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Table of Contents – Primary Author Publications

1. **Debuka E**, Kumar G, Dalal N, Kalra S. Fracture Characteristics and outcomes of acetabular fracture management with minimally invasive approach and percutaneous fixation. Ms. No. EJOS-D-20-01130R1 (Accepted in EJOST)

   Role: Data collection & analysis, Write-up
   Learning: Learned about how Acetabular fractures that are not amenable to ORIF may be managed percutaneously with a minimally invasive approach. I also learned from my guide on how to read CT scans for Acetabular fractures and classify them into different types.

2. **Debuka E**, Kushwaha NS, Kumar D, Singh A, Sharma V. Rust score–An adequate rehabilitation guide for diaphyseal femur fractures managed by TENS. Journal of clinical Orthopaedics and trauma. 2019 Sep 1;10(5):922-7. **PUB Med ID -31528069**

   Role: Conceptualization, Recruitment, Data collection, Analysis, Write-up
   Learning: Learned how to recruit patients and effectively follow them up. It was my first experience of understanding the importance of taking consent, getting ethics approval, data analysis and writing a research paper. During this study, I learned the indications of TENS Nails, its technique and complications.

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Rust score-An adequate rehabilitation guide for diaphyseal femur fractures managed by TENS

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ABSTRACT

Introduction

The optimal mode of treatment among the wide variety of surgical and nonsurgical treatment options for children between 5 and 15 years of age continues to be controversial. Elastic stable intramedullary nailing of long bone fractures in the skeletally immature has gained widespread popularity because of its clinical effectiveness and low risk of complications.

Methods and methodology

From Jan 2015 to August 2016, 35 patients including 37 limbs with diaphyseal fractures of the femur in the age group 5-15 years were managed by Titanium Elastic nailing and their clinico-radiological and functional outcome was assessed at 1 year post operatively as per the Flynn's criteria. RUST score was used as a guide for post-operative rehabilitation.

Results

37 patients were managed by TENS nailing including 28 males and 9 females. The outcome in proximal, middle or distal fractures of the shaft were found to be similar and the difference was statistically insignificant. Similarly, the difference in the outcomes as per fracture patterns was also found to be statistically insignificant. Partial weight bearing was allowed after a score of 6 was achieved and full weight bearing after a score of 8.

Conclusion

As per the Flynn's criteria, 75% of the patients (28 out of 37) were found to have an excellent outcome while 7 had a satisfactory outcome and two had a poor outcome. RUST score can be used as an effective guide for post op rehabilitation.

1. Introduction

Lower limb fractures, typically caused by blunt trauma, are the most common major pediatric injuries and 70% of those involve the femoral shaft.[1] Closed reduction and pop hip spica application is the most widely accepted management for diaphyseal femur fractures in children under 5 years of age while antegrade solid intramedullary nails are the standard treatment in skeletally mature adolescents of more than 15 years of age. [2-4]

Although there exist various surgical and nonsurgical treatment options for children between 5 and 15 years of age, operative reduction and fixation with flexible intramedullary titanium nails (TENS) has become the standard.[5] These simple load-sharing flexible nails are simple, effective and function as an internal splint as the fracture unites. Many studies support their use citing advantages like closed insertion, preservation of the fracture hematoma, early mobilization, micromotion at fracture site that encourages union and a physis sparing entry point.[6,7]

However, there is no definitive post-operative rehabilitative protocol for patients managed by elastic IM nailing. Several key factors like splintage and weight bearing resumption are a matter of surgeon's training and preference. This study was undertaken to assess the use of RUST score to guide the post-operative rehabilitative protocol and the safety and efficacy of TENS for femur fracture treatment in children between 5 and 15 years.

2. Materials and methods

This prospective study includes 37 cases admitted at the Department of Orthopedics Surgery, of our institution between Jan 2015 and Dec 2016. Twenty-eight patients were male and nine females. Nine patients (24.3%) were above the age of 12 years. Only children between the age of 5 and 15 years with a closed or a Gustillo Anderson Grade I diaphyseal fractures of the femur were included in the study.[8] Those with metaphyseal fractures, Gustillo Anderson grade II or III compound fractures, pathological fractures and those with congenital or medical co morbidities were excluded. A written consent was taken and an ethical committee clearance was obtained from the institution.

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0976-5662/

Pic 1–3. Patient 1 X-rays.

Pic 4–6. Patient 2 X rays.

The patients were assigned into 3 different groups based on the fracture pattern as per the AO classification of diaphyseal fractures of the shaft of femur. Group A included spiral or oblique (AO 32 A1 and 32 A2), group B - transverse (AO 32 A3) and group C – wedge or comminuted fractures (AO 32 B and C).[9] Further sub-grouping was done based on whether the fracture was in the proximal, mid or distal 1/3rd of the diaphysis.

2.1. Pre-operative work up

Patients were evaluated for their fitness for surgery and anesthesia as per our institution norms and were operated by a retrograde nailing technique within five days of admission. The internal diameter at the isthmus of the femur was calculated and two nails of forty percent of this measurement were selected so that the opposing bending forces were equal.[10]

2.2. Operative technique and considerations

All patients were operated under regional anesthesia on a fracture table. The entry was made using a bone AWL 2 cms proximal to the distal physis of the femur and 2 adequately sized pre-bent nails were introduced into the canal. The amount of bending was three times the diameter at the isthmus of the shaft.

In two cases, where closed reduction could not be attained, the fracture site was opened from the lateral aspect of the thigh, the soft tissue interposition released and the nails advanced. It was made sure that the patella was facing upwards and the foot was in neutral position at the time fixation to prevent rotational mal-alignment. The distal portions of the nails were left slightly protruding from the bone to prevent migration and ease their removal when required.

A Liston's long splint was given and removed after stitch removal on the 10th post-operative day. Those patients with comminuted fractures were given a POP hip spica for upto six weeks post operatively. Static in bed quadriceps and hamstrings exercises were done till splint or spica removal. Once removed, dynamic quadriceps and hamstrings drill were started and the patients kept non-weight bearing till adequate union was achieved

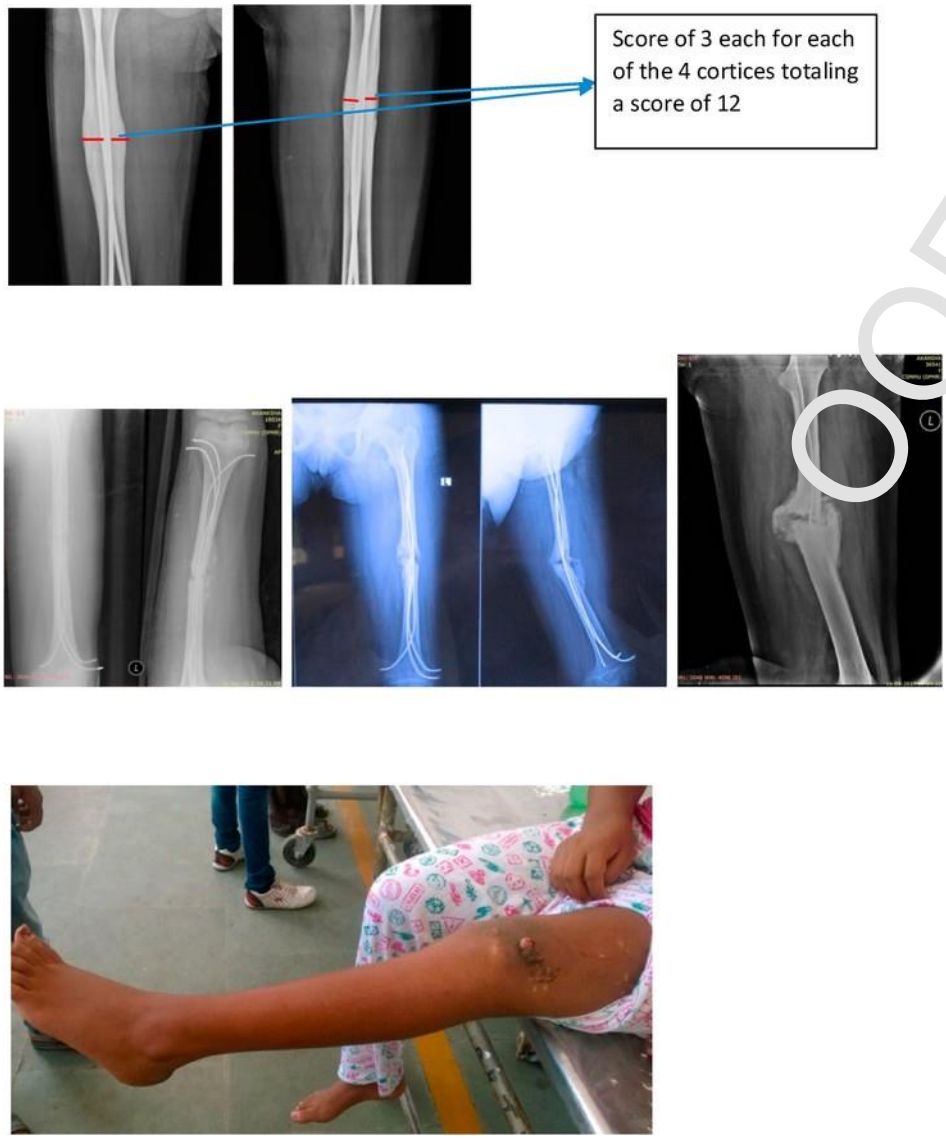
2.3. Post-operative follow up

Patients were followed up at 3 weeks, 3 months, 6 months and 1 year and assessed for clinical and radiological signs of union. The range of motion (flexion and extension) at the knee and the hip joints were noted with the help of a goniometer and complications like limb length inequality, angulations at the fracture site, infection or entry site ulcers were noted and duly addressed.

2.4. Outcome assessment

The Radiographic Union Scale for Tibia fractures (RUST) score [11] was used to assess the callus formation and radiological union. Each femur cortex (anterior, posterior, medial and lateral) was assigned a score from one to 3. A cortex with a visible fracture line and no callus was given a score of one, a visible fracture line but with callus present was given a score of 2 and callus without a fracture was scored as 3. The minimum total score was 4 and the maximum was 12 (healed).

This scoring was used to guide the post-operative rehabilitation in our patients at follow ups. Once a total score of 6 was achieved, the patients were allowed partial weight bearing with a walker. Full weight bearing was commenced when a minimum RUST score of 8 was achieved.



Pic 7–12. Patient with 3 TENS nails with complication of Non uion.

2.5. Statistical analysis

The outcome at the final follow up was assessed using the Flynn's criteria.[5] The complications were classified as major or minor and the final outcome classified as excellent, satisfactory or poor. Descriptive statistics like numbers, percentages, average and mean were used to represent the results and P value was used assess the significance of the results.

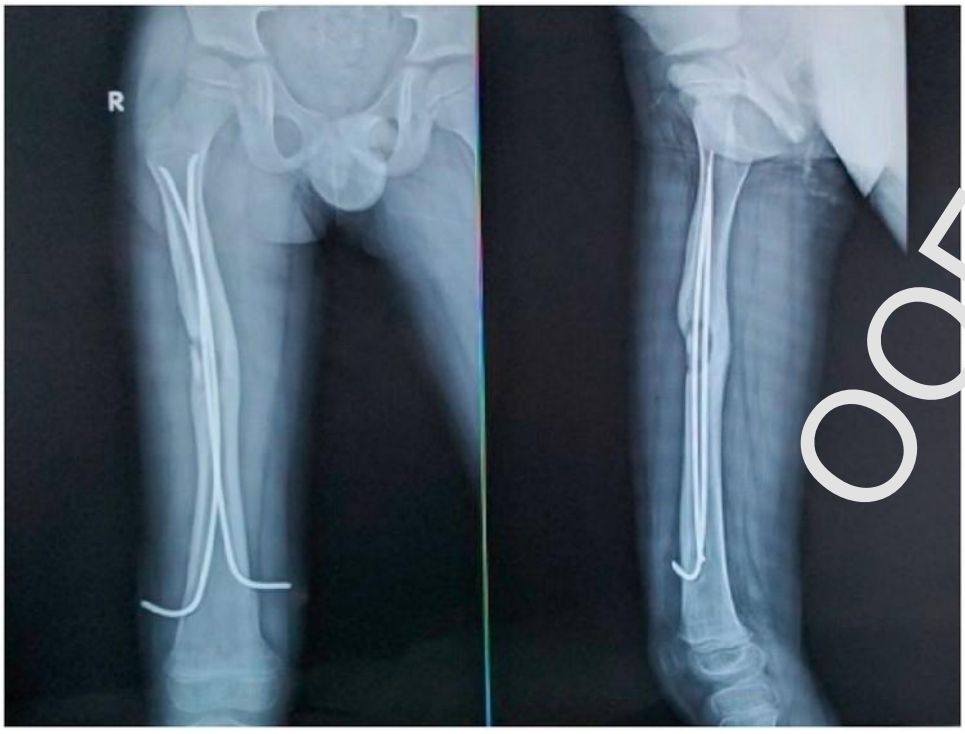
3. Results

The 37 patients were divided into three groups based on the fracture location on the diaphysis as proximal, mid and distal 1/3rd. Two patients had a Grade 1 compound fracture shaft femur. Road traffic accidents (72.9%) followed by fall from a height (21.6%) was the most common cause of injury. The average time of union was found to be 11.2 weeks (7.2-13.2 weeks). Two wires of the same size were used in all cases but one. The average duration of hospital stay was found to be 7.3 days (Table A1).

Partial weight bearing (RUST score of 6) was started at an average of 6.3 weeks in group A, 5.6 in group B and at 9 weeks in group C. Full weight bearing was allowed at a mean of 9.4 weeks in group A patients, 9.1 weeks in group B and 12 weeks in group C.

The average time of attaining a RUST score of 6 was 6.27 weeks and a score of 8 at 9.74 weeks. When classified as per the location of the fracture on the diaphysis, proximal fractures achieved a RUST score of 6 at 6.5 weeks and a score of 8 at 9.8 weeks. The mid shaft fractures had score of 6 at 7.2 weeks and 8 at 9.7 weeks. The distal shaft fractures had RUST score of 6 at 5.1 weeks and 8 at 11 weeks.

The average range of motion at the final follow up was compared between the different groups and best results were obtained for fractures in the middle one third. The difference though was not found to be statistically significant. ($P > 0.05$) Similarly the average range of motion at the final follow up was compared between patients with different fracture patterns. The best results were obtained with A3



Pic 13. Post op X ray at 6 months for patient with infection at fracture site.

Pic 14. Post saucerization x ray at 7 months for patient with infection.

type of fractures but the difference was not found to be statistically significant. (P > 0.05)

Five patients (13.5%) during the course of treatment developed entry point wounds of which 2 recovered with a short duration of antibiotics. The other 3 healed after implant removal post fracture healing. One patient developed non union and had implant breakage during the removal. Another patient developed infection at the fracture

Table A1
Number of patients classified as per fracture pattern and site of fracture.

Fracture pattern (AO Classification)	Proximal	Mid	Distal	Total
Group A	4(10.8%)	5(13.5%)	1(2.7%)	10(27%)
Group B	4(10.8%)	14(37.8%)	3(8.1%)	21(56.7%)
Group C	2(5.4%)	4(10.8%)	0	6(16.2%)
Total	10(27%)	23(62.1%)	4(10.8%)	37(100%)

site which required another surgery in the form of debridement, implant removal and sequestrectomy.

The final outcome was evaluated at the final follow up at 1 year using the Flynn's criteria. Twenty-eight patients (75.6%) had an excellent outcome, 7 had a satisfactory outcome (18.9%) and 2 (5.4%) had a poor outcome.

4. Discussion

Casting is considered the gold standard treatment for femur fractures especially in the young up to 11 years of age [3,12-15] Czertak et al. though advised casting as a viable option only up to 6 years of age because it leads to a period of prolonged immobilization and complications like shortening or angulation.[2] Elastic intramedullary nailing, a simple and effective method, has become the treatment method of choice for the age group between 5-15 years with a short learning curve, lesser infection rates and faster rehabilitation.[5,16,17]

The average duration of hospital stay in our study was found to be 7.1 days (4 to 18 days) which is similar to what is reported in literature of 5-10 days.[12,18,19] Greisberg J et al had reported a mean hospital stay of 6 days for TENS nailing versus 29 days for hip spica casting.[20] The duration of hospital stay is greatly reduced with elastic intra medullary nailing and allows quicker return to functional independence. Road traffic accidents (RTA) was the most common mode of injury (72.9%) in our patients. Most studies in literature report the same[2,21,22] but Nisar et al[23] found fall from height as the most common mode of injury.

Twenty-eight of our patients (75.6%) had an excellent outcome, seven had a satisfactory outcome and two patients had a poor outcome. Two patients who were managed by open reduction and had good outcomes like those managed by closed reduction. However, the numbers of patients managed by open reduction are too few to be able to compare the outcomes in our study. The difference in the outcome between patients with different types of fractures and location of fracture was not statistically significant. ($P > 0.05$) These findings are in accordance with those reported by Moroz et al [24] and Nascimento et al [18] (Pic 1-6).

Different studies have reported varying time periods for resuming weight bearing ranging from a few days to several months. There exists no prescribed objective protocol to guide the post operative rehabilitation. In the present study, we used the RUST score as a guide to rehabilitative care to clearly define a particular time at which we allowed for partial and full weight bearing. We believe that in time this could be standardized and used as a definitive guide for rehabilitation in such patients.

Intramedullary nails provide relative stability and allow for micro motion at the fracture site. This allows for abundant callus formation which, in time, bridges the fracture gap. The RUST score is a method to assess the maturity and completeness of this callus formed and thus function as a guide to rehabilitative decisions (Pic 7, 8).

Partial weight bearing was allowed after achieving a score of 6 and full weight bearing after a minimum score of 8 as per the RUST score. The average time to allow for partial weight bearing was 6.27 weeks and full weight bearing at 9.74 weeks. Bhuyan et al used the Anthoney classification for grading callus formation and guiding rehabilitation. [25] They reported partial weight bearing at an average of 3.5 weeks and full weight bearing at 9.5 weeks. The use of RUST score helped objectively determine a fixed time for resumption of weight bearing. This helps avoid early weight bearing which leads to an increased risk of angulation at the fracture site.

Entry point pain and wound complication were seen in seven patients (18.9%). All the patients had at least 15 degrees of limitation in the terminal range of motion due to nail impingement. Narayanan et al studied 79 patients over a period of 5 years and noted pain at the insertion site in 41 patients (51.8%) due to bent or prominent nail ends. [26] They reported complications like malunion, re-fracture, transient neurological deficit and superficial wound infection. They concluded that it had best outcomes with transverse, short oblique and spiral fractures with minimal comminution. Ligier[12] reported more positive outcomes with TENS with only 13 out of 118 patients with local ulceration and none with any functional issues at one year follow up.

We found a high number of patients (~20%) associated with pain and ulceration at entry site with one patient going into non union. The protruding nails lead to irritation of the muscle and the skin and stand the risk of migration as movement is started and the child grows. These complications often necessitate nail removal but it should be delayed until sufficient fracture healing has been attained. If the nails are not left protruding and are adequately bent, the complications can be greatly reduced.

The use of 3 TENS nails in one of our case was associated with a poor outcome with the patient developing entry point wound, limited knee flexion and non union with angulation at the fracture site. Six months post operatively, the nails were removed but it resulted in implant breakage. The broken nail being intra medullary in position was left in situ and the patient was given a thigh brace. The patient eventually recovered 0-110 degrees flexion at the knee joint and resumed weight bearing after 10 months from injury. The patient had 1.5 cms shortening at the final follow up and an anterior angulation of 23 degrees and external rotation mal-alignment (Pic 9-12).

Another patient developed a discharging sinus at the fracture site at the final follow-up but had attained fracture union. The implants were removed and an excision of the sinus tract followed by sequestrectomy and saucerization was done. The patient was disallowed for weight bearing and is under follow up for the same. (Pic 13, 14)

Elastic intramedullary nailing is an effective way to treat femur fractures in the skeletally immature with mostly minor complications that can be treated easily. Meticulous surgical technique can limit complications and can be used safely for all fractures of the femoral diaphysis. The shortcomings of our study are a relatively small sample size and limited follow up.

5. Conclusion

The RUST score can be used as an effective guide to post operative rehabilitative care and help prevent complications of early weight bearing.

Conflicts of interest

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

Appendix

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Confirmation of Acceptance of Paper

Cyril Mauffrey <em@editorialmanager.com> Mon, Jan 18, 1:11 AM (5 days ago)
to me

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Ms. No. EJOS-D-20-01130R1
Fracture Characteristics and outcomes of acetabular fracture management with minimally invasive approach and percutaneous fixation
European Journal of Orthopaedic Surgery & Traumatology

Dear Mr. Debuka,

Your article referred above was definitively accepted by the Reviewer Committee and will be published in one of the next issues of our journal European Journal of Orthopaedic Surgery & Traumatology.

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Fracture Characteristics and outcomes of acetabular fracture management with minimally invasive approach and percutaneous fixation

--Manuscript Draft--

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Full Title:	Fracture Characteristics and outcomes of acetabular fracture management with minimally invasive approach and percutaneous fixation
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Corresponding Author:	Ekansh Debuka Royal Liverpool and Broadgreen University Hospitals NHS Trust: Liverpool University Hospitals NHS Foundation Trust UNITED KINGDOM
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Corresponding Author's Institution:	Royal Liverpool and Broadgreen University Hospitals NHS Trust: Liverpool University Hospitals NHS Foundation Trust
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First Author Secondary Information:	
Order of Authors:	Ekansh Debuka
	Gunasekaran Kumar
	Neel Dalal
	Sanjay Kalra
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Funding Information:	
Abstract:	Purpose Aim was to assess acetabular fracture outcomes of PF (Percutaneous Fixation) with or without MIS (Minimally Invasive Surgery). Methods Between July 2011 and October 2016, acetabular fractures fixed with PF with or without MIS were included. Data collected: demographics, mechanism of injury, associated injuries, time to surgery, American Society of Anestheiologists (ASA) grade, fracture characteristics, surgical techniques, fracture reduction, secondary osteoarthritis (OA), revision surgery, patient survival and complications. Results 26 patients with mean age of 56 years (19 to 86) (22 males and 4 females), 11 were <50 years age (U50) and 15 were >50 years (A50). Most common pattern was anterior column with posterior hemi-transverse. Three out of 11 U50 were minimally displaced and had PF only, rest had MIS and PF. All had good fracture reduction but 2 had secondary OA at follow-up but no further surgery. 8/26 had secondary OA but only 3 needed surgery. Three (A50 with PF) with fair/poor reduction (deemed unfit for open reduction), had secondary OA but no further intervention. Three more (A50 with MIS+PF) had secondary OA treated with primary total hip replacement (THR). Complications - One foot drop recovered after immediate repositioning of screw, 1 cardiac event and 1 pulmonary embolism. Conclusion Fracture mal-reduction predicts secondary OA but good fracture reduction does not prevent secondary OA. MIS and PF in elderly is useful even with suboptimal reduction as it sets the bed for a non-complex THR. Despite MIS surgery, medical complications are potentially significant.

Dear Reviewer,

Thank you for reviewing my submission and your valuable inputs –

Questions

1. Can you discuss how the decision was made for PR +/- MIS?
   PF+/-MIS was not considered in cases with articular impaction, die punch injuries and displaced wall fractures. PF was performed in fractures that were reducible with either longitudinal traction +/- trochanteric pin traction. If acetabular articular surface remained incongruent despite adequate traction, MIS + PF was performed via lateral window of Ilio-inguinal approach and using specialist instruments (offset clamps/pointed reduction forceps, etc) fracture was reduced under fluoroscopy control and stabilised as required.

2. Make sure the legends for the graphs are correct and don't have extra information.
   The legends for the graphs have been amended to be more accurate.

3. Can you discuss the potential utility of this study in terms of deciding which patients might benefit from PF/MIS rather than ORIF?
   These techniques are valuable in frail patients who are unsuitable for open fracture reduction. Even if perfect reduction is not achieved, it provides early pain relief and prevents complications associated with prolonged bed rest. It also sets the bed for a non-complex THR if required.

4. The authors names have now been added to the Manuscript file in the same order as the title page.

We hope the above are in keeping with the desired clarifications.

ABSTRACT

Purpose

Aim was to assess acetabular fracture outcomes of PF (Percutaneous Fixation) with or without MIS (Minimally Invasive Surgery).

Methods

Between July 2011 and October 2016, acetabular fractures fixed with PF with or without MIS were included. Data collected: demographics, mechanism of injury, associated injuries, time to surgery, American Society of Anestheiologists (ASA) grade, fracture characteristics, surgical techniques, fracture reduction, secondary osteoarthritis (OA), revision surgery, patient survival and complications.

Results

26 patients with mean age of 56 years (19 to 86) (22 males and 4 females), 11 were <50 years age (U50) and 15 were >50 years (A50). Most common pattern was anterior column with posterior hemi-transverse. Three out of 11 U50 were minimally displaced and had PF only, rest had MIS and PF. All had good fracture reduction but 2 had secondary OA at follow-up but no further surgery.

8/26 had secondary OA but only 3 needed surgery. Three (A50 with PF) with fair/poor reduction (deemed unfit for open reduction), had secondary OA but no further intervention. Three more (A50 with MIS+PF) had secondary OA treated with primary total hip replacement (THR). Complications - One foot drop recovered after immediate repositioning of screw, 1 cardiac event and 1 pulmonary embolism.

Conclusion

Fracture mal-reduction predicts secondary OA but good fracture reduction does not prevent secondary OA. MIS and PF in elderly is useful even with suboptimal reduction as it sets the bed for a non-complex THR. Despite MIS surgery, medical complications are potentially significant.

Keywords

Trauma, Acetabulum, Fracture, Percutaneous fixation

INTRODUCTION

Acetabular fractures, with an incidence of 3/100000 per year, were first classified using the Judet and Letournel classification in 1964(1). Acetabular fracture incidence is increasing in the elderly and frail (12). The surgical "benchmark" is open reduction and internal fixation of these fractures with anatomical reduction being the aim to restore joint congruence and allow for rapid rehabilitation (2, 3).

However, the blood loss during open fixations can generally range from 400 cc to 1200 cc depending on the approach used and the fracture type (4,5). Open reduction and fracture fixation are also associated with potential morbidity and complications of neurovascular injury, blood loss, heterotopic bone formation, wound infection and delayed wound healing. (4-7). Although, open reduction and fixation remains the gold standard, it is potentially avoidable in certain fracture patterns and those unfit for an open fixation surgery, high BMI, frail or osteopenic patients (8-11).

With the advent of better imaging techniques, instruments and advances in science, minimally-invasive fixation techniques have become a viable option in this subset of frail or unfit patients. Percutaneous fixation reduces surgical time and blood loss and is associated with fewer complications (6). It allows for patients, who would generally be managed sub optimally by non-operative techniques, to have a chance at better outcomes with minimal risks.

Our study consists of 26 such patients who were managed by percutaneous fixation with or without minimally invasive surgery (MIS). These patients either had simple fracture patterns in younger patients that could be managed by percutaneous fixation or were unfit for an open reduction and internal fixation.

Aim of the Study

The purpose of this study was to analyse the radiological and clinical outcomes of percutaneous fixation of acetabular fractures.

METHODS AND METHODOLOGY

We performed a retrospective review of patients managed by percutaneous fixation of acetabular fractures in our hospital between July 2011 to October 2016. Twenty-six patients who matched our inclusion criteria of percutaneous fixation with or without minimally invasive surgery (MIS) were included in the study. Patients below 18 years of age, requiring open reduction or stabilization by osteosynthesis were excluded from the study. Also, patients fractures with articular impaction, die punch injuries and displaced wall fractures were excluded

The information on patient demographics, mechanism of injury, associated injuries, time to surgery, American Society of Anesthetists' (ASA) grade, fracture characteristics, surgical techniques, fracture reduction, secondary osteoarthritis, revision surgery, patient survival and complications were collected. Radiographs and Computerised Tomography (CT) scans were also reviewed pre- and post-operatively to assess the fracture pattern and classify them according to the Judet and Letournel classification (15). Follow up radiographs and clinical notes were also reviewed till fracture union, discharge, or revision surgery.

Study grouping

The 26 patients with a mean age of 56 years (19-86) were divided into 2 groups, U50 for those under 50 years of age and A50 for those above that. Eleven patients were found to be in the U50 group and all had high energy injuries and having either combined pelvi-acetabular injuries or other injuries. Only 2 patients in the A50 group had high energy injury while the rest had an isolated fracture. All U50 were ASA 1 or 2 while the A50 were ASA 3.

The follow up included radiological evaluation at 6 months and 2 years which included documentation of patient related outcome measures, any complications and secondary arthritis. The hospital records were reviewed for possible complications and their management including subsequent THR.

Surgical protocol

Fracture patterns amenable for percutaneous fixation and patients not suitable for open procedures were included.

All the patients underwent the same necessary pre-operative work up and were deemed fit for percutaneous screw fixation with or without a minimally invasive surgical approach

All had general anaesthesia (GA) and antibiotic prophylaxis. All were positioned supine on fully radiolucent operating table and 2-D fluoroscopy was used intra-operatively. Standard percutaneous and MIS techniques as described in the paper by Caviglia et al were utilised (22). In patients unsuitable for open procedures, whatever the best possible anatomical fracture reduction could be achieved was accepted and fracture fixation undertaken.

PF+/-MIS was not considered in cases with articular impaction, die punch injuries and displaced wall fractures. PF was performed in fractures that were reducible with either longitudinal traction +/- trochanteric pin traction. If acetabular articular surface remained incongruent despite adequate traction, MIS + PF was performed via lateral window of Ilio-inguinal approach and using specialist instruments (offset clamps/pointed reduction forceps, etc) fracture was reduced under fluoroscopy control and stabilised as required.

Post-operative rehabilitation protocols

Standard venous thromboembolism (VTE) prophylaxis as per hospital policy were undertaken for all patients. Post-operatively patients could sit out in a chair as soon as possible and weight bearing status was decided based on bone quality, fracture pattern, adequacy fracture reduction, fixation strength and ability of patients to mobilise partial weight bearing. Aim of rehabilitation was to achieve full weight bearing as early as possible and was tailored to the ability and needs of patients.

Follow-up

Follow up of patients was at 6 weeks, 3 months and 6 months and then as required. Standard Anteroposterior (AP) pelvic radiograph was performed at each visit. If there was any issue with fixation or fracture position or potential development of early avascular necrosis (AVN) of femoral head then, CT and Magnetic Resonance Imaging (MRI) scans of hips were performed. Patients were assessed by specialist physiotherapists and managed as per patient requirements. Patients were discharged from follow up when fracture had healed radiographically and clinically patients were able to fully weight bear without pain. Patients who developed secondary osteoarthritis (OA) were offered Total Hip Replacement (THR).

Statistical Analysis

Observational assessment of patient demographics and statistical analysis of the data comprising the demographics, fracture patterns, fixation and outcome was done using means, medians and ranges with a 95% confidence interval. Student's t-test was used to investigate differences in outcomes between the U50 and A50 groups. Data was analysed using R© (GNU General Public License).

RESULTS

There were 26 patients (22 males, 4 females) in this study with an average age of 56 years (18-70 years). The mean follow-up period was 46 months (24-88 months), with a minimum of 2 years excluding those that either died or were lost to follow up before that. There were 11 in U50 (all had high energy injuries) and 15 in A50 (only 2 had high energy injury) subgroups. The most common fracture pattern was found to be anterior column with posterior hemi transverse fractures (Table 1).

Fracture Type	Number
Anterior Wall	0
Anterior Column	7
Posterior Wall	0
Posterior Column	2
Transverse	1
Both Column	10
Anterior Column + Post Hemitransverse	4
T shaped	0
Transverse + post wall	0
Post column + Post wall	2

Table 1. Fracture patterns noted in the patients in the study

The breakdown of surgical intervention is shown in Figure 1 and 2. All the U50 group patients were a result of high energy injuries, of which only 3 were minimally displaced and amenable to percutaneous fixation while the rest had MIS and PF. Acceptable reduction (concentric, gap < 3mm and step off < 2 mm (20)) was attained in all of them but 2 patients went on to develop secondary OA on follow ups. These patients had not required surgery until the last follow up (Figure 3).

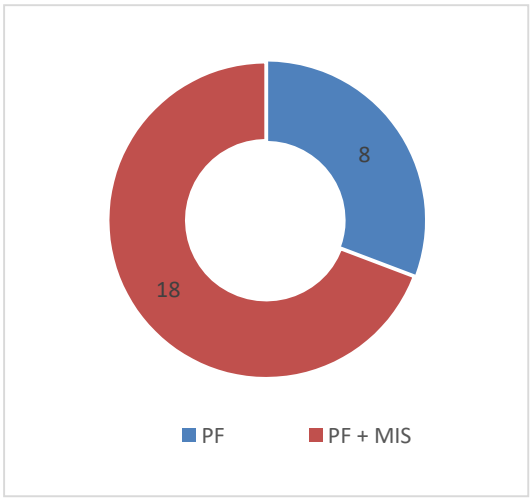

Figure 1 – Approach for fixation. (PF – Percutaneous Fixation, PF + MIS – Percutaneous Fixation + Minimally Invasive Surgery)

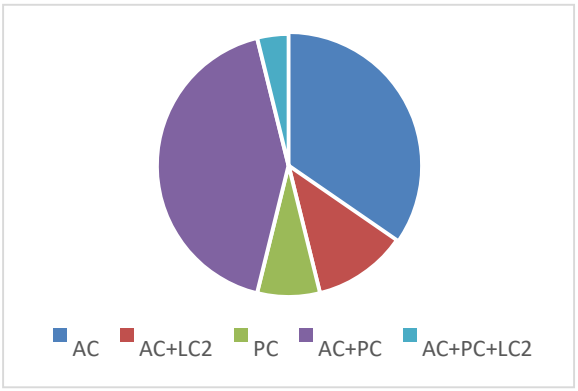

Figure 2 – Type of screw combinations used as per column. (AC – Anterior Column Screw, LC2 – Lateral Compression Type 2 Screw, PC – Posterior Column Screw, AC+PC – Anterior Column screw + Posterior Column Screw, AC+PC+LC2 – Anterior Column screw + Posterior Column Screw + Lateral Compression Type 2 Screw)

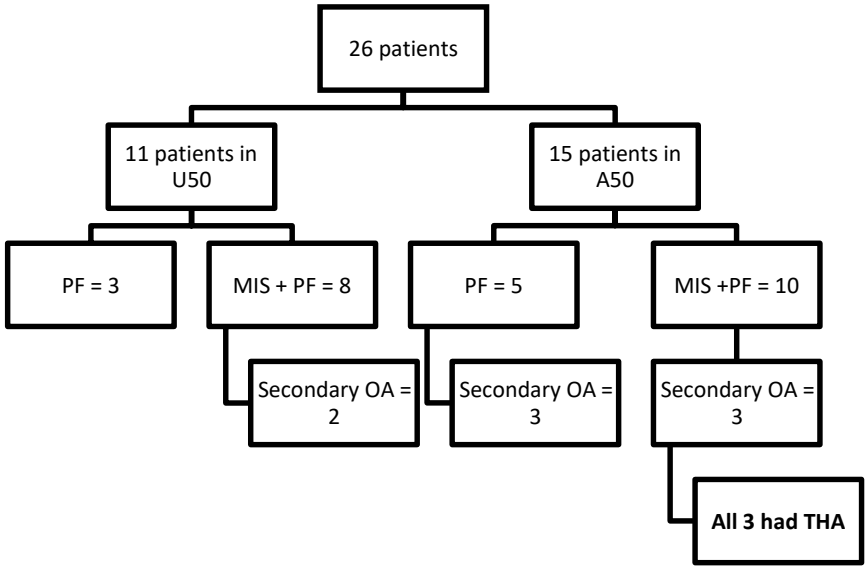

Figure 3 – Patient groups, fixation techniques and outcomes.

Figure 4. A – X ray Pelvis AP view showing Left Acetabular fracture. B – Post operative X ray of Pelvis AP view with secondary OA of Left Hip. C – THR of the Left Hip.

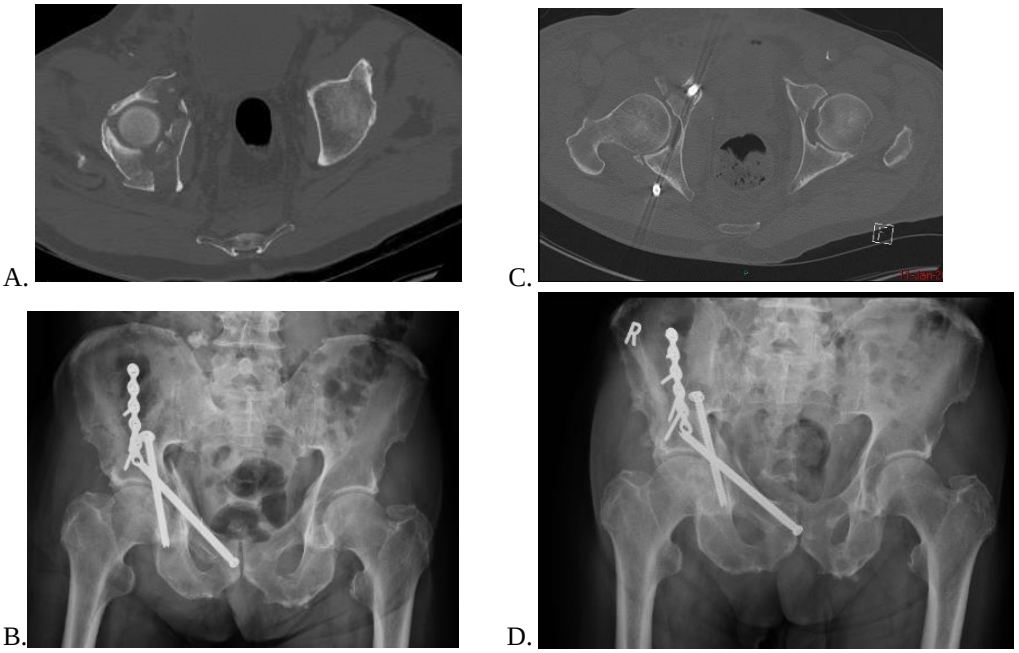

Figure 5 (Patient who developed foot drop). A – Preop Axial CT scan slice showing the fracture B – Post-operative radiograph. C – Post-op CT scan axial slice highlighting screw position. D – Post surgical revision for screw placement radiograph with recovery of foot drop.

All patients in the A50 group had displaced fractures but 5 of them were eventually managed only by PF while the rest needed MIS and PF. Three patients with only PF from this group had fair/ poor reduction as they were unfit for open reduction and consequently developed secondary OA. However, none of them required further surgery. Three other patients from the MIS and PF group had good post-operative anatomical reduction but went on to develop secondary OA and subsequently a THR (Figure 4).

One patient developed foot drop in the post-operative period and on evaluation was found to have been due to a prominent Posterior column screw. Foot drop recovered after revision surgery to reposition the screw. One patient had a cardiac event, and another had an episode of pulmonary embolism but both recovered uneventfully (Figure 5).

DISCUSSION

Judet and Letournel recognised that the principles of articular fixation also applied to the acetabulum. (17) In time, open reduction internal fixation of these fractures became the standard treatment for acetabular fractures but while it reduced incidence of post traumatic arthritis it was associated with extensile approaches and more complications. (18) Conversely, in patients with malunion of acetabular fractures, rehabilitation is challenging (14). If managed non-operatively, a vast proportion do not achieve a satisfactory reduction and struggle with rehabilitation. Magu et al (13) reported that only 57% of the patients treated non-operatively achieved a satisfactory reduction.

Percutaneous fixation of acetabular fractures has been associated with good results and lower complications rates (19). Also, it has been shown that in elderly patients with these fractures have similar outcomes and rate of conversion to a THR whether they are treated by open reduction or percutaneous fixation. (21)

Open reduction leads to much higher morbidity to the patients with risks to several important neuro-vascular structures in and around the pelvi-acetabular region. PF and MIS are good options for patients with high BMI but have less than optimal intra-operative fluoroscopy images. In our study, of the 15 patients in the A50 group, 3 didn't have anatomical reduction due to being unfit for open reduction. However, even though post-operative reduction was fair – poor in them and they developed secondary OA, all 3 have not had THR as their symptoms are managed with analgesia and lifestyle modification. Gary JL et al showed in their study that minimally invasive techniques reduce surgical time and blood loss (11) which are known complications with open reduction and internal fixation.

The complex acetabular geometry and narrow bone conduits makes percutaneous screw insertion a challenging procedure as it requires high precision and a steep learning curve. However, there are well proven PF techniques to achieve and maintain fracture stability via screws inserted along safe corridors in pubic rami, posterior column and along roof of acetabulum (16)

Spencer (15) reported that about two thirds of the patients managed to return to previous level of activities, however this did not necessarily co-relate with the radiological picture. This shows that good reduction is one of the many factors important to a good outcome in such patients.

The limitations of our study are that it is retrospective and has limited numbers and doesn't incorporate all types of fractures as per the Judet classification. However, with the medium term follow up of our patients it shows that the principles of PF and MIS are sound and have a strong role in the management of minimally displaced acetabular fractures and those unamenable to open reduction.

CONCLUSION

In acetabular fractures that do not have articular impaction or displaced wall fractures and are reducible either by traction or via MIS and specialist instruments, PF+/-MIS is a safe and effective option. These techniques are valuable in frail patients who are unsuitable for open fracture reduction. Even if perfect reduction is not achieved, it provides early pain relief and prevents complications associated with prolonged bed rest. It also sets the bed for a non-complex THR if required.

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Title page

Fracture Characteristics and outcomes of acetabular fracture management with minimally invasive approach and percutaneous fixation

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