance between the bony pelvis and the x-ray film and this distance can be affected by the size of the patient.[1] It is also not always possible to get x-rays of a constant magnification. Additionally, as conventional x-rays are being replaced by digital films in most hospitals, this method of templating using acetate templates on conventional radiographs is becoming redundant. Digital templating has been introduced to template on digital radiographs. However, digital templating

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software is expensive[2] and the use of the software requires special training[3] and each company has a specific software, which can be used with the implant of that particular company only. Hence there was a need to create an alternate method of templating using digital radiographs.

Our technique involves templating the digital radiographs on a LCD monitor using the standard acetate onlay templates for THR. Our objective was to see if this technique was accurate and reliable.

2. Materials and methods

All patients who underwent uncemented total hip replacement in a 6 month period starting from June 2014 were enrolled in the study. Exclusion criteria included patients with a pelvic tilt/flexion deformity of the hip (as in ankylosing spondylitis) and patients with altered bony morphology like ankylosed hips and protrusio acetabuli. Institutional IRB clearance was obtained for the study.

54 hips of 44 patients who fulfilled the inclusion criteria were included in the study. The acetabular component consisted of hemispherical Pinnacle Porocoat (n = 39) cup (DePuy, Warsaw, IN, USA) or R3 (n = 15) cup (Smith & Nephew, Memphis, TN, USA) and was implanted following a "line to line" reaming. The femoral components implanted were HA-coated Corail stem (DePuy, Warsaw, IN, USA)in 39 hips and porous-coated Synergy stem (Smith & Nephew, Memphis, TN, USA) in 15 hips.

A digital Antero-Posterior (AP) x-ray of the pelvis of the patient, centered just below the symphysis pubis was taken with both legs in 15° of internal rotation. A spherical metal ball of 30 mm diameter was strapped onto the affected hip at the level of the greater trochanter with adhesive plaster (Fig. 1). Viewing the digital radiographs displayed on a standard flat screen LCD monitor, the images were first magnified, using the Picture Archiving and Communication Systems (PACS) system, such that the 30 mm marker ball seen on the x-ray corresponded to 30 mm on the magnification scale of the acetate templates provided by the implant manufacturing company (Fig. 2). This sets the magnification of the digital X-ray image to the same magnification as the acetate template. Templating was done on the affected hip.The size of the matching acetabular cup was then directly read off using the acetate templates as per the method described by Della Valle et al.[4]

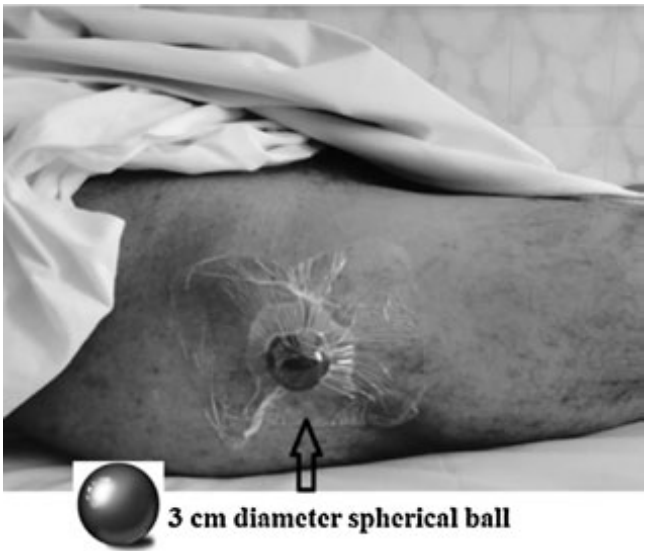

Fig. 1. Position of the 3 cm metal ball – held over the greater trochanter with adhesive plaster.

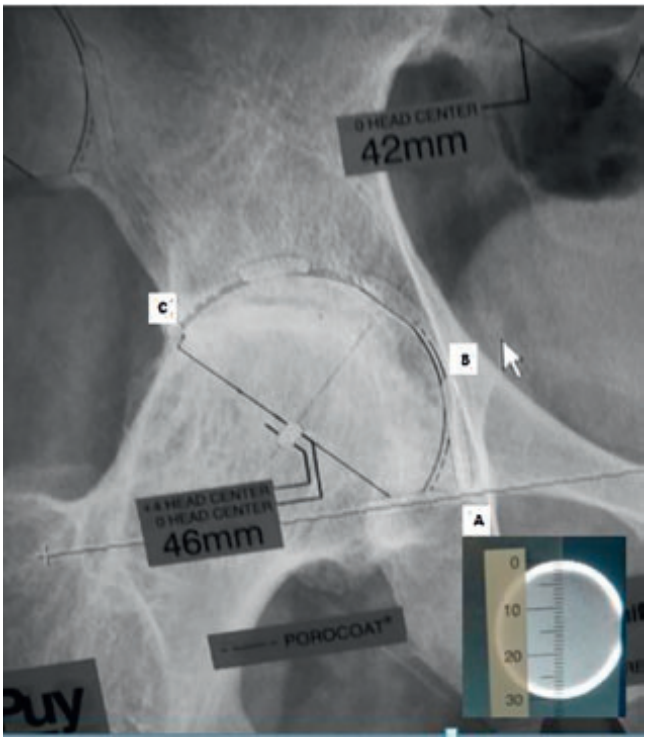

Fig. 2. Method of acetabular cup templating.
A – Base of the teardrop; B – Ilio-ischial line; C – Superolateral margin of the

2.1. Acetabular templating

Three radiographic landmarks were marked on the acetabulum (Fig. 2). They were – the base of the teardrop (A); ilio-ischial line (B); and the superolateral margin of the acetabulum (C). The teardrops (A) on either side were connected by a reference line. The acetabular cup template was then superimposed on the radiograph at 40–45° inclination, with the inferior margin of the template leveled at the inter-teardrop line. The template was then moved medially, to abut the ilio-ischial line (B) – the medial limit of cup positioning. The superior margin of the template was leveled against the superolateral margin of the acetabulum (C). The size of the cup that provided the most congruent fit was directly read using the template (Fig. 2).[4]

The centre of rotation (COR) of the templated acetabular component was then marked with a small circle, drawn using the circle annotation tool on the PACS system.

Femoral templating was then done using the following steps.

1 The anatomic axis of the femur was identified, and marked by drawing a line on the on the AP radiograph, through the entry point of the canal pathfinder (at the pyriformis fossa) and the midpoint of the femoral shaft near the isthmus.
2 The COR of the femur on the radiograph was then identified. In cases where there was no limb length discrepancy, this corresponded to a point just at or medial to the acetabular COR.
3 The femoral template was then superimposed over the femur on the radiograph, such that the vertical axis on the template was superimposed on the axis marked on the x-ray.
4 The template was then lowered down along the shaft of the femur, proximal to distal, till the neck axis of the template was superimposed on the COR of the femur on the radiograph (Fig. 3).

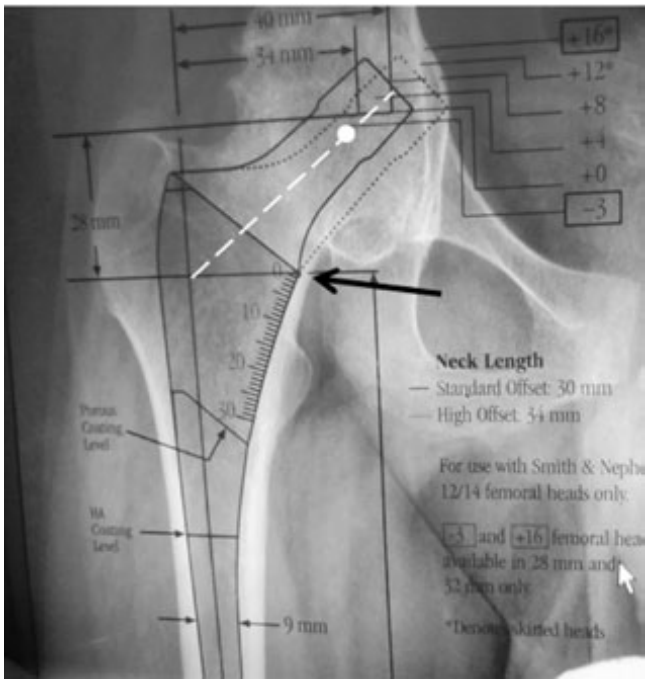

Fig. 3. Method of femoral stem templating.
Templating suggests that a 8 size stem with standard offset and "0" neck is required, if the neck cut is made 1 cm from the lesser trochanter.

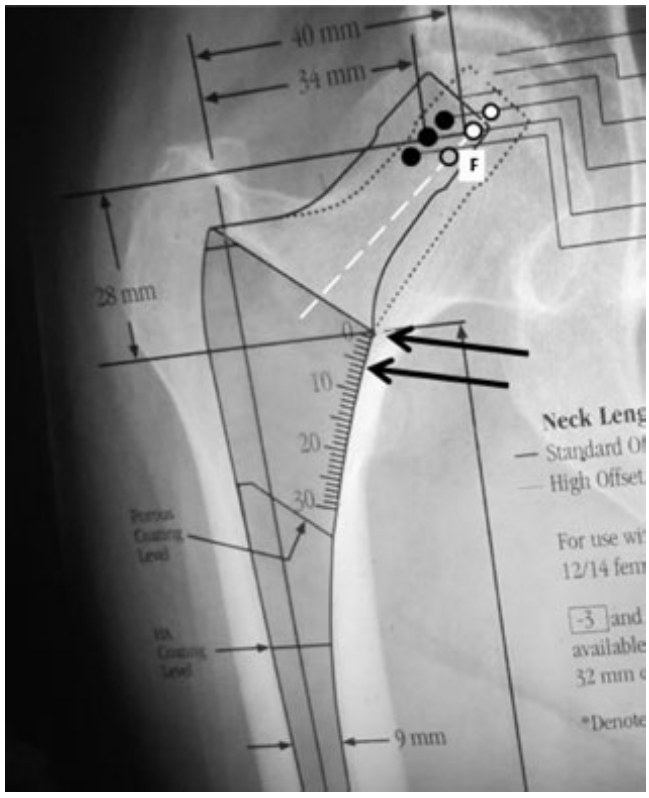

Fig. 4. Templating with high offset templates.
F – Centre of rotation (COR) of the femur (coincides with the COR of acetabulum in this example, as there is no limb length discrepancy).
White dots – CORs along the high offset neck axis.
Black dots – CORs along the standard offset neck axis.
Templating suggests that a stem with a high offset and "-3" neck is required, if the neck cut is made 6 mm above the lesser trochanter.

It should be noted that the template has outlines for the standard offset and high offset femoral stems. The vertical offset or the neck length of the high offset stem is the same as that of the standard offset stem – but the neck axis is positioned more medially (Fig. 4). The neck axes of both stems have several CORs marked along their axis, which represent various neck lengths. It is possible to adjust the position of the template to vary the choice of the femoral offset and neck size, so as to get the COR of the required stem to coincide with the COR of the femur on the X-ray.

5 The anatomic fit of the stem was noted, and if the fit was not satisfactory, the size of the stem was changed, and the steps repeated to get good cortical contact with the femoral shaft on the X-ray. Once a good fit of the stem was obtained, the size of the implant to be used was noted.
6 The neck length was noted, as was the offset of the stem (Figs. 3 and 4).
7 Using the scale on the acetate template, the distance from the upper border of the lesser trochanter to the level of the neck cut was noted. Using this method, it was possible to predict the size of the femoral implant, the offset and the neck length to be used, provided the surgeon intra-operatively made the neck cut at the level that was predetermined by the template (Fig. 4).

Using the techniques described above, all radiographs were independently studied by two observers on two occasions separated by a period of four weeks. All digital films were templated at least 1 month after the index surgery. The investigators were blinded to the actual size of the acetabular prosthetic cup and the femoral stem used. The reliability was assessed using Intraclass Correlation Coefficient (ICC). An ICC value above 0.8 was considered good. To determine the accuracy of this method of templating, the size of the templated acetabular cup and the femoral stem were compared to the actual size of the implants that were used during surgery. The accuracy was tested for the templating done by the Orthopaedic resident (Investigator 2) and Arthroplasty fellow (Investigator 1). It was also compared with the accuracy of templating performed by the main surgeon (Investigator 3). All statistical analyses were performed using SPSS for Windows version 12.

3. Results

The hybrid technique of templating described in this study was found to be extremely reliable and reasonably accurate.

On templating the acetabulum, there was excellent intraobserver reproducibility with an ICC value of 0.96 and interobserver reproducibility (ICC value of 0.93). The technique for templating the femur was also very reliable, with excellent intraobserver reproducibility (ICC = 0.93) and interobserver reproducibility (ICC = 0.88).

The acetabular cup size was accurately predicted using this technique in 70% (38/54) of the cases by the arthroplasty fellow (Investigator 1) [Table 1]. The acetabular cup size was accurately predicted by the Orthopaedic resident (PR) in 43% (23/54) of the hips. When accuracy to within one size of the implanted cup size was considered, templating was accurate in 96% (52/54) of the cases for the arthroplasty fellow and in 93% (50/54) of the cases for the resident. The accuracy was better when templated by the main surgeon, with the cup size being accurately predicted in 78% (42/54), and within one cup size in 98% (53/54) [Table 1].

In the case of femur, the arthroplasty fellow accurately predicted the size of the femoral stem in 44% (24/54) of the cases [Table 1]. When accuracy to within one size above or below the implanted stem size was considered, templating was accurate in 82% (44/54) of the cases. The femoral stem size was accurately

Table 1
Accuracy of femoral and acetabular templating with acetate templates on digital Xrays.

Accuracy	Investigator		
	Investigator 1 (Fellow)	Investigator 2 (Resident)	Investigator 3 (Surgeon)
Acetabular Templating			
Predicted Same Size in (%)	70% (38/54)	43% (23/54)	78% (42/54)
Predicted to within 1 Size in (%)	96% (52/54)	93% (50/54)	98% (53/54)
Predicted to within 2 size in (%)	100% (54/54)	98% (53/54)	100% (54/54)
Femoral Templating			
Predicted Same Size in (%)	44% (24/54)	37% (20/54)	56% (30/54)
Predicted to within 1 Size in (%)	82% (44/54)	69% (37/54)	83% (45/54)
Predicted to within 2 sizes in (%)	93% (50/54)	91% (49/54)	94% (51/54)

predicted by the resident in 37% (20/54) of the hips. When accuracy to within one size was considered, it was found to be accurate in 69% (37/54) of the hips. When accuracy to within two sizes was considered, templating was accurate in 91% (49/54) of the hips. Femoral size was more accurately predicted when templated by the main surgeon – 57% (30/54) same size femur, and 86% (45/54) within one size [Table 1].

4. Discussion

Preoperative planning and templating are integral in achieving a successful outcome in Total Hip Replacement. Inaccurate templating can result in complications like femoral fractures, limb length inequality, insufficient offset, instability and failure to achieve bone ingrowth.[1] Templating using conventional hardcopy radiographs and acetate onlay templates have proven to be an accurate and effective method in predicting prostheses sizes.[4–6] Various implant companies provide onlay acetate templates at magnifications varying from 110 to 120% for this purpose.

Conventional radiographs are being replaced by digital radiographs in many hospitals. The accuracy of digital templating in predicting the size of the implant has been assessed and found to be good.[7–12] However, as digital templating requires expensive software[2] and the use of the software requires special training,[3] many centres have stopped templating prior to surgery. Lakshmana et al.[13] found that though digital templating was available in 50% of the NHS hospitals, none used them for preoperative templating, as most were unaware of how to use the system. 43% claimed that they had stopped templating, as all radiographs in their hospitals were available only on the Picture Archiving and Communication Systems (PACS) system and hard copies could not be obtained. This highlights the fact that there was a need to develop an alternate, but accessible method of templating – one that combines the use of digital radiographic images and standard acetate templates.

Several authors have assessed the efficacy and accuracy of the different methods of templating [Tables 2 and 3]. Both digital and acetate templating have been able to predict the size of the implant reasonably well. Templating for the acetabulum is more accurate than for the femur- irrespective of the method used to predict the size of the implant.

Gamble et al.[8] in their study comparing digital templating to standard onlay templating showed that the acetabulum was accurately predicted using computer templating in 38% (15/40) of the cases and in 20% (8/40) of the cases using the standard onlay technique. When the accuracy to within 1 size was considered, computer templating was correct in 80% (32/40) of the cases, as compared to 60% (24/40) of the cases using the standard onlay technique.[8] The femoral component was accurately predicted using computer templating in 35% (14/40) of the cases, as compared to accurate prediction in 40% (16/40) of the cases using the standard onlay technique. When considering the accuracy within 1 size, both the computer templating and standard onlay techniques were correct in 85% (34/40) of the cases, respectively.[8]

In a similar study done by Petretta et al.[2] using the hybrid technique of templating with a 25 mm marker disc, the acetabular implant size was predicted exactly in 28% of cases and within one size of the final implant size in 77% of cases. The femoral component size was accurately predicted in 33% of cases and within one size in 75% of cases in their study. The hybrid technique of templating was found to be more accurate than digital templating. Using digital templating, the acetabular size could be predicted to within one size in 70% of the cups, and in 60% of the femoral stems. This study seemed to suggest that the hybrid technique is more accurate and should substitute digital templating. They stated that it is quicker to perform and much less expensive. They rightly concluded that hospitals and practices need not purchase expensive software, particularly at lower volume centers.

An earlier study[3] had looked at the accuracy of preoperative templating of digital radiograph films using standard onlay templates. The Xray was taken in a manner similar to this study, with a 30 mm ball strapped onto the greater trochanter. The digital radiograph could be viewed on the computer or as a hard copy film on the Xray view box. Using the acetate templates, the size of the metal ball (X mm) and the matching acetabular cup (Y mm) were determined on the film, without any adjustments in magnification. The actual size of the acetabular cup to be implanted was estimated using the formula 30*Y/X. The study had showed good validity and reliability of this method of hybrid templating. However, this method was originally described for situations where PACS or similar magnification software are not available. It involved mathematical calculations and hence the increased the chances of associated errors. The present study, wherein the metal ball is digitally magnified to 30 mm as measured by the magnification scale of the acetate template, has the advantage

Table 2
Comparison with other templating studies – acetabular cup.

Methods of Templating	Author	Accuracy- same size as acetabular cup(%)	Accuracy within +/− 1 size (2 mm)%
Conventional	Della Vella (2005)	83%	99%
	Unanuntana (2001)	42%	90%
	Whiddon (2011)	31%	67%
Digital	Shaarani (2013)	38%	80%
	Gamble (2010)	38%	80%
	Whiddon (2011)	39%	78%
Hybrid Templating	This study	78%	98%

Table 3
Comparison with other templating studies – femoral implant.

Methods of Templating	Author	Accuracy- same size as Femoral stem(%)	Accuracy within +/− 1 size (%)
Conventional	Unanuntana (2001)	69%	98%
	Gamble (2010)	40%	85%
	Whiddon (2011)	33%	82%
Digital	Shaarani (2013)	36%	75%
	Gamble (2010)	35%	85%
	Whiddon (2011)	61%	90%
Hybrid Templating	This study	56%	83%

that the size of the matching acetabular cup and the femoral stem can be directly read off using the templates. It also does not involve calculations and has made preoperative templating easier and less time-consuming.

The present study showed that the acetabular cup size was accurately predicted in 70% (38/54) of the cases using the hybrid technique. When accuracy to within one size (2 mm) above or below the implanted cup size was considered, templating was accurate in 96% (52/54) of the cases. Like in all other studies, the accuracy was slightly less for the femur – with the size being accurately predicted in only 44%, and 82% within one size. This could probably be because a large number of the stems used were Corrail- a hydroxyapatite press fit stem, which is based on the impaction model.

Experience of the person performing the templating seemed to have a role in the accuracy of templating. The main surgeon was able to predict the implant size more accurately than the Orthopaedic resident or the Arthroplasty fellow. This finding could partly be explained by the fact that the surgeon had implanted the final acetabular cup based on his preoperative templating. However, both the Orthopaedic resident and the arthroplasty fellow had several training sessions in templating with the surgeon. This fact could also potentially have affected the observed outcome.

This hybrid technique described with the metal marker is reasonably accurate and reproducible. Surgeons who are unable to access special software for digital templating can use the standard acetate templates provided by the companies with this technique. The digital radiographs can be read off the flat screen computer monitors or laptops, or can be read off a digitally magnified x-ray film. The 3 cm metal marker can be procured at most hardware shops and provided to the radiology department, with appropriate instructions on its placement. The marker is to be placed at the level of the greater trochanter and not on the table/radiograph plate. Other authors have kept the ball marker in the groin – just below the pubic symphysis. It is also essential that the marker is a metal ball of uniform diameter. The use of a coin or scale is not acceptable, as the size and width of the image could change, based on the tilt of the coin. The scatter of X-rays would be uniform of a metal ball is used, and hence the size and width would be constant.

One of the limitations of the study is that it does not assess how preoperative templating helped in per-operative limb length and offset adjustments. The study also does not address the use of templating in determining the neck length of the femoral head and level of neck cut.

5. Conclusion

Using the hybrid technique of templating described, the exact size of the acetabular component can be accurately predicted in 70% of the cases and to 96% if prostheses within 1 size (2 mm above or below the implanted cup size) are included. The size of the femoral stem can be accurately predicted in 40–45% of the cases; the accuracy rising to greater than 82% if prostheses within 1 size (above or below) are included. This method is valid and reliable and offers a less expensive alternative to digital templating and also obviates the need for printing digital radiographs for the purpose of templating.

Contributors' form

We certify that we have participated sufficiently in the intellectual content, conception and design of this work or the analysis and interpretation of the data, as well as the writing of the manuscript, to take public responsibility for it and have agreed to have our name listed as a contributor. We believe the manuscript represents valid work. We attest that, if requested by the editors, we will provide the data/information or will cooperate fully in obtaining and providing the data/information on which the manuscript is based, for examination by the editors or their assignees. Financial interests, direct or indirect, that exist or may be perceived to exist for individual contributors in connection with the content of this paper have been disclosed in the cover letter. Sources of outside support of the project are named in the cover letter.

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Research paper

Cemented Vs Uncemented modular Bipolar hemiarthroplasty treatment for femoral neck fracture in elderly patients☆,☆☆

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ABSTRACT

Objectives: Femoral neck fractures in the elderly are associated with high morbidity and mortality. The optimal treatment remains controversial regarding the use of cement in hemiarthroplasty when treating a displaced femoral neck fracture in elderly patients. The primary hypothesis of this study was that the use of cement would afford better visual analog pain and activity scores in elderly patients.
Methods: This study included 84 patients over 64 years of age with fracture neck femur treated with cemented and uncemented Modular Bipolar hemiarthroplasty. The patients (49 female, 35 male; mean age: 79.5 years; range: 64–95 years) included and were followed-up regularly till 02 years. Patients were divided equally into two groups: group A(n = 42) was treated with cement; and group B(n = 42) without cement. Both groups were compared in terms of preoperative features (demographics and associated diseases), pre- and postoperative complications, mortality rates, pain and activity levels, and hip scores.
Results: We found no statically significant between-groups differences in terms of length of hospital stay, Harris Hip Score and complications. However in Uncemented group 03 patients developed loosening of implant at the end of 2 year without any clinical of biochemical sign of infection. Walking ability and pain scores were better in the cemented group in the early follow-up period.
Conclusion: Based on our study we reached the conclusion that the use of cement during hip hemiarthroplasty in patients over 64 years of age who invariably has osteoporotic bone and wide femoral canal had no negative impact on mortality or morbidity. Hemodynamic changes during cement application are important, but it is noteworthy that patients fitted with cemented endoprostheses had increased levels of activity and lower pain levels.

1. Introduction

Femoral neck fractures in the elderly is associated with high morbidity and mortality. The optimal treatment remains controversial. The fractures can be caused by low-energy trauma. Hemiarthroplasty using modular head partial prostheses is a common surgical procedure used to treat elderly patients with femoral neck fractures. These prostheses can be inserted with or without bone cement.[1]

Hemiarthroplasty[2] in fracture neck femur in elderly contributes to early ambulation and good functional recovery. However, controversy persists as to whether cemented or uncemented hemiarthroplasty is preferable for elderly patients. While femoral neck fractures treated via cemented hemiarthroplasty may be less prone to periprosthetic fracture and prosthetic loosening, they are also more likely to trigger embolisms and decreased cardiac output during insertion of the bone cement.[1] Conversely, although uncemented hemiarthroplasties are associated with higher rates of postoperative aseptic prosthesis loosening, they require shorter operation times and are associated with less intraoperative blood loss. Treatment of a displaced femoral neck fracture is currently determined by the mobility and functional demands of the patient. Cementing the prosthesis affords more secure fixation and may

☆ The study was conducted at Department of Orthopaedics, Indian Naval Hospital Ship Asvini, Colaba, Mumbai, 400005, India, between Jan 2013 to July 2015.
☆☆A total of 84 fracture neck femur patients were treated with a cemented and uncemented hemiarthroplasty from Jan 2013 to July 2015.
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result in less postoperative mid thigh pain and a reduced long-term revision rate.[3]

In the literature the optimal treatment choice has been debated, and whether cemented is better than uncemented hemiarthroplasty remains uncertain. Many studies have suggested that cemented hemiarthroplasty reduces the risk of residual pain and affords better functional results.[4]

In a few studies uncemented implants yield the same clinical results as cemented implants when used to treat displaced femoral neck fractures.[5] Nonetheless, the postoperative rate of prosthesis loosening is higher after uncemented hemiarthroplasty.

The purpose of our study was to compare the results of hemiarthroplasty using a cemented or press-fit uncemented implant, focusing on the following three research aims: (a) Are any differences in intraoperative events? (b) Are there any differences in functional outcomes and quality of life at 1 and 2 year?, and (c) Are the rates of postoperative complications similar between the two groups?

2. Material and methods

The study was conducted at Department of Orthopaedics, Indian Naval Hospital Ship Asvini, Colaba, Mumbai, 400005, India, between Jan 2013 to July 2015.

A total of 84 fracture neck femur patients were treated with a cemented and uncemented hemiarthroplasty from Jan 2013 to July 2015. The patients (49 female, 35 male; mean age: 79.5 years; range: 64–95 years) were followed-up regularly. During the study period, no institutional guidelines on the choice of cemented or uncemented stems were in place. Patients were divided into one of two groups: group A was treated with cement; and group B without cement. Both groups were compared in terms of preoperative features (demographics and associated diseases), pre- and postoperative complications, mortality rates, pain and activity levels, and hip scores. Hospitalization time, average surgical duration, and time from fracture to operation were also recorded. Mean follow-up duration was 18.07 (range: 6–30) months. We recorded demographic variables, dates of admission and surgery, types of fracture, associated medical comorbidities, history of medications used, type of implant used, type of anesthesia given, hemodynamic status immediately before and after cement application and in recovery, and time and cause of death. Patient age, sex, associated comorbidities, and prefracture ambulatory status were recorded. Ambulatory status was classified using the Barthel Index of Activities of Daily Living and the Harris Hip Score. Postoperative pain was assessed using the visual analog scale with responses ranging from 0 to 10. Postoperative complications were also recorded.

Every patients were subjected to preanaesthesia check up prior to surgery. The surgeon performed cemented and uncemented modular Bipolar hemireplacement arthroplasty surgery using the same standard surgical technique, (posterior approach) patients were placed in the lateral decubitus position and longitudinal skin incisions centered over the greater trochanter were made in the lateral position. After removing the femoral head, the hip was gently flexed, adducted, and internally rotated. The femoral canal was prepared by sequential reaming with reamers of increasing diameter. After cortical reaming was attained, broaches were precisely placed and the fit of each broach within the canal was assessed. The trial femoral stem was inserted and evaluated in terms of the responses to rotational and extraction forces. After inserting the predetermined (carefully dimensioned) femoral modular bipolar head, the hip was reduced and the stability of the hip joint was tested. Finally cementing was done and Modular Bipolar prosthesis was inserted as per stem and cup size. Closed suction drain was placed in all patients. Similarly uncemented modular Bipolar hemiarthroplasty was done using above mentioned technique. All patients were given intravenous Teicoplanin just before surgery and continued till 04th post operative days until contraindicated, and Tab Rivaroxaban 10 mg for DVT prophylaxis for 03-04 weeks even after patients started ambulation.

3. Results

The cemented and cementless groups did not differ significantly in terms of age, sex, number of major comorbidities, or prefracture ambulatory status (Tables 1 and 2). The average age of patients was 79 years (49 female, 35 male; mean age: 79.5 years; range: 64–95 years). The median time between injury and surgical treatment was 04 days. At the end of 02 year follow-up evaluation, 03 patients had died (01 of Uncemented and 02 of cemented). The mortality rate during the first year after surgery was nil and it was 03% at the end of 02 year.

In our series the follow-up periods of the cemented and uncemented groups did not differ significantly. The mean Harris Hip Score of the group with cemented modular bipolar prostheses was $81.50 \pm 9.47(83.0)$, and that of the group with cementless partial prostheses was $75.87 \pm 8.37(81.0)$ points (no significant difference; $P = 0.276$). The Barthel activity and pain scores were better in the cemented group ($P = 0.728$). Thus, patients in both groups attained similarly good functional results. Of all patients, 38% (n = 32) required intensive care, 03% (n = 03) developed post operative infection. (Table 3). Two (n = 02, 04%) developed posterior dislocation which was reduced under anaethesia however none has developed DVT in either group.

4. Statistical analysis used in study

In our study statistical analysis was performed using the NCSS 2007 (NCSS, LLC, Kaysville, UT, USA) statistical software. Normality of the distribution of all parameters was tested using the Kolmogorov–Smirnov test. Parametric tests were used to explore

Table 1
Demographic details –Group A(n = 42) Cemented modular Bipolar hemiarthroplasty.

Age group	No of patients (n = 42)	Time of surgery since injury (days)	Barthel score (Range 0–100) Mean ± SD	Harris Hip Score (Range 40–80) Mean ± SD
65–75	21	05–07 days	59.70 ± 39.15	79.50 ± 8.58
76–85	13	03–06 days	53.80 ± 23.12	81.50 ± 9.47
>85	08	04–06 days	51.90 ± 32.19	72.50 ± 7.64
			$P = 0.718$	$P = 0.236$

Table 2
Demographic details –Group B(n = 42) Uncemented modular Bipolar hemiarthroplasty.

Age group	No of patients (n = 42)	Time of surgery since injury (days)	Barthel score (Range 0–100) Mean ± SD	Harris Hip Score (Range 40–80) Mean ± SD
65–75	25	02–06 days	49.54 ± 28.18	81.51 ± 9.42
76–85	10	02–04 days	47.65 ± 35.11	75.87 ± 8.37
>85	07	01–03 days	45.23 ± 45.22	69.48 ± 8.63
			P = 0.728	*P* = 0.276

Table 3
Demographic details –Both Group A & B (n = 84) and according to treatment given.

Characteristics	Uncemented (n = 42) Mean ± SD (median)	Cemented (n = 42) Mean ± SD (median)	*P value*
Age (years)	79.5 ± 4.04	79.5 ± 5.04	0.645[a]
Operation day	04	04	
Harris Hip Score (n = 84)	75.87 ± 8.37(81.0)	81.50 ± 9.47(83.0)	0.276[b]
Barthel score(n = 84)	47.65 ± 35.11(48.0)	49.54 ± 28.18(51.0)	0.728[b]
VAS score	3.14 ± 1.78 (3.00)	2.86 ± 1.4 (3.00)	0.256[b]
Mortality time (years) n = 03	0.63 ± 0.84 (0.25) n = 01	0.41 ± 0.56 (0.17) n = 02	0.912[b]
Sex	n (%)	n (%)	0.543[c]
Male 35(41.6%)	19(45%)	16(38.1%)	
Female 49(58.3%)	23(54%)	26(61.9%)	
Associated co-morbidity			0.987[d]
DM	21(50%)	19(45%)	
IHD	03(07%)	04(9%)	
CKD	06(14%)	02(4%)	
HT	12(28.5%)	17(40%)	
ICU care			0.923[d]
Needed (n = 32)38%	11(26.2%)	19(45.2%)	
Does not needed (52)	31(73.8)	23(54.7%)	
Infection			0.772[d]
Present (n = 03)03%	02(4%)	01(2%)	
Absent(n = 81)	40 (96%)	41(98%)	
Implant loosening present (n = 01)	01	–	
Absent(n = 83)	41	–	
Periprosthetic fracture	nil	nil	
Dislocation occurred(n = 02) 04%	02(4%)	01(2%)	0.756[d]
Nil (n = 82)	40(96%)	41(98%)	
Perioperative complications (Hypotension, Tachycardia, blood loss,)	03(7%)	07(16.6%)	0.05
Mortality at end of 02 year			
Died(n = 06)	02(4%)	04(9%)	
Alive(n = 78)			

Note: [a]Student's t-test; [b]Mann–Whitney U-test; [c]Pearson's chi-squared; [d]Yates continuity correction.
Abbreviations: n: sample number; SD: standard deviation; VAS: visual analog scale, DM: diabetes mellitus, IHD: ischemic heart disease, CKD: Ch kidney disease, HT: hypertension.

differences between variables that were normally distributed, and nonparametric tests were used to explore those that were not normally distributed. Normally distributed variables were expressed as means ± standard deviations. Student's *t*-test was used to compare normally distributed data and the Mann–Whitney *U*-test was used otherwise. The Yates continuity correction test was applied, and Pearson's correlation coefficients were calculated to examine the extent of the associations between variables. Statistical significance was defined as $P < 0.05$ and $P < 0.001$.

5. Discussion

Fractures of the proximal femur are common in the elderly. Osteoporosis, comorbidities, and increased levels of minor trauma increase the incidence and complicate the treatment of such fractures. Although cemented hemiarthroplasty has been used to treat most of these cases worldwide, however uncemented prostheses are gaining popularity. Foss and Kehlet[6] in his study concluded that randomized studies afforded only limited evidence that cementing the prosthesis may reduce the amount of postoperative pain and possibly improve mobility. Although serious cement-related complications have been reported in the literature, we however hypothesized that, relative to cemented hemiarthroplasty, uncemented bipolar hemiarthroplasty would yield similar technical and functional outcomes and complication rates, but it would be associated with shorter operation times.

In the literature there are early-stage of success associated with the use of cemented bipolar hip replacements; complications are relatively few and mortality rates are low.[7] Periprosthetic femoral fractures have been reported with uncemented hemiarthroplasty. Elderly patients and especially who have severe osteoporosis with widening of femoral canal benefit from bone cement this reinforces the osteoporotic proximal femur.[8]

Elmaraghy et al.[9] suggested that cemented hemiarthroplasty had no effect on the development of fat emboli. However in another study, Donaldson et al.[10] suggested that morbidity and mortality rates might be minimized by preferring cementless arthroplasty in high-risk patients. The reported risk of cement-related death is low but not negligible.[11] Although some uncemented hemiarthroplasties have given as good result as cemented counterparts. The risk of periprosthetic fractures may also differ between cemented femoral stems differing in design.

In elderly patients ($>$64 years or older) without severe cardiopulmonary compromise who were treated with hemi-arthroplasty for a displaced femoral neck fracture, use of a cemented bipolar implant and use of an uncemented implant provided a comparable outcome with regard to clinical outcome and pain. However, implant-related complication rates were significantly lower in the Based on this theory, cementing the prosthesis could lead to higher mortality.

However, the pooled results of our meta-analysis showed that perioperative mortality during surgery, and while cementing and during insertion of femoral stem of a cemented prosthesis was 03 (7%) and it was 03(7%) for an uncemented prosthesis; ($p = 0.05$) these prostheses were associated with 2-year mortalities of 04(9%) and 02(4%), respectively. Although not significant, the mortality rate was slightly higher in the cemented group.

6. Conclusion

The aim of our study was to explore whether the uncemented modular bipolar hemiarthroplasty in fracture neck femur would perform similarly to a cemented stem. We examined differences in Harris Hip and Barthel pain scores, femoral fractures, overall health outcomes, complications, rate of reoperation, and mortality rates.

Base on our study we can conclude that he use of cement during hip hemiarthroplasty in patients over 64 years of age who invariably has osteoporotic bone and wide femoral canal had no negative impact on mortality or morbidity. Hemodynamic changes during cement application are important, but it is noteworthy that patients fitted with cemented endoprostheses had increased or decrease levels of activity and post operative complications. Therefore we could not find any statically significant deference between two groups.

Conflict of interest

None.

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Research paper

Tibial avulsion fractures of pcl—A comparison of outcomes between isolated, associated and missed injuries

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ABSTRACT

Objective: Avulsion fracture of Posterior Cruciate Ligament from its tibial insertion is not a common injury and is missed most often, particularly when associated with multiple injuries or fractures around the knee and hip. While arthroscopic fixation has a steep learning curve, open reduction and fixation remains the gold standard treatment. Paucity of literature on missed and associated PCL injuries motivated us to do this study.

This study aims to compare the clinical outcomes of three groups of displaced PCL avulsion fractures viz. isolated, associated and missed injuries, treated with open reduction and internal fixation.

Materials and Methods: We prospectively analyzed 52 cases of displaced PCL avulsion fracture from tibial insertion managed at our tertiary care center from 2009 to 2015. Open reduction was done through our own modification of the Burks and Schaffer approach and fixation done using 4 mm or 6.5 mm partially threaded cannulated cancellous screws with washer. Missed injuries that are more than 6 weeks old were excluded. The clinical outcome was assessed using the Lysholm knee scoring scale and objective tests like looking for tibial sag and posterior drawer, at 12 months following fixation.

Results: Statistical analyses revealed predominantly excellent outcome in isolated injuries, good in associated injuries and fair to poor outcome in missed injuries. The incidence of post-operative laxity was significantly higher in case of comminuted fractures. But there was no statistically significant difference between the Lysholm scores of cases with grade I laxity and those without laxity.

Conclusion: The Burks and Schaffer approach is technically simple and safe; our modification enables better reduction and easy fixation. Functional outcome of the knee is best in isolated injuries; good in associated injuries despite the presence of other fractures; fair in treated missed injuries and definitely poor in untreated cases. Identifying the tell-tale signs will help us avoid missed injuries.

1. Introduction

Avulsion fracture of PCL from its tibial insertion is not a common injury and is missed often, particularly when associated with multiple injuries or fractures around the knee and hip. Recent awareness regarding the anatomy of PCL and its role in maintaining normal knee kinematics has resulted in an increased interest in the identification and management of PCL injuries.

Surgical fixation can be achieved either by open or arthroscopic technique but ORIF is the gold standard [1,2,3]. There are several studies on surgical fixation of isolated PCL avulsion fractures. But there is insufficient data on the outcome of fixation of missed PCL avulsion fractures and those associated with other fractures. In this series we present our experience with ORIF of PCL injuries that are isolated, associated with other fractures and missed during initial presentation.

2. Purpose of the study

To compare the clinical outcomes between three groups of displaced PCL avulsion fractures (isolated, associated and missed) treated with open reduction (our modification of Burks and Schaffer's approach) and fixation (using cancellous screws).

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3. Materials and methods

In this series we prospectively analyzed 52 cases of avulsion fracture of tibial insertion of PCL treated in our hospital from 2009 to 2015. Male: female ratio was 25:1. 34 (65%) cases had injury on the right side and 18 (35%) on the left side. A motor vehicle accident was the cause of injury in 41 cases (79%) and falls on a flexed knee in 6 cases (12%). Of the 52 cases, 11 cases (21%) were isolated injuries and the rest (79%) were associated with other injuries in the same limb.

9 (17%) cases with associated injuries were missed on initial presentation and identified during follow up within first 6 weeks were fixed (The average time delay for fixation 32 days with the maximum being 42 days) and those detected later were subjected to ligament reconstruction. The average time delay for fixation in the 43 cases (83%) diagnosed at initial presentation was 5 days with the maximum being 12 days.

ATLS protocol for clinical examination, digital radiography of the knee joint with antero-posterior and lateral views, Computed tomogram & magnetic resonance imaging were done for all patients to study the fracture pattern and assess the status of ligaments and menisci. All patients with PCL avulsion fracture were evaluated for neurovascular injuries clinically and if in doubt using CT-angiogram.

All avulsion fractures were treated with ORIF using our modification of Burks and Schaffer's approach and fixation using 4 mm or 6.5 mm partially threaded cannulated cancellous screws with washer. The clinical outcome was measured using the Tegner modified Lysholm knee scoring scale and objective tests like tibial sag sign and posterior drawer test at 3, 6 and 12 months following fixation.

3.1. Inclusion criteria

Displaced avulsion fracture of the tibial insertion of PCL.

3.2. Exclusion criteria

- Poly trauma with life threatening injuries, Grade III open injuries or with associated neurovascular injury.
- PCL avulsion from femoral attachment, or ligamentous injury without bony avulsion.
- PCL avulsion fracture more than 6 weeks old.

3.3. Surgical technique

3.3.1. Our modification of burks and schaffer approach (Fig. 1)

Surgical fixation was done under regional anesthesia with the patient in prone position, surgeon operating from opposite side for better vision with image intensifier from the surgeon's side. The average operating time was 40 minutes.

Tourniquet was used in all patients except in patients with femur fracture or if any contraindications.

A bolster was placed below the distal thigh to reduce the tibial sag and enable fracture reduction.

An inverted L shaped incision is made with the horizontal limb 1 cm above the popliteal crease (our modification) and vertical limb along with medial border of gastrocnemius. Skin, superficial and deep fascia are elevated altogether to avoid skin necrosis.

Semitendinosus is identified and retracted medially and the medial head of gastrocnemius along with the neurovascular bundle is retracted laterally, exposing the posterior capsule.

Posterior capsule is torn in most of the cases; capsulotomy is done if there is no rent to identify the avulsed PCL fragment and the crater.

The crater is cleared from soft tissue and deepened. Then the fracture is reduced and over compressed to restore tension of the ligament.

A single large fragment was fixed using two 4 mm partially threaded cannulated cancellous screws with washer. However a single small fragment or an avulsion fracture with multiple small fragments was fixed using a 6.5 mm cancellous screw with large washer over the intact soft tissue sleeve which provided a buttressing effect on the fragments (Figs. 2–5).

In case of associated injuries primary fractures like shaft of femur, patella or proximal tibia were addressed first and the PCL fracture was addressed either at same stage or after 5–7 days

Fig. 1. Patient positioning, bolster, Skin incision, deep dissection.

Fig. 2. Case 1- PCL avulsion associted with comminuted patella fracture and lateral femoral condyle avulsion managed by patellectomy, femoral condyle and PCL fixation.

Fig. 3. Case 2- PCL avulsion associted with knee dislocation managed by patellar tendon repair, MCL and PCL avulsion fixation.

depending on patient's general condition. Case examples of the associated injuries have been explained in Figs. 2–4. In case of missed injuries only those diagnosed within 6 weeks were fixed. A case example of missed injury has been explained in Fig. 5, diagnosed within 6 weeks of injury and addressed.

3.3.2. Post OP Protocol

- 0–3 weeks: Immobilization in a Long knee brace, Toe-touch weight bearing.
- 3–6 weeks: Intermittent protected ROM upto 90^0 flexion, Partial weight bearing.
- After 6 weeks: ROM brace promote full ROM, Full weight bearing walking.

In cases with associated injuries, Weight bearing was delayed according to the healing rate of associated fractures.

The fractures healed both clinically and radiologically by 12–14 weeks in all the 52 cases. Clinical outcome was measured using the Tegner modified Lysholm knee scoring scale [7] (score of $>$90 is excellent; 84-90 as good; 65-83 as fair and $<$65 as poor outcome). The objective tests like tibial sag sign and posterior drawer test were done at 3, 6 and 12 months follow-up.

3.4. Statistical methods

- The Lysholm score was compared between the following groups.
  - Isolated PCL avulsion injuries vs those with associated injuries and missed injuries.
  - Cases with associated injuries that were fixed within 2 weeks vs missed PCL injuries (fixed between 2 to 6 weeks).
  - Simple PCL avulsion fractures vs comminuted avulsion fractures.
  - Cases with post-operative laxity vs those without laxity.
- Dichotomous variables were analyzed using a chi-squared test.
- The paired *T*-test was used to assess the difference in incidence of post-operative laxity between different groups.A p-value < 0.05 was considered statistically significant.

4. Results

- The average Lysholm score for all the 52 cases was 83. 23% cases had excellent, 44% had good, 27% fair and 6% had poor outcomes. The Lysholm score was significantly higher in cases with isolated injuries as compared to other groups. There was no significant difference in the Lysholm scores between cases with post-

Fig. 4. Case 3- PCL avulsion associted with proximal tibia fracture managed by single stage fixation.

Fig. 5. Case 4- Missed PCL avulsion in a case of fracture both bones leg fixed at 32 days along with ACL reconstruction.

operative laxity and those without laxity. The results of statistical analysis are as shown in (Table 1 and 2).

- 27 (52%) cases had Grade-I posterior laxity even after healing of the fracture. There was a significantly higher incidence of post-operative laxity among the cases with a comminuted fracture pattern. Comparison of the incidence of laxity in different groups is as shown in (Table 3).
- From the above analyses we understand that
  - The knee function following fixation of PCL avulsion fractures is significantly better in cases with isolated injuries, simple fracture patterns and fixation done within the first 2 weeks **(missed PCL injuries have poor functional outcome)**.
  - The incidence of laxity is significantly higher in case of comminuted fractures (Fracture pattern is the important determinant of post-operative laxity in the knee).
  - There is no statistically significant difference between the Lysholm score of cases with laxity and those without laxity **(The presence of post-operative laxity does not significantly affect the functional outcome of the knee)**.

5. Discussion

PCL is an extra-synovial, intra-capsular ligament and stronger of the two cruciates. Its fibers are arranged in two bundles; anterolateral (stretches in flexion) and posteromedial (stretches in extension). It serves as a primary restraint against posterior tibial displacement and aids in screw home mechanism of knee along with the ACL.[1,9]

PCL avulsion injuries are less common and are often missed during initial presentation. Also they are often managed conservatively due to various reasons like complex anatomy, proximity of neurovascular structures and lack of experience.

A direct blow to the proximal anterior tibia in a flexed knee with forceful posterior displacement of the tibia usually results in a

Table 1
Comparison of Lysholm scores between different groups.

GROUPS COMPARED	LYSHOLM SCORES	P VALUE
ISOLATED VS ASSOCIATED	**94** VS **80**	**0.00001**
EARLY FIXED ASSOCIATED VS MISSED	**83** VS **70**	**0.02**
SIMPLE FRACTURE VS COMMINUTED FRACTURE	**85** VS **80**	**0.035**
POST OP LAXITY VS NO LAXITY	**81** VS **85**	**0.06**

midsubstance tear, often with disruption of the posterior capsule. Dashboard injuries and falls on a hyperflexed knee are mechanism of injury. Because of the high-energy forces associated with motor vehicle accidents, dashboard injuries are usually combined with other ligamentous, osteochondral, or meniscal injuries. Hyperextension injuries typically result in avulsion of the tibial attachment. Associated ACL rupture is common in this mechanism when present, the possibility of a transient knee dislocation should be considered.[12,13,16]

Ecchymosis on posterior aspect of the knee with abrasions on its anterior aspect are tell-tale signs of PCL injuries which should be looked for in all lower limb injuries to avoid missing PCL injuries.[22] Knee effusion is classically seen in ACL injuries but it is slow to develop in PCL injuries as blood seeps into the posterior compartment muscles and produces swelling in the proximal calf region. In our series motor vehicle accident was the cause of injury in 41 cases (79%), fall on a flexed knee in 6 cases (12%) and others in 5 cases (9%).

PCL avulsion fracture from its tibial insertion is an injury which, if diagnosed early and treated with the simple ORIF gives spectacular results.[1,3,8,10] Surgical fixation remains the gold standard for a displaced avulsion fracture (>2 mm). Various approaches and methods of fixation using K-wires, staples, cancellous screw, suture with ethibond, fiberwire or SS wire have been described in the literature.[5,6,17,21] The Burks and Schaffer's approach is safe and simple.[4,20,21]

Mohamed et al. [1] in his surgical technique had placed horizontal limb of the incision 1–2 cm below popliteal crease with good outcome. But we prefer to place it 1 cm above the popliteal crease for better visualization of the fracture and easy screw placement at appropriate angle. It also avoids skin maceration and infection.

Our technique of placing bolster beneath the distal femur, which indirectly corrects the posterior tibial sag has not been described in the literature so far. A single large fragment was fixed using two 4 mm partially threaded cannulated cancellous screws with washer. However an avulsion fracture with a single small fragment or multiple small fragments was fixed using a 6.5 mm cancellous screw with large washer over the intact soft tissue sleeve which provided a buttressing effect on the fragments.[5,6,18] We prefer this technique over using fiberwire, ethibond or stainless steel wires for comminuted fractures.

In the current era of increasing number of high velocity injuries, PCL avulsion fractures are often associated with other complex fractures of femur and tibia. In such situations these injuries are easily missed or neglected.[2,10,11] So a high index of suspicion is very important to identify these injuries. We did not find adequate mention in the literature about the outcome of fixation of missed PCL avulsion fractures and those associated with other fractures in the same limb.

Displaced avulsion fractures when treated conservatively, end up in residual instability and early degenerative arthritis.[9,10,12,19] The phobia of injuring the neurovascular structures in the popliteal fossa often inhibits the surgeon from proceeding with fixation of the avulsion fracture.

Szalay reported anterior cruciate ligament rupture to be the most common associated injury, followed by femoral fractures. Blacksin [14] reported that, on MR imaging of the knee in patients with femoral shaft fractures, PCL rupture (21%) was the second most common associated ligamentous injury next to MCL rupture; but none were avulsion fractures. De Composet al.[15] arthroscopically examined 40 cases of femoral fractures and found that only 3 (7.5%) patients had posterior cruciate ligament rupture, and again none had avulsion fracture. Moore et al. [18] studied 320 cases of diaphyseal femoral fractures and found posterior cruciate ligament avulsion or rupture injury in only five (1.5%) patients.

Trickey [20] in his study of seventeen cases with rupture of the posterior cruciate ligament reported four (24%) cases of avulsion of the posterior cruciate ligament from tibia and one among them (6%) had associated comminuted fracture of the ipsilateral femur. Kumar et al. [2] has reported 3 cases of ipsilateral femur fracture with PCL avulsion fracture.

Of the 52 cases in our series, 11 cases (21%) were isolated injuries and the rest (79%) were associated with other injuries in the same limb. Tibial plateau fracture was the most common associated injury 14 cases (27%), followed by fracture shaft of femur in 9 cases (17%) and MCL, ACL avulsion fracture or ligamentous injury in 7 cases (14%).

In 9 cases (17% of total cases and 22% of cases with associated injuries) with associated injuries, were missed at initial presentation and were fixed later. All these fractures were fixed within 6 weeks from injury with an average time delay of 32 days.

Arthroscopic reduction and fixation with suture bridge technique of PCL avulsion fractures is a demanding procedure with a learning curve.

Most authors recommend post-operative knee immobilization in 30^0 flexion [1] for 4–6 weeks. But we immobilized the knee in extension using a long knee brace because it is more comfortable

Table 2
Distribution of outcomes in different groups.

OUTCOME	ISOLATED INJURIES (11)	EARLY FIXED ASSOCIATED (32)	MISSED INJURIES (9)
EXCELLENT	10 (91%)	2 (6%)	--
GOOD	1 (9%)	20 (63%)	2 (22%)
FAIR	–	10 (31%)	4 (45%)
POOR	–	–	3 (33%)

Table 3
Comparison of the incidence of laxity in different groups.

GROUPS COMPARED	CASES WITH LAXITY	P VALUE
ISOLATED VS ASSOCIATED	**5 OUT OF 11** VS **22 OUT OF 41**	**0.628**
EARLY FIXED ASSOCIATED VS MISSED ASSOCIATED	**17 OUT OF 32** VS **5 OUT OF 9**	**0.897**
SIMPLE FRACTURE VS COMMINUTED FRACTURE	**11 OUT OF 31** VS **16 OUT OF 21**	**0.0039**

for the patient. Functional range of motion was achieved in all patients by the end of 6 to 8 weeks.

6. Conclusion

- The Burks and Schaffer's approach is technically simple and safe our modification enables better reduction and easy fixation.
- Functional outcome of the knee is excellent in isolated injuries, good with associated injuries inspite of the complexity of the injury and fair in treated missed injuries but poor in untreated cases.
- Identifying the tell-tale signs like abrasions on anterior aspect or ecchymosis on posterior aspect of the knee with minimal effusion missing these injuries.
- The presence of Grade-1 laxity does not significantly affect the functional outcome.

Conflict of Interests

None.

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Research paper

Ender nail fixation of humeral diaphyseal fracture: Indications and outcome – A series of 46 cases

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ABSTRACT

Objectives: To evaluate the clinical and functional results of closed fixation of humeral diaphysial fractures using Ender nails.
Material and methods: This was an observational study conducted between January 2008 and September 2014 in which 46 cases of humeral diaphyseal fractures were treated by closed reduction and percutaneous fixation with Enders nails. Clinical follow up evaluation was done and Serial radiographs were taken to look for the time taken for the fracture union and the fracture alignment, positioning and migration of the nails if any.
Results: Average blood loss during the surgery was 30 ml while average radiation exposure time was 1 min. Fracture united in mean 12.8 weeks (range 12-28 weeks). Primary union was achieved in 40 cases, whereas 6 had delayed union at 24 weeks for which autogenous bone grafting was done. Proximal migration of nails occurred in 6 cases and 3 cases had superficial stitch infection. Full range of shoulder and elbow movement was achieved in 40 cases within 24 weeks. In rest of the cases, there was limitation of abduction (average 75°, Range 65° to 85°).
Conclusion: Ender nailing for fracture shaft of humerus is a cost effective, time saving, minimally invasive technique with minimal blood loss. It has many benefits, with good results attainable and comparable with those seen with conservative modalities and other surgical modalities making it a viable option.

1. Introduction

Shaft fracture or diaphyseal fracture of the humerus is defined as extra articular fractures of the humerus excluding 5 cm at each ends.[1] This fracture accounts for 3% of all fractures.[2] With the growing mechanization and increasing road traffic accidents, it often presents in a bizarre way and becomes difficult to manage, especially at the ends. It has a bimodal distribution. In younger age group, there is male preponderance while in older age group there is female preponderance. High energy trauma (especially motor vehicle accidents) is more common in the young males while low energy trauma (trivial fall at home) is more common in the elderly females.[3]

There is no universal consensus on the most appropriate method for management. Conservative management is a rational option for the treatment of minimally displaced humeral shaft fractures.[4,5,6] Sir John Charnley in his treatise "*The closed treatment of common Fractures*" states that "Humerus is one of the easiest major long bone fractures to treat by conservative methods."[7] However conservative management has its own limitations: (a) It requires a long period of immobilization, which carries an increased risk of shoulder joint stiffness. (b) Delayed union and nonunion with this method of treatment are common due to excessive weight of the cast.

Surgical management is particularly indicated in cases of Polytraumatised patients, unstable fractures (spiral/long oblique), comminuted fractures, segmental fractures, pathological fractures, open fractures & fractures associated with neurovascular injury. Plate is the unanimous choice and a variety of plates are in use

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today. There has also been a change in the technique from open reduction to minimally invasive fixation. Minimally invasive technique offers the advantage of preservation of fracture hematoma and less disturbance of surrounding soft tissues. In adults, interlocking intramedullary nails are also in use. However, injury to the rotator cuff has restricted its use to a great extent. Problems such as iatrogenic fracture comminution (especially in small diameter canals), and nonunion (with significant difficulty in its salvage) have also been reported. Reoperations for implant removals are also important issues.

The Enders nail (Fig. 1), which is thin, flexible and premolded, was first described by Ender for treating intertrochanteric hip fractures. It works on the principal of three point fixation and achieves stability by stacking. It has been mostly used for tibia and femur fractures, especially in children. This study was conducted to evaluate the functional outcomes of Ender nails in management of humerus fractures by closed technique.

2. Material & Methods

This was an observational study conducted between January 2008 and September 2014 during which 46 cases of humeral diaphyseal fractures were treated in Patna Medical College & Hospital by closed reduction and internal fixation with Enders nail. Our study population consisted of 32 males and 14 females. The mean age of the patients at the time of surgery was 38 years (range, 10-70 years). The Right arm was the predominantly affected limb. Only cases having closed or grade I or grade II open fractures as determined by Gustilo-Andersons classification with fracture angulation more than 20 degrees in the sagittal or coronal plane, with or without overriding between the segments (more than 2 cm) were included in the study. Cases having sustained multiple system trauma were also included in the study. Patients with Open grade III fracture, severely comminuted fractures, segmental fractures, fractures of proximal fourth or distal fourth of humerus, pathological fractures and fractures associated with neurovascular injury were excluded. There were 6 cases of open fracture and 5 patients were having other long bone fracture as well.

2.1. Surgical technique

The surgery was performed under general anesthesia or regional block. An intravenous antibiotic was administered preoperatively. The patients were placed in supine position on a reversed operating table to allow clearance for the image intensifier. Shoulder was elevated with folded towels or sand bag under the medial border of scapula and arm adducted. In those cases with open fracture thorough debridement of the wound was done. The entry portal was made under fluoroscopy guidance, lateral and approximately 5 mm distal to the upper margin of greater tuberosity. At this point, a longitudinal incision of around 2 cm was made and an entry portal in the bone was made using a bone awl (Fig. 2).

Fracture was manipulated to align proximal and distal fragment and achieve reduction, nails were negotiated across the fracture under image intensifier guidance. Most often only two nails were used. Nail diameter should measure 40% of the narrowest diameter of the diaphysis. Nails should be contoured with long, gentle bend such that apex of the convexity will be at the level of the fracture and distal tip of the nail fans out and engages in the metaphysis of the distal humerus. (Fig. 3B) Fanning of distal ends of the nails was one of the most crucial steps to achieve stability at the fracture site. It was decided to insert three nails when instability was observed at the fracture site after arm rotation tests during surgery (Fig. 3).

2.2. Post-operative protocol

Patients were put in U-slab after surgery. On 3rd postoperative day wound inspection was done and Patients were given shoulder immobilizer. They started flexion and extension exercises for the elbow and pendulum exercises for the ipsilateral shoulder as the pain subsided. An initial follow-up was done at 10 days for wound review. At 3 weeks, patients were encouraged to start active shoulder exercises. Patients were further followed up at 6 weeks, 3 months, 6 months and 1 year. Minimum duration of follow up was 1 year.

Functional evaluation of the patient was done for presence of pain, Range of motion of shoulder and elbow, ability to perform activity of daily living and appearance of complications, if any. Serial radiographs were taken for evaluation of fracture union and consolidation at the fracture site at each visit. (Fig. 4) Radiographic union was defined as observation of an osseous bridge between the fragments. Clinical union was defined as absence of motion or tenderness on movement or manipulation of the arm.

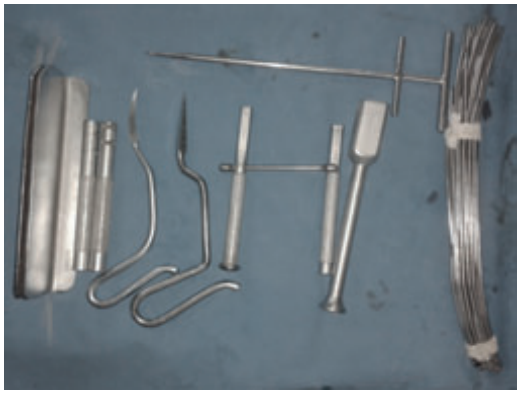

Fig. 1. Enders nail instrumentation set.

Fig. 2. Entry portal being made by bone awl.

Fig. 3. (A) Pre operative X-ay of a displaced fracture shaft of the Humerus. (B) Post operative X ray, showing fanning of nail with engagement in distal metaphysis. 3rd nail was introduced to fill the medullary canal and increase stability.

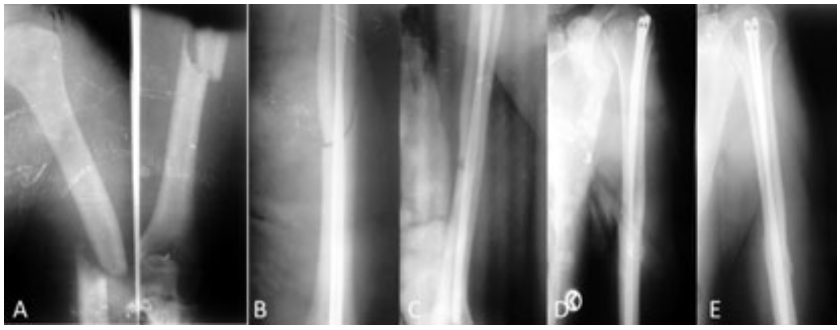

Fig. 4. Serial radiograph of a patient showing progress of fracture healing (A) Pre-op (B) Immediate Post –op (C) 6 weeks (D) 3 months (E) 6 months.

3. Results

Average blood loss during the surgery was 30 ml (Range, 10–70 ml). The mean operation time was 35 minutes (Range, 25–50 minutes). Average period of hospital stay postoperatively was 4 days (Range,3-5 days). The mean time taken for fracture union was 12.8 weeks (range, 12-28 weeks). Primary union was achieved in 40 cases. In 6 cases there was delayed union at 24 weeks for which autogenous bone grafting was done. Proximal migration of nails with soft tissue irritation occurred in 6 cases and the nails were removed in them after union. These were the earlier cases after which we started tying together the eyelets of ender nails by sutures (Ethibond no 5). Superficial stitch infection occurred in 3 cases which were managed by antibiotics and wound care. Pain reduced significantly by the end of 3 weeks and patients were able to do active elbow and shoulder range of motion exercises, however in cases with delayed union mild discomfort at the fracture site was present, and also patients with proximal migration of nail were having pain at the shoulder joint. Full range of shoulder and elbow movement was achieved in 40 cases within 24 weeks. In rest of the cases (6), there was limitation of abduction (average 75°, Range 65° to 85°). These were the cases where proximal migration of nail has occurred and full range of motion was achieved after dedicated physiotherapy. Our series did not have any post-operative nerve injuries, deep infections, refracture, nonunion or cosmetic malunion.

4. Discussion

The majority of humeral diaphysis fractures can be treated conservatively with good clinical and functional results.[5,6,7] Surgical treatment is indicated for polytrauma patients, unstable fractures (spiral/long oblique), comminuted fractures, segmental fractures, pathological fractures, open fractures, fractures associated with neurovascular injury and failure of conservative treatment.[8,9] Currently the two types of implant for which there is the greatest amount of evidence regarding surgical treatment of humeral diaphysis fractures are plates and intramedullary nails.

Anatomical reduction of the fragments, which is the objective when plates are used, requires greater perioperative exposure, with greater damage to the soft tissues and periosteal vasculature, which possibly can be correlated with a higher infection rate and

delayed union.[2,9,10] On the other hand, rigid intramedullary nails cause less soft tissue damage. However, their use has been associated with postoperative shoulder pain and high numbers of second interventions for delayed union and nonunion.

In the present study, 100% of the fractures treated using Ender nails finally united, with 13% cases of delayed union. In the meta-analysis of Ouyanget al.[11] 8.3% of the fractures treated using locked intramedullary nails evolved to pseudarthrosis and 17% to delayed consolidation. Likewise, 6.75% of the fractures treated using plates evolved to pseudarthrosis and 5% to delayed consolidation. Chiu et al. showed a pseudarthrosis rate of 9.4% among fractures treated using Enders nails and attributed the cause of this to excessive dislocation at the focus of the fracture. In all the cases, the gap between the main fragments during the postoperative clinical follow-up was greater than 0.5 cm, even though fragment impaction had been performed during the operation so as to produce a gap of less than 3 mm at that time.[9]

In our series, we encouraged patients to perform early active flexion and extension of the elbow. It is believed that this movement helps to maintain the impaction of the fragments through the strength of the biceps. Further high fracture union rate and low complication rate in our series arose from the basis of the principle of biological fixation, as described by Gerber et al., who emphasized maintenance of the integrity of the soft tissues surrounding the fracture, through indirect reduction of the fracture.[12] No cases of postoperative neurological complications were observed. The data of Ouyanget al[11] showed that among the patients treated with rigid intramedullary nails, the radial paralysis rate was 2.5%, while among those treated with plates, it was 4.8%. Hall and Pankovich reported two cases of paralysis of the radial nerve after fixation of the humeral fracture using a retrograde Ender nail and achieved spontaneous improvement without exploration of the nerve.[13]

Surgery to implant Enders nails for treating humeral diaphysis fractures is a rapid, minimally invasive procedure with lower costs than those of other implants. In a randomized study on 91 fractures that were treated surgically using dynamic compression plates and Enders nails, Chiu et al. showed that the blood loss was smaller and the duration of the operation was shorter in the procedure with Enders nails, which corroborates the findings of the present study.[9]

After removal of plates there is need of protecting the arm in brace or slab for 3 weeks. In case of enders removal, it can be performed easily and post-operative protection of arm is seldom necessary.

5. Conclusion

Ender nailing for fracture shaft of humerus is a cost effective, minimally invasive time saving technique with minimal blood loss. It provides union in the same time as the conservative method and functionally it gives results similar to other surgical methods. Further, relatively cheaper implant and reduced period of hospital stay make it appropriately suited implant (where indicated) in Indian scenario where percapita expenditure on health is meager. However it is a small series and needs further evaluation for generalization of results.

Conflict of interest

None.

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Case report

A rare variant of posterolateral tibial plateau fracture – A case report

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ABSTRACT

Tibial plateau fractures are very complex articular fractures with varied fracture configuration and soft tissue damage. Posterolateral corner injuries generally involve soft tissues; hence fractures in this area are very rare. Management of such injuries is a unique challenge in itself as it requires careful identification of fracture pattern and associated soft tissue lesions, proper surgical planning and execution, appropriate post-operative rehabilitation and timely management of complications in order to maximize the functional outcome. Only radiographs may not be sufficient in proper assessment of these injuries, hence CT scan is usually required for better delineation of the fracture pattern and further surgical planning [1]. Here, we present an interesting case of such injury with an insight into fracture configuration, surgical fixation and management of complications which resulted in an excellent outcome enabling the individual to resume his pre-injury activity levels.

1. Case report

A 31 year old young adult reported to a tertiary care Centre after 02 days of an alleged history of two wheeler accident on 22 Dec 2015. He was symptomatic with severe pain and swelling in the right knee. On evaluation, right knee was swollen with few abrasions over the patella and infrapatellar region. A tense effusion of the knee and a large of area of ecchymosis were noted on the lateral aspect of the knee. The knee was tender on palpation in the lateral and posterior aspect and the movements were grossly restricted. There were no distal neurological deficits. Lachman's test was negative. Radiograph of the knee revealed displaced comminuted fracture of the lateral tibial condyle with one of the fragments found in the anterior aspect behind the patellar tendon (Fig. 1A,B). A CT scan of the knee showed two displaced articular fragments (larger measuring $2 \times 2 \times 1$ cm) detached from the posterolateral corner lying freely in the knee joint (Fig. 1C–F). MRI revealed avulsion of lateral meniscus from the capsular attachment into the knee joint. In view of the above, individual was managed with wound dressings and Robert Jones bandage for initial 5–6 days.

He was planned for definitive management on 28 Dec 2015 as the soft tissues status improved and allowed surgical fixation. Initially a diagnostic arthroscopy was done which revealed a severely comminuted articular fracture of posterior aspect of lateral condyle with two large free fragments, one lying in lateral gutter and the other in retropatellar region. Lateral meniscus was completely avulsed and was lying loose in the joint cavity. There was diffuse synovitis and chondral damage (Outerbridge grade II) in the medial and lateral femoral condyles. He was taken up for open reduction and internal fixation of the articular fragments through posterolateral approach to the knee. Care was taken while dissection in order to prevent injury to common peroneal nerve. Two large fragments lying loose in the joint were extracted (Fig. 2A, B) and were repositioned with k-wires on the posterolateral aspect of lateral tibial plateau at their native location. After assessment of articular congruity, these fragments were fixed using 2×2.7 mm titanium Herbert screws (Fig. 2C,D). Post fixation, the fracture stability and knee range of motion were checked and found satisfactory. The avulsed lateral meniscus was pulled back to its original place and was sutured to its attachment with the help of fiberwire sutures at multiple places. After the fixation, an arthroscopic confirmation of the joint cavity was done and small loose fragments of cartilage and bone not amenable to fixation were removed. Finally the wound was closed in layers after adequate hemostasis and joint lavage.

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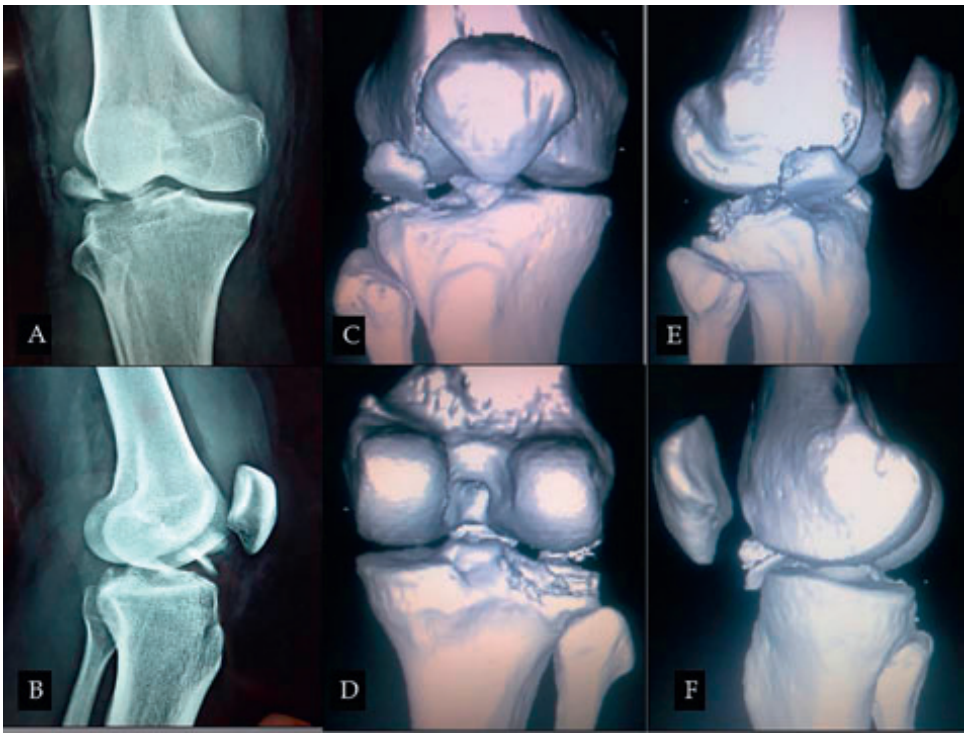

Fig. 1. (A) Pre-operative Anteroposterior radiograph showing the fracture (B) Pre-operative Lateral radiograph showing the fracture (C) Pre-operative 3D CT Scan showing the fracture (anterior view) (D) Pre-operative 3D CT Scan showing the fracture (posterior view) (E) Pre-operative 3D CT Scan showing the fracture (lateral view) (F) Pre-operative 3D CT Scan showing the fracture (medial view).

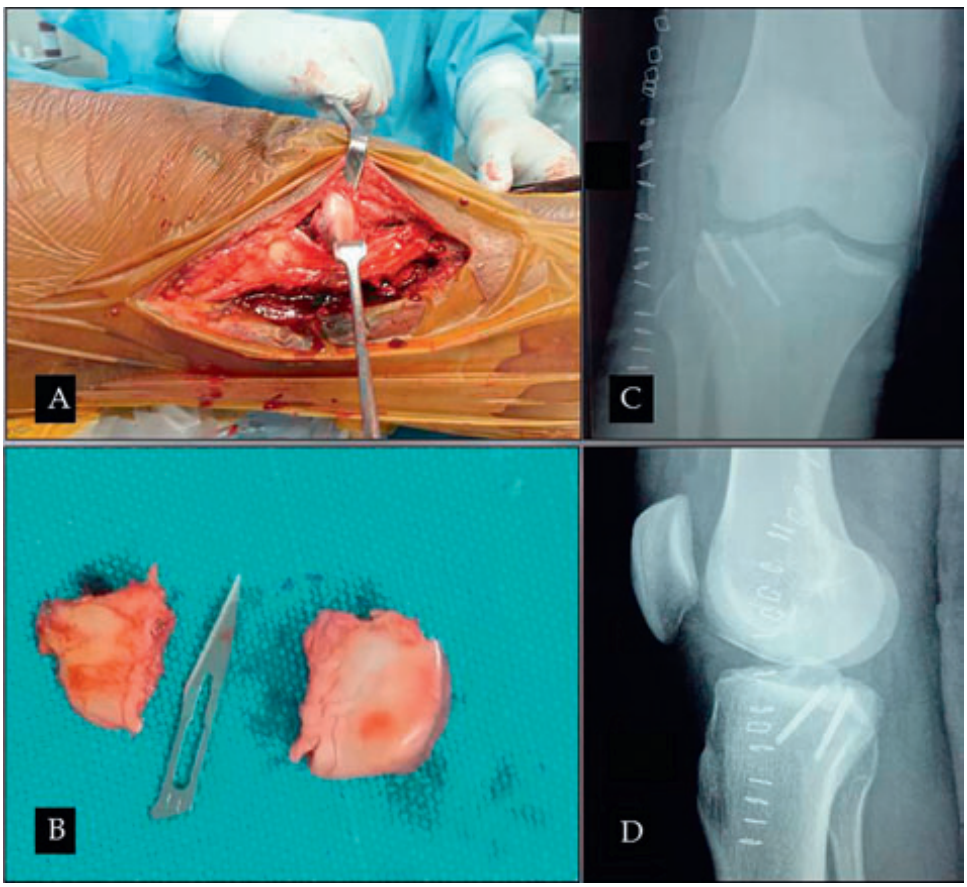

Fig. 2. (A) Intra-operative image showing the retrieval of loose fragments (B) Intra-operative image showing loose fragments (C) Immediate post-operative radiograph showing the fracture fixation (anteroposteriorview) (D) Immediate post-operative radiograph showing the fracture fixation (lateral view).

As the fixed fragments were of only 01 cm depth, knee was immobilized for a period of 04 weeks in a knee brace in order to allow soft tissue and bone healing. During this period, static quardriceps and hamstring exercises were advised with non-weight bearing ambulation. After 04 weeks, gradual knee ranges of motion exercises were instituted and quadriceps strengthening encouraged. At the end of 08 weeks, patient had 10–70 degree knee range of motion. At this juncture, a repeat arthroscopy carried out to evaluate intraarticular structures revealed arthro-fibrosis of the knee joint. The lateral tibial plateau showed minimal articular incongruity at certain places with both the fixed fragments uniting with the native bone. The lateral meniscus was intact and stable although it had some frayed margins at places (Fig. 3A) which were shaved off and balanced with the help of the shaver. The adhesiolysis (Fig. 3B) was done arthroscopically with the help of shaver and radiofrequency ablation. Intraoperatively, 0–130° of knee motion was achieved. Post-operatively, an injection of Depomedrol 80 mg and Bupivacaine was injected for pain relief which also facilitated aggressive rehabilitation. At 12 weeks follow-up post-injury, patient had a satisfactory painless range of motion of 0–120° and fracture consolidation was in progress (Fig. 3C, D). Patient was started on gradual weight bearing ambulation as per tolerance from 03 months post-operatively. At 06 month follow-up, individual was full weight bearing ambulant with minimal pain and discomfort. Later on at 01 year follow-up, individual had an excellent outcome as he was asymptomatic with full range of motion and a well united fracture (Fig. 4A–D).

2. Discussion

Posterolateral tibial plateau fractures are rare and are seen as a split, compression or split compression injuries.[2] In our case, it was a comminuted fracture with two of its big fragments lying loose in the joint. These fractures are not been described clearly in any of the fracture classifications like Schatzker,[3] Mason,[4] Kennedy,[5] or Moore.[6] The AO/OTA classification [7] seems to be versatile and practical in grouping posterolateral tibial plateau fractures into partial articular type i.e., 41-B. The most common mechanism of injury of such injuries is axial compression and valgus force to a flexed knee during motor scooter accident as reported by Hsieh CH.[2] Our case also had the similar mode of injury. Though, associated soft tissue and ligamentous injuries are rare but can occur when a greater force is applied. With greater force, subluxation of femur can occur posteriorly resulting in anterior cruciate ligament tear.[1] In our case, we had avulsion of lateral meniscus into the joint cavity which was repositioned and held with fiberwire sutures. There was chondral damage to both femoral condyles along with meniscal avulsion and posterolateral tibial plateau facture which signifies high energy trauma.

With regard to treatment of these injuries, non-operative treatment is reserved only for selected cases as these injuries result in flexion instability.[1] The approach used is generally posterior as it gives better visualization and accurate fracture reduction.[8,9] However the risk of neurovascular damage is high with this direct exposure. In a study by Carlson,[10] a direct posterior approach was used with dual incisions. Chih-Hsin Hsieh [2] managed these injuries

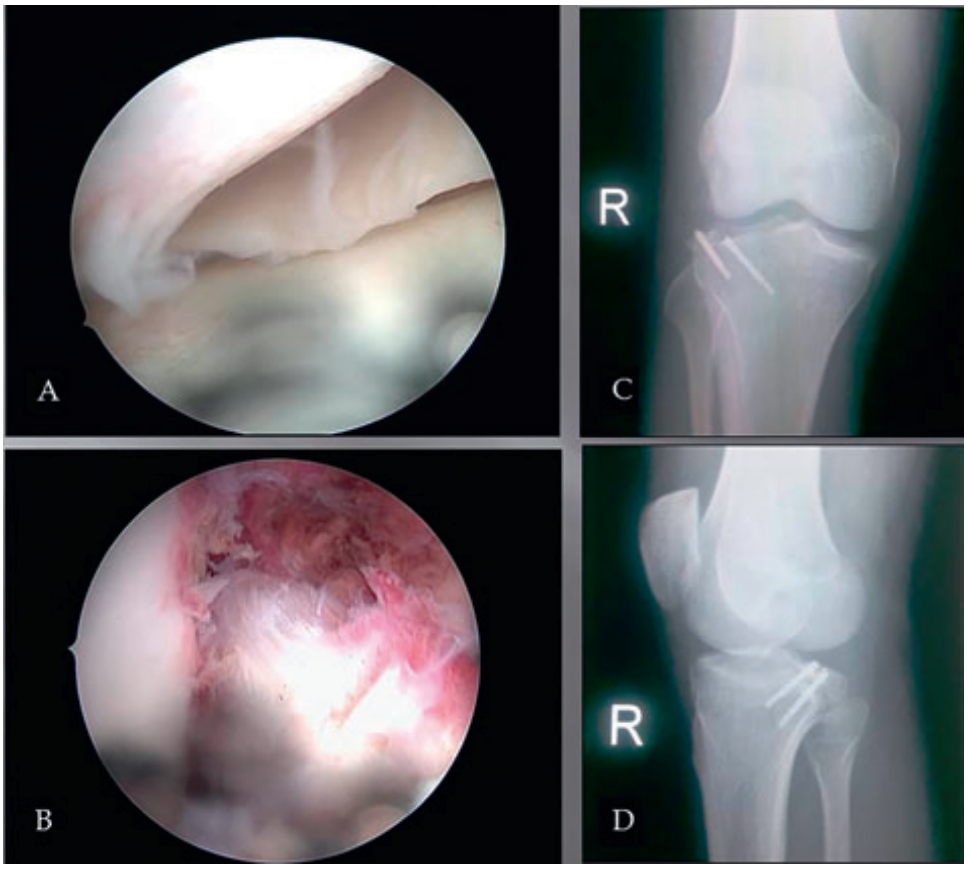

Fig. 3. (A) Intra-operative arthroscopic image showing lateral meniscus and its frayed margins (B) Intra-operative arthroscopic image after the arthrolysis of the intercondylar notch (C) 03 months post-operative radiograph showing the uniting fracture (anteroposterior view) (D) 03 months post-operative radiograph showing the uniting fracture (lateral view).

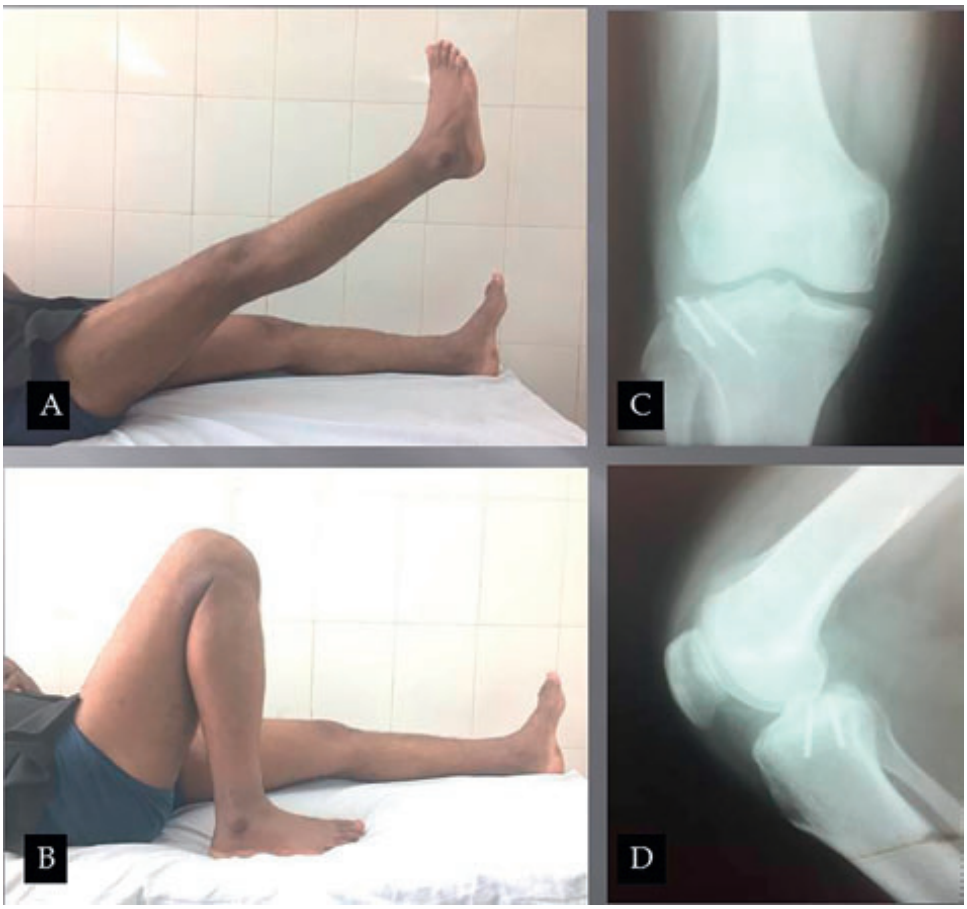

Fig. 4. (A) Clinical image showing full extension of the knee at 01 year follow up (B) Clinical image showing full flexion of the knee at 01 year follow up (C) 01 year post-operative radiograph showing the fracture union (anteroposterior view) (D) 01 year post-operative radiograph showing the fracture union (lateral view).

with an anterior surgical approach and showed better results with no complications. We used posterolateral approach based on the fracture pattern and expertise of the surgeon. Though a high risk of flexion contracture and peroneal nerve injury is reported with posterolateral approach in the literature, we didn't have any of such complications in our case.

The choice fixation of these injuries differs from case to case. Some authors have used cancellous screws and buttress plates for these injuries.[2] We used Herbert screws for fixation of the big fragments and got near normal reduction. Post operatively at 03 months follow-up, with careful rehabilitation fracture union was achieved with minimal articular incongruity and knee range of motion of 0–120° with no neurovascular complications. The unique features of this case were the comminuted posterolateral tibial plateau fracture with free fragments in the joint and the use of Herbert screws with the posterolateral approach. This case report reaffirms that for an uncommon fracture pattern like posterolateral tibial plateau fracture, the evaluation and management should be individualized based on the fracture pattern, age and condition of patient and surgeons expertise with the approach and choice of implants to get a better outcome.

Conflict of interest

None.

Acknowledgements

None.

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Case report

Trapdoor technique for intralesional excision of chondroblastoma of proximal humerus

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ABSTRACT

Chondroblastoma is a rare benign cartilaginous tumour affecting the epiphysis of long bones. Curettage and bone grafting constitute the primary treatment of choice, but localising the tumour intra-operatively may be a daunting task, in spite using an image intensifier. We describe a novel technique to localize the sub chondral tumour intra-operatively using a Kirschner (K) wire and to treat the same employing a trap-door technique in a case of chondroblastoma of proximal humerus, which was completely missed during a previous attempted curettage. Our technique is simple and effective and easily reproducible. To the best of our knowledge this technique has not been described in the literature for the treatment of chondroblastoma of proximal humerus.

1. Introduction

Chondroblastoma is an uncommon benign cartilaginous neoplasm typically involving the epiphysis or apophysis of long bones, accounting for only 1% of all primary bone neoplasms. The most common sites of predilection are distal femur, proximal femur, proximal humerus and proximal tibia.[1,2] Plane radiographs are usually sufficient for establishing the diagnosis in typical cases presenting as juxta-articular geographic lytic lesion with a thin sclerotic rim and well defined borders. CT and MRI are useful for defining the relationship of the tumor to the joint, proximity to the physis, integrity of the cortex, and intralesional calcifications. Curettage and grafting constitute the treatment of choice, but at times intra-op localisation and surgical access to the tumor may be a real challenge.[3,4] We describe a simple technique to localize the tumor intra-operatively and to treat the same using a novel trapdoor technique in a case of chondroblastoma of proximal humerus.

2. Case report

An 18 year old boy presented to our clinic with the complaints of pain in the left shoulder for a period of 2 years. The pain was more intense at night, not aggravated with movements. The range of movements of the shoulder was terminally restricted and painful. Plain radiography and magnetic resonance imaging (MRI) showed a well defined lytic lesion in the epiphysis of the proximal humerus (Figs. 1 & 2). The patient gave a history of surgical intervention 6 months back for the same problem in a local hospital, but was not relieved of his symptoms. The details of the previous surgical procedure were not available. So we repeated the MRI to see for recurrence of the tumor, but to our surprise the tumor was intact and untouched. The previous surgeon had totally missed the tumor and just created a window and curetted the normal bone in the proximal humerus (Fig. 2). To avoid the same mistake, we planned to curette the tumor using trap-door technique which provides a direct access to the site of the pathology.

2.1. Surgical technique

The patient was positioned on a radiolucent operating table in beach chair position. Standard deltopectoral approach was utilized to expose the proximal humerus. The limb was slightly abducted and externally rotated to visualize the articular surface of the

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Fig 1. Pre-operative radiograph showing an eccentric lytic lesion in the humeral head.

humeral head. Since the lesion was in the sub chondral region and the articular cartilage was intact, we were unable to clearly identify the tumour in spite of using an image intensifier. Hence we decided to use a 0.8 mm [0.031 inches] diameter smooth stainless steel Kirchner (K) wire to localise the tumour. It was impossible to penetrate the K-wire in the area of normal cartilage but in the area overlying the chondroblastoma the K-wire entered with effortless ease. After identification, we made a 20×10 millimetres window over the articular cartilage using a sharp surgical knife [surgical blade no-11] and an osteochondral flap was cut open (Fig. 3A&B). The entire tumour was visualised through this trap-door, which was thoroughly curetted out (Fig. 3C). The walls of the cavity were burred using a high speed burr. This was followed by pulsatile lavage of the tumour cavity. Cortico-cancellous autograft harvested from the iliac crest was used to compactly pack the residual cavity (Fig. 3A). The under surface of the osteochondral trap-door was also thoroughly curetted before it was repositioned to its original position. Anatomic reduction of the articular surface was achieved and was fixed with a single titanium Herbert's screw (Fig. 3D).

There were no peri-operative complications; the suture was removed on 14th postoperative day. The histopathology of curetted sample revealed numerous chondroblasts with round to ovoid nuclei along with occasional multinucleated giant cells in a chondroid matrix. Additionally, characteristic chicken-wire pattern of calcification was also seen (Fig. 4). The patient was given arm pouch sling support for 6 weeks, and advised range of movement exercises as tolerable. At 3 year follow up, the patient was pain-free with full range of movements and there were no clinical or radiological signs of recurrence (Fig. 5).

3. Discussion

The surgical treatment options for chondroblastoma are manifold. These include – Curettage with or without cancellous bone grafting, or filling the cavity with polymethylmethacrylate bone cement, or in combination with cryosurgery.[1,2,5] Marginal resection and endoprosthesis is also recommended in rare cases of aggressive chondroblastoma with soft tissue involvement.[6] Radiofrequency (RF) heat ablation is another viable option. RF ablation is a focal form of thermal ablation in which the deposited energy

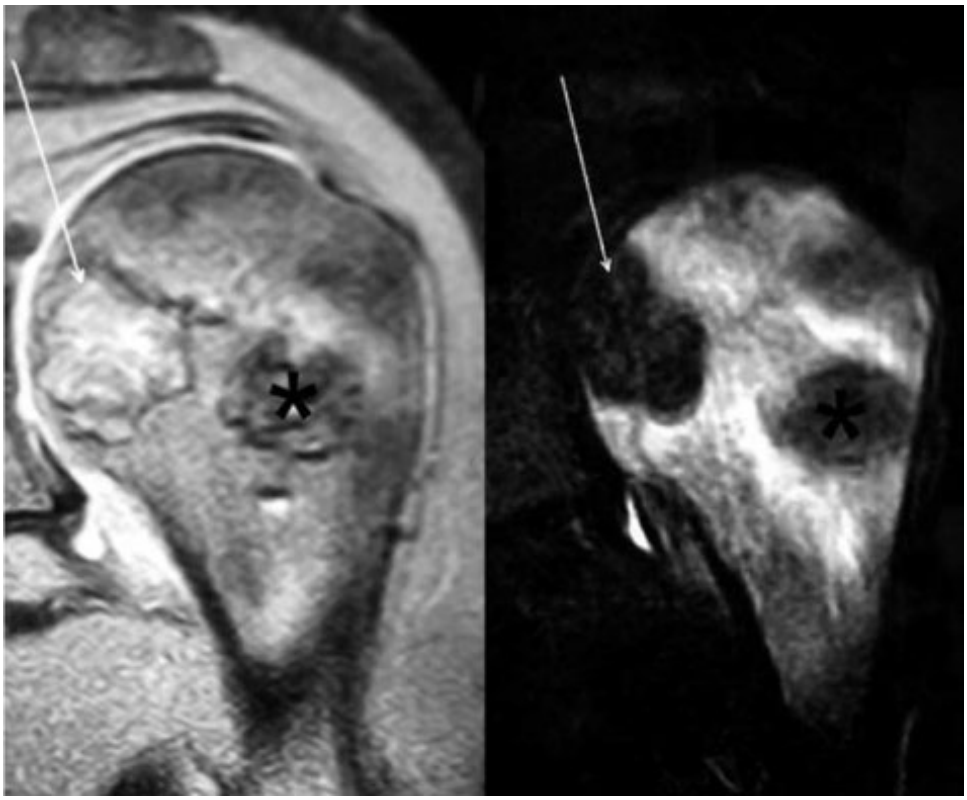

Fig. 2. Pre-operative MRI [T1 & T2 images] showing geographic subchondral lesion [white arrow] which was completely missed during previous curettage [black star].

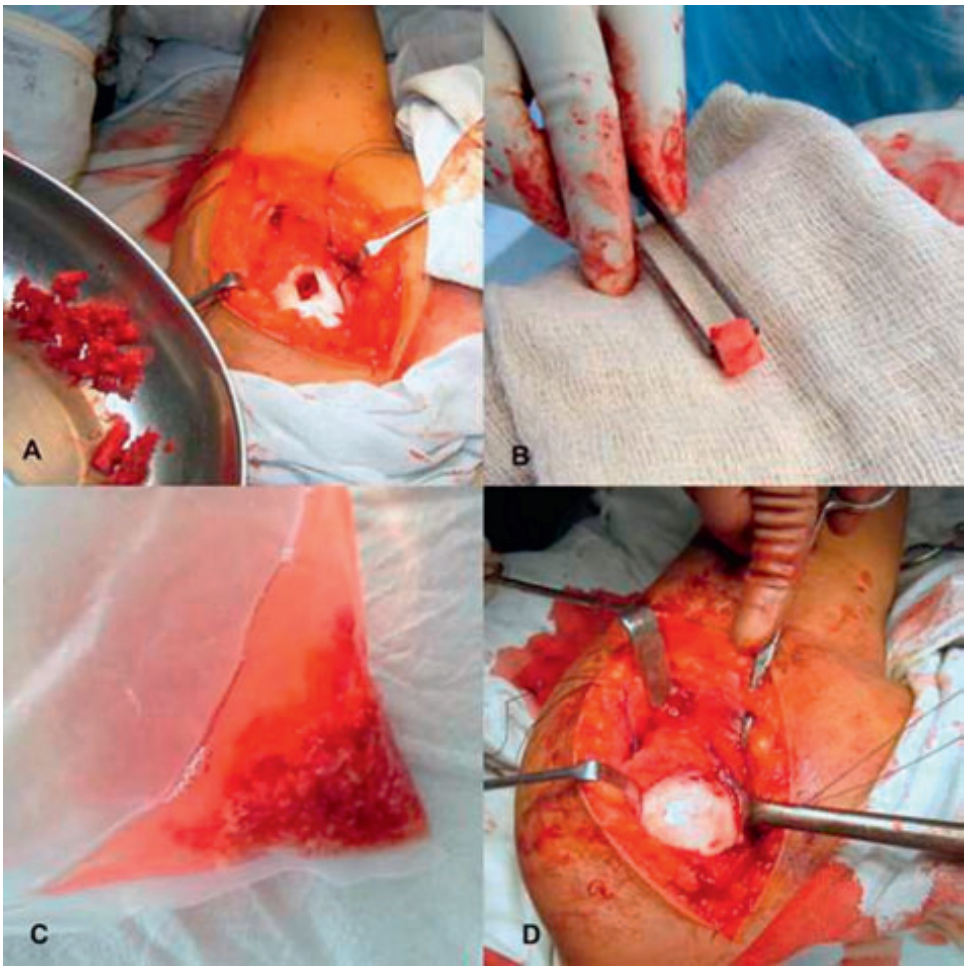

Fig. 3. A Osteochondral window [Trap-door] cut open in the humeral head directly over the tumor. Autogenous iliac crest bone graft was used to pack the cavity after curettage. B. Trap-door fragment. C. Curetted tumour tissue. D. Final photograph after anatomical repositioning and fixation of the trap-door.

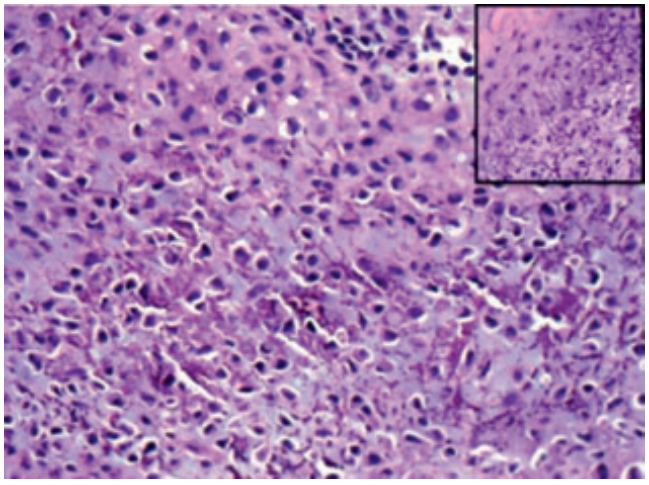

Fig. 4. Histopathological photomicrograph showing numerous closely packed uniform polygonal cells [immature chondrocytes]. Inset shows classical pericellular chicken wire calcification.

causes ionic oscillation, frictional heating and coagulation necrosis of the tissues.[7,8]

The management of chondroblastomas located in the epiphysis of skeletally immature patients is very challenging. Accessing a precariously seated tumour which is sandwiched by the articular cartilage on one side and the growth plate on the other, without damaging either of them, is a daunting task.[9] Complete eradication of the neoplastic tissue will be compromised if adequate access to the tumour is not obtained. Hence, it is imperative to choose the best route which not only provides maximum exposure of the tumour but also causes minimum damage to the juxtaposed vital structures. The direct approach through the lateral cortex of humerus might not be a preferable option in younger children because of the potential risk of damage to the growth plate and difficulty in localizing a subchondrally placed tumor. The latter is evident by the initial unsuccessful surgical attempt in our case.

Trap-door technique is a well known method described for the treatment of avascular necrosis of femoral head.[10] Dead bone is curetted out and replaced by cortico-cancellous autografts which stimulate bone formation (osteoinduction) and support the subchondral bone and articular cartilage of the femoral head (osteoconduction). This technique has also been successfully employed for the management of chondroblastomas arising in the femoral head.[9,11,12] We used similar technique to treat the chondroblastoma near the articular surface of the proximal humerus. The main intra-operative challenge was to exactly delineate the subchondrally placed tumour, in spite of using an image intensifier. Our method of localisation of the tumour is not only simple and novel, but also, cheap and effective. Since the size of the K-wire used was only 0.8 millimetres, there was no damage to the normal articular surface. Our trap-door technique is an easy and reproducible procedure, which provides full access to the

Fig. 5. Post-operative radiograph at 3 year follow up showing full incorporation of bone graft with the humeral head. The joint space is maintained and the articular congruity is intact.

tumour allowing the best chance of obtaining a thorough local control. To the best of our knowledge this technique has not been described in the literature for the treatment of chondroblastoma of proximal humerus.

Even though the articular cartilage was violated to access the tumour, following a few simple measures will ensure normal joint function. These include- meticulous use of a sharp knife to make the osteochondral flap, compact packing of the curetted cavity with bone graft, accurate repositioning and fixation of the trap-door on the grafted bed after ensuring absence of any articular step off. Since the shoulder, unlike the hip, is a non-weight bearing joint, the chances of stress loading of the trap-door fragment does not occur. Hence, the question of collapse of the grafted segment or subsequent deterioration of joint function does not arise. Moreover, the grafted bone incorporates with the host bone in six to eight weeks of time, thereby restoring the normal bony architecture. As the trap-door is made directly over the roof of the tumour cavity, complete visualisation and hence thorough curettage of the neoplastic tissue is guaranteed, thereby minimising the chances of tumour recurrence. Our patient has excellent joint function and has shown no clinical or radiological evidence of recurrence during this three year follow up.

4. Conclusion

Intra-op delineation of the tumour using a K-wire is a novel and effective method for demarcating subchondral tumours. Trap-door technique is an easy and reproducible surgical procedure, which allows a better visualisation of the tumour allowing a greater chance of obtaining local control.

Conflict of interest statement

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Case report

Total knee arthroplasty in long standing post-traumatic isolated bony ankylosis of patellofemoral joint☆

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ABSTRACT

Conversion of a fused knee to a total knee arthroplasty is seldom done at most of the orthopaedic centers globally due to high level of expertise required as well as high risk of complications. Conversion of long standing isolated patellofemoral bony fusion to total knee arthroplasty has not been reported in literature till now and one such case is being reported with successful outcome. The management of this case of isolated post-traumatic patellofemoral fusion is briefly described and various precautions required to be observed as well as a few surgical tips are discussed to obtain a successful outcome in such a case. Though complication rates are high and post-operative recovery is relatively longer, the results of such a conversion can be extremely satisfying.

1. Introduction

Conversion of a fused knee to total knee arthroplasty (TKA) is quite an uncommon procedure undertaken only at very select centers across the world due to high level of experience required and high post-operative complication rate.[1] Though conversion of tibiofemoral fusion to total knee arthroplasty have been reported in many reports and case series, conversion of long standing patellofemoral bony fusion to total knee arthroplasty has not been reported in literature (English language only).[2–4]

2. Case report

52-year old male, a trader with sedentary lifestyle, presented to our hospital with history of having sustained an open comminuted fracture of distal femur and open injury of knee 12 years ago which was managed by wound debridement and external fixation followed by internal fixation (no documents related to injury or treatment were available). Post-operatively, he developed surgical site infection which was managed by wound dressings initially and internal fixation implant removal was done after 12 months when fracture union had been obtained. Infection became quiescent at this stage and he had developed ankylosis of the knee in full extension. He did not seek any further treatment as his knee was pain free though immobile, and he was counseled against any further surgical interventions at that stage.

At the time of presentation to our OPD, he was extremely dissatisfied with complete loss of left knee movements, had difficulty in sitting on normal chairs/furniture and had psycho-social challenges due to his physical limitation secondary to ankylosis in full extension. The bony ankyloses in full extension of knee led to requirement of increased space and significantly decreased manoevurability in almost every physical activity of daily life, ranging from commuting in public transport and travelling to even sitting at workplace/social visits. Clinical and radiological assessment revealed scarred skin laterally and anteriorly (sequelae of old injury and surgeries), bony ankylosis of patello-femoral joint with well united fracture of distal femur and patella baja with evidence of calcification in substance of ligamentum patellae (Fig. 1a and b). He had also developed low backache secondary to asymmetrical gait pattern. Patient underwent total knee arthroplasty under combined spinal epidural anaesthesia utilizing a rectus snip surgical approach and posterior stabilized prosthetic components (Genesis-II, Smith & Nephew, Memphis, Tenn). Osseous ankylosis of patello-femoral joint was taken down by osteotomising it with adequate care to preserve the soft tissue sleeve and preserving adequate (12 mm) residual bone

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Fig 1. a and b: Radiographs showing isolated post-traumatic patallofemoral fusion with calcification in substance of ligamentum patellae.

thickness as well to enable safe resurfacing of patella. Fibrous ankylosis of tibio-femoral joint could be released by careful progressive soft tissue releases, though there was significant difficulty encountered. Intra-medullary instrumentation was used for femoral component and extra-medullary instrumentation was used for tibial component. Flexion obtained during surgery was 110° without reducing the quadriceps mechanism and 90° after reducing the quadriceps mechanism. No special procedures like quadriceps lengthening or tibial tubercle osteotomy were needed. Calcified mass within substance of ligamentum patellae was well localized and excised. No constrained components or augments were needed and prosthetic fixation was achieved using Palacos bone cement (Heraeus Medical GmbH, Germany). Routine antibiotic prophylaxis as per institutional protocol for primary TKA was followed, i.e. 3rd generation cephalosporin for 24 h peri-operatively, with first dose being given at induction of anaesthesia.

During follow-up, there was no instability of the knee. The extensor lag of 25° due to quadriceps weakness (Grade 4, immediate post-operative) improved to 0° within 3 months with patient regaining grade 5 quadriceps power. Patient has been followed up for two years (Fig. 2). At last follow-up, patient felt that there was significant improvement in his quality of life as he had regained adequate range of motion (0–90°), could walk and climb stairs without any support/aid. He does not face any physical restrictions or have any special requirements during most of his professional or personal activities.

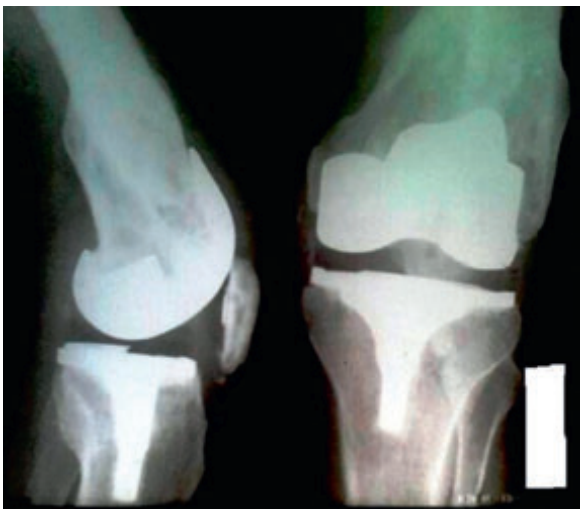

Fig. 2. Post-operative follow-up radiograph at 2-years following total knee arthroplasty.

3. Discussion

An adequately fused painless knee can also cause significant impairment of quality of life as well as functional and social restrictions to force a patient to seek a solution for same and even a high risk procedure is acceptable to them. Although total knee arthroplasty is gradually becoming an acceptable procedure for management of arthrodesed or ankylosed knees, variable outcomes have been reported.[2–4] Results vary from significant improvement in quality of life to high complication rates. However, despite high complication rates, most patients, including our patient, prefer to have a mobile knee rather than a fused knee which is causing them significant functional loss and social dysfunction.

Conversion of long standing isolated patellofemoral bony fusion to total knee arthroplasty has not been reported in literature. Successful conversion in this case report highlights that TKA can be a possible solution to manage such a fusion. However, patient must be counseled about possibility of high complication rates.

There are multiple precautions to be taken in such conversions and each case is different with the specific aim of giving the patient a mobile, painless and stable knee.[5] Our case required certain specific precautions which are as follows: (a) an extensile approach to ensure adequate visualization; (b) gentle handling of the extensively scarred soft tissues to prevent tissue necrosis and wound dehiscence; (c) prevention of overstuffing of patellofemoral compartment by: (i) using a femoral component with thin anterior edge and deep trochlea, (ii) placing the femoral component as posterior as possible; (iii) patellar ostoetomy to as thin as possible without compromising the strength of residual bone. Recrudescence of previous infection is also a possibility which fortunately did not happen in our case. Use of constrained knee prosthesis has been frequently described in conversions of fused knees but we did not need any additional constraint other than posterior stabilized knee prosthesis as ligamentous balance and stability could be achieved intra-operatively.

Though many techniques have been described to lengthen a shortened extensor mechanism or reconstruct a deficient extensor mechanism, the functional results of most of these techniques have been poor, e.g. V-Y quadricepsplasty, wire reinforcement or synthetic ligaments.[4,6,7] Post-operatively, patients can be disappointed by the initial range of motion, extensor weakness causing extensor lag and the post-operative pain. However, all these improve with continued range of motion as well as muscle strengthening exercises to achieve satisfactory results on long term basis.[1,3] Our patient could achieve 90° flexion which is satisfactory to him. Higher flexion could not be achieved because of previous trauma, infection and multiple surgeries causing extensive scarring of ligamentum patellae as well as other soft tissues surrounding the knee leading to patella baja as well as ossification within substance of ligamentum patellae.

Despite high complication rates and long recovery time, patients continue to opt for this high risk procedure of conversion of fused knees to knee arthroplasty and are extremely satisfied in successful procedures. This case is reported to highlight the previously unreported conversion of a long standing post-traumatic and post-infection patellofemoral fusion to knee arthroplasty successfully.

Conflict of interest

None.

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