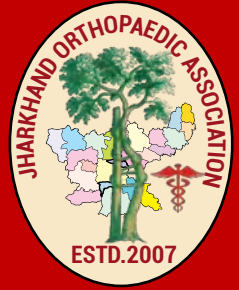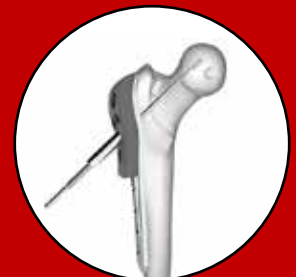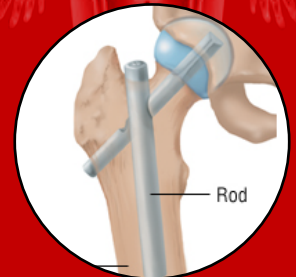# JOURNAL
OF JHARKHAND ORTHOPAEDIC
ASSOCIATION

An Official Publicationof Jharkhand Orthopaedic Association

Rod

CONTENT

FROM THE EDITOR'S DESK

"WE NEVER SETTLE FOR BEING THE BEST, WE ALWAYS STRIVE TO BE BETTER"

It gives me immense pleasure to present before you this third edition of JOA Journal . All of us have beared the brunt of the Painful Covid situation and yet the peril still persists. But I firmly do believe that even in this tough time our endeavour of learning should not stop. With this in the mind I have compiled this work which is having a crisp , concise and comprehensive texts on different interesting topics, with an insight into the new and upcoming scientific advancements in the field of Orthopaedics and trauma surgery.

I would also like to thanks to all the contributors of this edition for they have made a great and wonderful effort to make it a worthful edition . And I hope that may browsing through this enlighten you and let you gain from this .

It is my continuous and sincere endeavour to make our this JHARKHAND ORTHOPAEDIC ASSOCIATION (JOA) JOURNAL , as one of the reputed journals in the country.

I wish that we together will make this JOACON 2021 very fruitful and memorable.

Enjoy Reading..

Dr. Govind Kr. Gupta
Hon.Secretay, JOA
Associate Professor
RIMS, RANCHI

ARTIFICIAL INTELLIGENCE IN ORTHOPAEDICS

Dr. Govind Kumar Gupta

Associate. Professor

Department of Orthopaedics, Rajendra Institute Of Medical Sciences, Ranchi

ABSTRACT

As the term ARTIFICIAL INTELLIGENCE (AI), came into use first in the 1950s, it has found an increasing application through rapid technological advances and has also found its way in Health care sector including Orthopaedics. AI aims to reproduce human intelligence using computers. It provides machines with the ability to perform tasks using algorithms governed by pattern recognition and self-correction on large amounts of data to narrow options in order to avoid errors. Machine learning (ML) is a form of AI that uses computational algorithms that learn and improve with experience. The two main forms of ML are supervised and unsupervised. The greatest benefit of ML is in its ability to learn from real-world clinical use and experience, and thereby its capability to improve its own performance. Many successful applications are known in orthopaedics, but have yet to be adopted and evaluated for accuracy and efficacy in patients' care and doctors' workflows

INTRODUCTION

Artificial Intelligence has seen tremendous growth in recent years, and some of its major applications such as search engines, voice recognition software, and autonomous driving vehicles are now part of our daily lives. Artificial intelligence (AI) is believed to have the capacity to change the scope of medicine, much as the introduction of smartphones changed our day-to-day lives. AI research is now also being a part in different medical fields, and shows great promise in promoting practice efficacy, personalizing patient management, and improving research capacity.

AI and machine learning (ML) are terms commonly used to cover a range of computer applications such as ML-derived clinical decision support, deep learning (DL)-based computer vision and natural language processing (NLP). In essence, computers use human-created algorithms for analysing patterns in data and improve their performance by learning from their own mistakes. The increase in (cheap) powerful computers and availability of larger and more robust data have fuelled the use of ML in healthcare[1]. In this article I hereby aim at outlining the current applications and future perspective of artificial intelligence in orthopaedics.

DISCUSSION

AI has got a diverse forms of applications in different medical specialities including orthopaedics. Some of them with most common and most promising applications with their current application and potential future application are –

A) AI IN IMAGING TECHNOLOGIES

AI has an important application in various imaging techniques in the medical field ranging from data acquisition to reconstruction and from analysis to interpretation. By utilising information from the patient's medical records (including symptoms, laboratory results, and physical examination findings), AI identifies the most appropriate patient-specific imaging examination and determines the most appropriate protocol. AI can also potentially increase the speed of magnetic resonance imaging (MRI) data acquisition and decrease the computed tomography (CT) radiation dose.[1]

The most popular area of AI research is image interpretation. Definitely it does not aim at replacing the radiologist but helps the radiologist to improve the diagnostic accuracy and preventing errors and observer biasing . AI algorithms have

been applied to different conditions, including the diagnosis of fractures, osteoarthritis, bone age, and bone strength. AI performs as well as or better than orthopedic surgeons in detecting fractures of the proximal humerus, hand, wrist, ankle, and vertebral compression fractures on radiographs. AI improves the accuracy of bone age interpretation compared with aging done by a radiologist alone; however, the most accurate values are achieved when AI is used in combination with a radiologist AI can help automate the grading of lumbar disc pathology on MRI using various classification systems, with an accuracy of 95.6% for disc detection and labeling. AI also improves quantitative image analysis by allowing automatic segmentation of the area of interest, and many studies have focused on knee cartilage segmentation, with promising initial results. However, whilst AI-assisted image interpretation can be accurate, it does require large training datasets, which may be costly and attenuate service inequality. With ongoing technological advances, AI in imaging will improve and become more widely applied.

B) ROLE OF AI & ML IN PREDICTING ORTHOPAEDIC OUTCOMES

A major potential use for AI in healthcare is in predicting the clinical outcome of patients based on a clinical dataset, genomic information, and medical images. Risk assessment and outcome prediction have always been challenging in clinical medicine. AI offers a new direction that could potentially overcome these challenges. In orthopedics, ML can be used to guide the management of patients by providing a patient-specific predicted rate of post-operative complications following lumbar fusion surgery.In addition, visual and inertial sensor data can be analyzed by ML to predict injury risk patterns associated with dynamic knee valgus[5].

The AI technique can help the doctor to make a diagnosis or decision. Clinical decision support systems also provide recommendations on the diagnosis and treatment of low back pain; these systems can classify subjects, and further progress could enable the combination of AI plus clinician to make more rigorous classifications than human decision-making alone. Thus, AI may enable more accurate allocation to services in the future, whilst increasing the accessibility and speed of self-referral.

C) ROLE OF AI IN THE MANAGEMENT OF ACL INJURIES

In orthopaedic sports pathology, close to half of all injuries involve the knee. Of these injuries, tears of the anterior cruciate ligament (ACL) are frequently encountered, with noncontact ACL injuries making up to 78% of all sport-related knee pathology[2]. Although common, the diagnosis of clinically significant ACL injuries can be challenging for clinicians. ML may facilitate this by providing ways of addressing the variability of certain clinical tests, such as the pivot shift, while improving the diagnostic accuracy of magnetic resonance imaging (MRI). However, along with improving diagnostics, AI may also serve to provide more robust solutions to other issues relating to the management of ACL tears. The accurate prediction of individuals at risk of ACL injury or reinjury, the identification of complex anatomic landmarks intraoperatively, and the optimization of pain control and rehabilitation protocols postoperatively present unique challenges that are well suited to ML modalities. There are studies which show , how ML, with its ability to assess complex nonlinear relationships, can be used to address and improve the detection, treatment, and rehabilitation of individuals with ACL injuries.

D) ROLE OF AI IN MUSCULOSKELETAL ONCOLOGICAL RADIOLOGY

Computer-aided detection (CADe) and computer-aided diagnosis (CADx) algorithms have been used for the last two decades predominantly in mammography, detection of lung, and colon malignancies. The first attempts to introduce computational power into diagnostic procedures of primary bone tumors date back to the 1960s. Based on Bayes' formula, a computer program accurately

predicted a bone tumor diagnosis in 77.9% of cases[3]. Later in 1980, the same author set a milestone by publishing an article about computed-based radiographic grading of bone tumor destruction. This was a cornerstone for further research and implementation of neural networks into the diagnosis of focal bone lesions.

Healthy and tumorous bone differs in numerous characteristics. Unlike healthy osseous tissue, which consists of cortical and trabecular part, primary bone malignancies may penetrate cortex and spread into adjacent soft tissue, as well as cause swelling around the bone or even weaken the bone architecture and lead to pathological fracture. Radiologically, they differ in absorption rate, which can be quantitatively evaluated. For example, CADx has been used to detect and classify primary bone tumors into benign and malignant lesions using x-ray images. In their study, Ping et al. an overall greater intensity of pixels for malignant bone tumors compared to benign bone tumors. Another study by Bandyopadhyay et al. proposed a CADx method to automatically analyze bone x-ray images. By integrating several classifiers, the method achieved accurate decisions regarding a bone-destruction pattern, stage, and grade of cancer in 85% of cases.

When describing sarcomas, diagnosed on MRI, features like tumor size, shape, and enhancement pattern are estimated and taken into consideration along with patient's demographic data. Machine learning and artificial neural network excel in quantifying and extracting supplementary features, which can correlate with clinical characteristics, diagnosis, and outcomes. Most of these are out of human visual perception and include inter-voxel relationships, image intensity analysis, and filtered images analysis. Deep learning-based algorithm has also been developed to predict survival rates in patients with synovial sarcoma. Its prediction was more precise compared to the Cox proportional hazard model, which is a commonly used regression model in medical research.

In primary bone tumors, bone tumor matrix, its density, and zone of transition represent suitable characteristics than may be classified through deep learning techniques. In fact, recurrent convolutional neural network outshined experienced musculoskeletal radiologists in bone tumor matrix classification with 86% vs. 72%, respectively. Li et al. proposed a super label guided convolutional neural network to classify CT images of bone tumors[4]. In comparison, results exceeded the classic convolutional neural network. However, the classification included only nine types of the most common skeletal tumors.

These are some of the application of AI & ML in the field of Orthopaedics with a very promising future in enhancing our ways of management of patients. AI has revolutionized the face of modern orthopedic surgery, but at present, its use is neither universal nor perfect. The limitations of AI are existing. First, the use of AI is limited by the high capital cost, the time needed for its use (both in preparation and intra-operatively), the variable reliability of AI technologies, and the absence of long-term follow-up studies. Therefore, the cost and time of the AI technique needs to be decreased, and more long-term studies are required. Second, there are ethical considerations regarding the use of ML in orthopedic surgery. Working with bulk datasets increases the risks of breaching patient confidentiality and consent unless safeguards are in place, especially where conflicts exist between patient and commercial interests. Furthermore, in cases of misdiagnosis or maloperation, it is unclear whether the doctor or the robot should be held responsible. Thus, it is important that ML is meticulously studied, managed, and appropriately validated. Third, to date, surgical robots and the AI technique can only be used to perform relatively simple procedures, and possess little autonomy and decision-making authority in treatment; these limitations have caused some people to question the usefulness of AI. However, scientists and engineers are making substantial advancements in AI-assisted procedures from non-autonomic robot assistance

to task-autonomy or conditional autonomy and, eventually, full automation. Self-learning machines will be able to directly perform independent tasks in the future. However, there may be circumstances where human clinicians are unable to control or override these procedures made by an AI device. Finally, as AI is a new and emerging field in medicine, patient interests may be at risk due to technological advances invariably preceding proper governance and patient-protective legislation.

Despite its pitfalls and potential shortcomings, AI &ML provides a unique ability to create meaningful change

REFERENCES

1. Han XG, Tian W. Artificial intelligence in orthopedic surgery: current state and future perspective. Chin Med J (Engl). 2019; 132(21): 2521-2523. doi: 10.1097/CM9. 0000000000000479

2. Corban, Jason et al. "Artificial Intelligence in the Management of Anterior Cruciate Ligament Injuries." Orthopaedic journal of sports medicine vol. 9,7 23259671211014206. 2 Jul. 2021, doi:10.1177/23259671211014206

3. Vogrin M, Trojner T, Kelc R. Artificial intelligence in musculoskeletal oncological radiology. Radiol Oncol. 2020;55(1):1-6. Published 2020 Nov 10. doi:10.2478/raon-2020-0068

4. Maffulli N, Rodriguez HC, Stone IW, et al. Artificial intelligence and machine learning in orthopedic surgery: a systematic review protocol. J Orthop Surg Res. 2020;15(1):478. Published 2020 Oct 19. doi:10.1186/s13018-020-02002-z

5. Bayliss L, Jones LD. The role of artificial intelligence and machine learning in predicting orthopaedic outcomes. Bone Joint J. 2019 Dec;101-B(12):1476-1478. doi: 10.1302/0301-620X.101B12.BJJ-2019-0850. R1. PMID: 31786999.

ROLE OF ADJUNCTIVE FIBULAR FIXATION IN DISTAL TIBIAL EXTRAARTICULAR FRACTURE (AO/OTA TYPE 43A1) MANAGED WITH LOCKED INTRAMEDULLARY NAILING

Dr. Ravindra Prasad[1] Dr. Bimal Thapa[2] Prof. Dr. L.B Manjhi[3]

1. Senior Resident 2. Junior Resident 3. Professor and Head of Department

Department of Orthopaedics, Rajendra Institute of Medical Sciences, Ranchi

ABSTRACT

Introduction: Lower tibial extra articular fractures constitute about 15% of all distal tibial fractures and commonly occur as a result of high energy trauma as in RTA or fall from height. Presence of a concomitant lower fibular fracture as seen in 80% of these cases renders these fractures highly unstable. However, the decision of whether to fix concurrent fibular fractures especially when there is no syndesmotic instability is still under scan as different studies conducted have not been uniform in their conclusion.

Aim: to assess the role of adjunctive fibular fixation in the treatment of extraarticular distal tibial fracture with regard to radiographic outcome, non-union and infection rate.

Method: a prospective, randomized study consisting of 28 patients having distal tibia extraarticular fracture with fibula fracture at the same level distributed in two groups A and B in which group A (n=13) patients were managed with locked Intramedullary nailing tibia with adjunctive fibular fixation with one third tubular plate or 3.5mm DCP or locking plate while group B patients were treated with IM nailing tibia without concurrent fibular fixation. Parameters evaluated included radiological outcome in terms of malalignment of tibial shaft, sagittal and coronal plane and rotational deformities, rates of nonunion and infection and functional outcome assessed using Olerud and Molander score.

Result: Mean age of the patients in group A where fibula fixation was carried out was 32.7 years (range 24-54 years) while in group B where no fibula fixation was done, it was 35.3 years (range 28-61 years). No statistically significant difference was found between the two groups with regard to age, sex as well as type of fracture. Mean time of union was 19.4 weeks in group A while in group B, it was 18.6 weeks. No significant difference was found in varus or valgus deformity and anterior or posterior angulation between the two groups. However, rotational deformity was significantly lesser in fibula fixation group. Final functional outcome evaluated using Olerud and Molander score at 6 months shown excellent result in 15.4% cases, good result in 53.8% cases and fair result in 30.8% cases in group A patient. For group B patients, excellent result was seen in 13.3% cases, good result in 40% cases and fair result in 46.7% cases.

Conclusion: In distal tibial extraarticular fracture with fibula fracture at the same level treated with locked intramedullary nailing, adjunctive fibular fixation is advisable to improve rotational deformity thereby increasing mechanical stability of construct. However, it may not lead to any reduction in the rate of sagittal or coronal plane deformity or malreduction.

Keywords: distal tibia extraarticular fracture, fibula fracture, tibia nailing, fibula plating

INTRODUCTION

Lower tibial extra articular fractures constitute about 15% of all distal tibial fractures and commonly occur as a result of high energy trauma as in RTA or fall from height. Presence of a concomitant lower fibular fracture as seen in 80% of these cases renders these fractures highly unstable. High velocity trauma associated with these fractures along with limited

tissue cover over lower leg significantly increases the risk of complications arising from operative fixation of these fractures like increased infection rate, soft tissue complication and delayed union. As intramedullary nailing techniques have evolved over past years, they are preferred implants for these elementary fractures whenever feasible compared to plating as they cause minimal tissue damage in already traumatized distal part of the leg. However, the decision of whether to fix concurrent fibular fractures especially when there is no syndesmotic instability is still under scan as different studies conducted have not been uniform in their conclusion.

Biomechanical studies performed over cadaveric models have favored fixation of fibula in view of improved ability to obtain and maintain reduction in complex fracture patterns, thereby increasing stability of construct. However, this stable construct also anticipates increased risk of complications in the form of delayed or nonunion as it inhibits cyclic loading on tibial fracture. Moreover, placing an incision in already traumatized soft tissues in this region for open reduction and internal fixation of fibula inherently carries an increased rate of wound complications.

Hence, our study is aimed to assess the role of adjunctive fibular fixation in the treatment of extraarticular distal tibial fracture managed with locked intramedullary nailing with regard to radiographic outcome, non-union, infection rate and functional outcome.

METHOD

This is a prospective, randomized study carried out at Rajendra Institute of Medical Sciences, Ranchi between April 2020 to March 2021. It included 28 patients of distal tibia fibula fractures who met the inclusion and exclusion criteria. Randomization of all patients was done in two groups A and B in which group A patients were managed with locked intramedullary nailingalong with adjunctive fibular fixation with one third tubular or 3.5mm DCP or locking plate. Group B consisted of patients who

received IM nailing without any fixation of fibula. A written informed consent was taken from all patients undergoing the study.

INCLUSION CRITERIA:

1. extra articular distal tibial fracture (AO/OTA Type 43A1) with a concomitant fibular fracture at the same level

2. Age more than 18 years

3. closed and Open Grade 1 (Gustilo Anderson classification)

EXCLUSION CRITERIA:

1. distal tibial fractures with intraarticular extension (Pilon fracture)

2. fibula fracture below the level of distal tibiofibular syndesmosis.

Upon arrival of the patients in the Emergency room, a careful history elicited to reveal the mechanism of injury and severity of trauma. General medical condition of the patient assessed. Radiographs of injured leg including knee and ankle both AP and Lateral obtained and fracture classification was done as per AO/OTA as we included only Type 43A1 in our study. Routine preoperative investigations then carried out with optimization of associated comorbidities if any. An above knee POP Slab support was given along with limb elevation for the relief of pain and allow the swelling to subside. Antibiotic prophylaxis was started one day prior to scheduled day of operation. Most of the cases were operated within a week of trauma.

Surgical technique: All the cases were operated with the patient positioned supine over standard radiolucent table under image intensifier guidance. In patients of group A, fibular fixation was done through an open reduction through posterolateral approach and fixation with one third tubular or 3.5mm DCP or locking plate prior to fixation of tibia. For locked IM nailing of tibia, patellar tendon splitting approach was used and closed reduction

done by traction, manipulation and use of reduction clamps. Central positioning of guide wire into the distal metaphyseal fragment was ensured and after appropriate reaming, tibial nail introduced with 2 or 3 screws interlocked in distal fragment.

Postoperatively, all patients were kept in strict limb elevation. Gentle ankle toes movement, static quadriceps and knee and ankle ROM exercises were initiated from the next postoperative day. Absolute non weight bearing was adopted in first month. After 1 month, partial weight bearing ambulation was started on surgeon's discretion which later progressed to full weight bearing based on clinical and radiological evidence of callus formation.

Follow up protocol: All the patients were followed up at 2 weeks, 4 weeks and monthly thereafter until fracture union and assessed clinically and radiologically for malalignment or malrotation of tibial shaft, varus or valgus angulation, anterior or posterior angulation, internal or external rotational deformity, non-union and infection. For evaluation of final functional outcome, Olerud and Molander score was used at 6 months which consists of self-administered patient questionnaire with score ranging from zero to hundred.

Radio graphic union was defined as cortical bridging on three or more cortices on orthogonal radiographic views. Nonunion was defined as a fracture with no radiographic progression toward healing at 9 months after surgery on consecutive radiographs over a minimum 2-month period accompanied by clinical symptoms of nonunion.Delayed union was defined using the same definition, but for fractures between 6 and 9 months. Varus-valgus deformity was defined as coronal plane deviation>5° on final radiographs. Anterior-posterior deformity was defined as sagittal plane deviation>10° on the final radiograph. Rotational deformity was defined as an internal/ external rotation deformity>10° compared to the normal contralateral limb.Malreduction was defined as coronalor sagittal plane deviation of>5° on immediate postoperative radiograph.
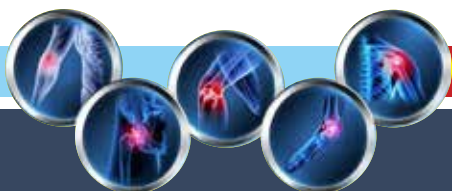
RESULT

We included a total of 28 patients for this study. Group A patients where adjunctive fibula fixation was carried out included 13 patients whereas GroupB included 15 patients where fibula was not fixed.

Mean age of the patients in group A where fibula fixation was carried out was 32.7 years (range 24-54 years) while in group B where no fibula fixation was done, it was 35.3 years (range 28-61 years). Incidence of fracture was seen predominantly in male population accounting for 67.85% cases probably related to increased outdoor activities. Commonest mode of injury was RTA seen in 82.1% cases followed by fall from height in 14.3% cases. We included only A0/OTA type 43A1 distal tibia fibula fractures in this study. No statistically significant difference was found between the two groups with regard to age, sex as well as type of fracture.

Parameter	Group A (fibula fixed)	Group B (fibula not fixed)
Sample size (n)	13	15
Mean age (year)	32.7	35.3
Gender (M/F)	7/4	13/5
Laterality (R/L)	9/4	11/7
Mean union time (week)	18.4	17.6
Nonunion/delayed union rate (%)	6.6	7.7
Infection rate (%)	none	none

Table/ Fig-1: Relevant Patient related, functional and complication related variables between the two groups

Mean time of union was 19.4 weeks in group A while in group B, it was 18.6 weeks. No statistically significant difference was found between the two groups with regard to time to union.One case each of delayed union was seen in each group with a

delayed union rate comparatively lower in group A (6.6%) than group B (7.7%). This was also found to be statistically insignificant. Hence, this study doesn't favor the theory that additional fibular plate fixation increases the risk of infection in contrast to some studies conducted earlier.

We evaluated the radiographic outcome with respect to malalignment or malrotation of tibial shaft, sagittal and coronal plane angulation and rotation deformity.

Radiographic alignment	Group A	Group B
Varus/Valgus angulation	7.5°	8.4°
Anterior/Posterior angulation	4.3°	4.9°
Int/Ext rotational deformity	8.7°	13.6°

Table/Fig-2: Radiographic outcome between the two groups

This study found no significant difference in varus or valgus deformity and anterior or posterior angulation between the two groups. However, rotational deformity was significantly lesser in fibula fixation group. Also, no significant difference was found regarding Malreduction in both the groups indicating that concurrent fibular fixation doesn't affect the surgery over tibia.

However, many studies have indicated that adjunctive fixation of fibula in distal tibia fibula fractures preserves the reduction of tibia and have advocated concurrent fibular fixation in such cases. Study by Kumar et al favored fibular plate fixation in view of increased rotational stability after distal tibia fractures in comparison to treatment by IM nailing alone. Other clinical studies such as by Tabake et al and Goh et al also mentioned that rate of complication was highest when additional fibular plate fixation was not done and recommended fibular fixation in combined distal tibia and fibula fractures at the same level. In a laboratory experiment conducted by Strauss et al to compare IM nail with locked plates
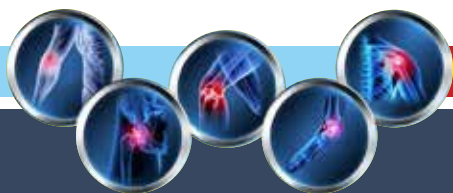
in treatment of distal tibia fractures with concurrent same level fibula fracture found that imperfect fibula achieved by osteotomy significantly increases the rate of construct displacement regardless of the type of fixation used. They concluded that an intact fibula may improve fracture fixation stability of the distal tibia. Study by Kumar et al on cadaveric models investigated the effect of fibular platefixation on axial rotation of simulated fracture of distal tibia fibula. They also found that additional fibula plate fixation decreases axial rotation and increases rotational stability without increasing rotational stiffness. However, study by Weber reported that effect of fibular plate fixation on stability was weakened if tibia was fixed with an IM nail.
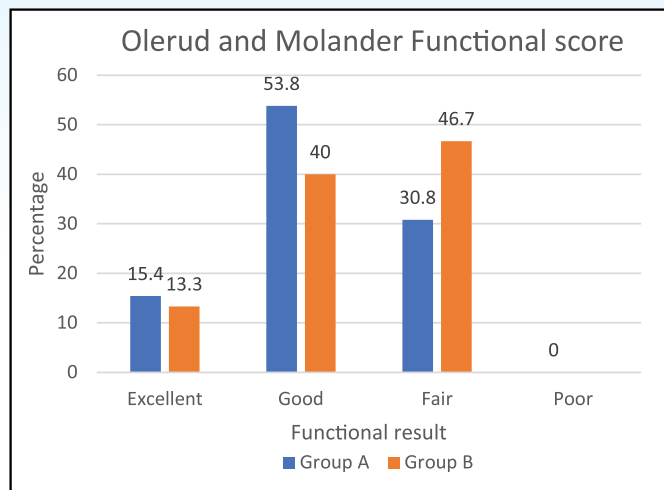

Table/Fig-3: Pre and postoperative radiograph showing tibial fracture fixation without concurrent fibular fixation

Table/Fig-4: Pre and Postoperative radiograph showing tibial fracture fixation with adjunctive fibular fixation

Table/Fig-5: Final functional score among the two groups

Final functional outcome evaluated using Olerud and Molander score at 6 months shown excellent result in 15.4% cases, good result in 53.8% cases and fair result in 30.8% cases in group A patient. For group B patients, excellent result was seen in 13.3% cases, good result in 40% cases and fair result in 46.7% cases. None of the patients in either group had poor result.

Limitation of this study remains a relatively smaller sample size with shorter duration of follow up. A larger size of the sample with longer follow up is required for stronger validation of results.

CONCLUSION

Based on the results of this study, it can be concluded that in case of distal tibial extraarticular fracture with fibula fracture at the same level treated with locked intramedullary nailing, adjunctive fibular fixation is advisable to improve rotational deformity thereby increasing mechanical stability of construct. However, it may not lead to any reduction in the rate of sagittal or coronal plane deformity or Malreduction.

REFERENCES

1. F. Pogliacomi, S. Paolo, C. Filippo, C. Francesco, and V. Enrico, "When is indicated fibular fixation in extra-articular fractures of the distal tibia?" Acta Bio Medica, vol. 89, no. 4, pp. 558–563, 2019

2. M. Githens, J. Haller, J. Agel, and R. Firoozabadi, "Does concurrent tibial intramedullary nailing and fibular fixation increase rates of tibial nonunion? a matched cohort study," Journal of Orthopaedic Trauma, vol. 31, no. 6, pp. 316–320, 2017.

3. M. Javdan, M.A. Tahririan, M.Nouri,"Theroleoffibular fixation in the treatment of combined distal tibia and fibula fracture: a randomized, control trial," Advanced Biomedical Research, vol. 6, p. 48, 2017

4. M. Berlusconi, L. Busnelli, F. Chiodini, N. Portinaro,"To fix or not to fix? the role of fibular fixation in distal shaft fractures of the leg," Injury, vol. 45, no. 2, pp. 408–411, 2014

5. D. Torino and S. Mehta, "Fibular fixation in distal tibia fractures: reduction aid or nonunion generator?" Journal of Orthopaedic Trauma, vol. 30, no. 4, pp. S22–S25, 2016

6. R. Varsalona, G. T. Liu, "Distal tibial metaphyseal fractures: theroleoffibular fixation," Strategies in Trauma &Limb Reconstruction, vol. 1, no. 1, pp. 42–50, 2006

7. M. Prasad, S. Yadav, A. Sud, N. C Arora, N. Kumar, and S. Singh, "Assessment of the role of fibular fixation in distalthird tibia-fibula fractures and its significance in decreasing malrotation and malalignment," Injury, vol. 44, no. 12, pp. 1885–1891, 2013.

8. A. Rouhani, A. Elmi, H. Akbari Aghdam, F. Panahi, and Y. Dokht Ghafari, "Theroleoffibular fixation in the treatment of tibia diaphysis distal third fractures," Orthopedics & Traumatology: Surgery & Research, vol.98, no.8, pp.868–872, 2012.

9.   B. C. Taylor, B. R. Hartley, N. Formaini, and T. J. Bramwell, "Necessity for fibular fixation associated with distal tibia fractures," Injury, vol. 46, no. 12, pp. 2438–2442, 2015

10.   E. J. Strauss, D. Alfonso, F. J. Kummer, K. A. Egol, and N.C. Tejwani, "The effect of con current fibular fracture on the fixation of distal tibia fractures: a laboratory comparison of intramedullary nails with locked plates," Journal of Orthopaedic Trauma, vol. 21, no. 3, pp. 172–177, 2007

11.   R. Schnettler, M. Borner, and E. Soldner, "Results of interlocking nailing of distaltibial fractures," Unfallchirurg, vol.93, no. 11, pp. 534–537, 1990

12.   A. Kumar, S. J. Charlebois, E. Lyle Cain, R. A. Smith, A.U. Daniels, J.M.Crates, "Effect of fibular plate fixation on rotational stability of simulated distal tibial fractures treated within tramedullary nailing," Journal of Boneand Joint Surgery, vol. 85, no. 4, pp. 604–608, 2003.

13.   T. G. Weber, R. M. Harrington, M. B. Henley, and A. F. Tencer, "The role of fibular fixation in combined fractures of the tibia and fibula: a biomechanical investigation," Journal of Orthopaedic Trauma, vol. 11, no. 3, pp. 206–211, 1997.

EVOLUTION OF FRACTURE TREATMENT WITH BONE PLATES

Dr. Unmesh Kumar Sahoo[1] Dr. Subhankar Mandal[2]

1. Senior Resident 2. Junior Resident

Department of Orthopaedics, Rajendra Institute of Medical Sciences, Ranchi

ABSTRACT

Internal fixation of bone fractures by plate osteosynthesis has continuously evolved for more than 100 years. The aim of internal fracture fixation has always been to restore the functional capacity of the broken bone. The principal requirements of operative fracture management, those being anatomical fracture reduction, durable fixation, preservation of biology, promotion of fracture healing and early patient mobilization, have always been crucial but were accomplished to different extents depending on the focus of the specific fracture fixation principle employed. The first successful approach for internal fracture fixation was anatomic open reduction and interfragmentary compression. This secured the fracture fragments, maintained alignment and enabled direct healing of the fracture fragments. However, the highly invasive approach inflicted an immense amount of biologic stress to the area surrounding the fracture site. Modern preferably anatomically pre-contoured locking plates with relative stability of the bone-implant construct enable durable fixation while allowing a less invasive approach that preserves the biology at the fracture site. In contrast to conventional plating, locked plating provides a certain amount of flexibility, which is required to induce the formation of periosteal callus through interfragmentary motion. Most recently the concept of dynamic plating was introduced, which aims to induce more controlled interfragmentary motion and active stimulation of periosteal callus formation. This review article describes the historic development of plating from conventional plating to locked and dynamic plating

KEYWORDS

Bone, Fracture, Bone plate, Active plating

HISTORY OF FRACTURE TREATMENT BY PLATES

The internal fixation of broken bones only became possible after the introduction of aseptic techniques for open reduction of fractures and direct fixation with metallic hardware. It was Joseph Lister (1827–1912), a British surgeon who promoted the idea of sterile surgical intervention by using carbolic acid (phenol) to sterilize surgical instruments and to clean wounds [1]. This enabled Lister to successfully open closed fractures of the patella and fix them by wiring without causing wound infection and sepsis [2]. Not much later, by the end of the 19th century, the concept of fracture fixation using screws and plates was introduced by several European surgeons, including Carl Hansmann (1853–1917), William Arbuthnot Lane (1856–1943) and Albin Lambotte (1866–1956). Hansmann introduced the concept of temporary internal fixation with nickel coated steel plates [3]. The plates provided a sort of handle which penetrated the skin and was used for percutaneous removal after the fractures were consolidated. William Lane's strict adherence to sterile, no touch procedures enabled him to pioneer the technique of open reduction and internal fixation (ORIF). He employed a variety of steel plates, screws and cables for the stable fixation of fractures if possible with interfragmentary compression to maintain fracture alignment [4]. Lambotte further increased the variety of fractures he treated and the types of implants he used, leading to the inception of contemporary "osteosynthesis", as formulated in 1912: "…the most certain way to obtain a good functional result is to secure a good anatomical result." [5,6] Nevertheless, all the implants used in these times were doomed to fail through metal

corrosion and were thus required to be removed soon after completion of fracture healing. Developing implants from corrosion resistant metal alloys which provided sufficient strength and holding power for plates, screws, pins, and cables required engineering knowledge [7]. This eventually led to introduction of the nonferrous steel alloy of cobalt with chromium and molybdenum as well as titanium and its alloys [8,9].

With the availability of more biologically inert materials for fracture fixation, further development of ORIF focused on techniques to optimize the fracture healing process. Robert Danis (1880–1962) studied the biology of fracture healing and published in his "Théorie et pratique de l'ostéosynthèse" that "[Callus] should be regarded as a pathological structure whose formation can usually be prevented by internal fixation" [10]. Consequently, his idea of internal fixation was rigid fixation of fractures obtained through axial interfragmentary compression and prevention of any interfragmentary movements. After Danis' formulation of the principle of rigid

Fig. 1. Internal fixation of a forearm shaft fracture using rigid small fragment compression plates in radius and ulna shaft.
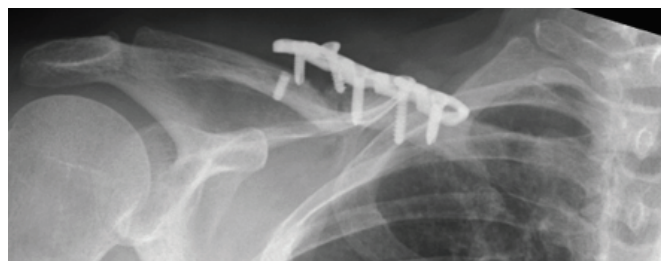
fixation and compression, various technical solutions were developed that enabled the application of compression to a fractured bone. These included the coapteur of Danis, a compression clasp by Venable [11], the tensioner by Müller and the compression plate by Bagby [12] which was the predecessor of the dynamic compression plates (DCP) by the Arbeitsgemeinschaft für Osteosynthesefragen (AO). In 1950, Maurice E. Müller, who was a student of Danis, gathered a group of Swiss surgeons and formed the AO group with the purpose of conducting research in bone healing, with particular emphasis on the influence of the mechanical environment of the fracture upon its healing pattern. The AO group agreed that effective treatment of fractures should include anatomical reduction, rigid internal fixation, atraumatic techniques and early active mobilization of the injured extremity [13]. An excellent and much more detailed description of the historic development of internal fixation with plates can be found in a historic review article by Philippe Hernigou [14].

CONVENTIONAL PLATING

The foundation of the AO and later the constitution of the AO Foundation in 1984 heralded the era of fracture fixation with bone plating. Bone plating fulfils various mechanical functions. Firstly, it transmits forces from one end of the bone to the other and thus enables load transfer and/or load bearing. Secondly, it maintains the mechanical alignment of the fracture fragments. And thirdly, it stabilizes the

Fig. 2. Secondary metal loosening of bone plate and screw breakage with development of non-union based most likely to be caused by the use of a too short and too thin plate.

fracture zone and protects it from overloading, thus eventually enabling the fracture healing process [15]. Conventional bone plating (in contrast to locked plating) relies on absolute stability of the fracture and aims to avoid any relative movement between the fracture fragments (Fig. 1). This stable fixation promotes direct healing of the fracture gap without any callus formation. This process of primary healing is related to remodelling of the fractured zone by intramembraneous bone healing [16] and has been adequately phrased by Danis [10] as "autogenous welding". Direct healing of fractures can occur by contact healing or by gap healing. Contact healing requires the surfaces of the fractured bone to be in direct contact to each other and leads to remodelling of the fracture zone by newly formed osteons [17]. If the fracture ends are not in direct contact but form a small gap not wider than 0.5mm, woven bone infiltrates the gap before osteonal remodelling can begin The mechanical stability in conventional plating is generated by pressing the plate on to the surface of the bone (Fig. 1). The load transfer of axial forces from the bone to the plate and back to the bone is provided by the friction from the compression of the plate onto the bone surface. The compression between plate and bone is generated by screws, which engage bicortically in the bone. The rounded screw head is free to toggle in the plate hole and therefore pulls the plate tight to the bone surface. The compressional force is directly produced by the tightening torque of the screws. Depending on the frictional coefficient between screw and plate as well as screw and bone, a tightening torque of 2 Nm can easily exceed compressional forces of 1000 N, equivalent to approximately 100 kg load [18]. In order to increase the load which can be transferred by the plate, the friction between bone and plate can be increased by contouring the plate to match the bone surface and also by increasing the tightening screw torque. In particular, increasing the screw torque generates considerable compressional strain on the bone surface and also tension in the cortical bone around the screw threads. Thus, the weakest element in conventional plating is usually the bone at the screw-bone interface. The bone at this interface is already pre-strained by screw tightening and experiences further shear strains if it is loaded during patient activities. Each screw is loaded individually at the screw-bone interface and the outer screws tend to experience the largest interface loads [18]. Not surprisingly, a major clinical failure scenario in conventional plating is screw failure as a result of screw loosening or pull-out (Fig. 2).

The stability of fracture fixation in conventional plating can be further enhanced if the fracture ends are compressed. Interfragmentary compression firstly restores anatomical alignment of the bone and secondly reduces the interfragmentary strain by pre-compression of the fracture fragments. Interfragmentary compression can be obtained by an externally applied compression device, pre-bending of the plate or special design of the holes in the plate which force the bone fragments to glide towards each other during screw tightening. External tensioning devices, which had been temporarily attached to the bone plate, fell out of favour due to the large surgical exposure they required. Plate pre-bending at the site of the fracture (concave bending with the plate lifting off at the site of the fracture) brings the far cortex under compression. During loading the near cortex tends to close, creating further compression at the fracture gap [19]. Self-compressing plates, such as the dynamic compression plate (DCP), convert the screw torque into a shearing force between the plate and bone. The screw head slides down an inclined plane within the plate's screw hol, converting the descending movement of the screw into gliding of the plate at right angle. The resulting shear force compresses the fracture, thereby increasing the stability of fracture fixation. Over the years, surgeons together with engineers perfected the technique of rigid fixation and compression of fractures, only to realize that fracture fixation with absolute stability also has some disadvantages. In order to fit conventional plates to the bone surface, a large and wide-open approach to the fracture is necessary. This causes denudation of the bone over a large area and disturbance of blood supply

in the periost and the surrounding soft tissues. The disturbed biology leads to delays in bone healing and produces a potential source for infections. Furthermore, the compression of the plate on the bone surface interferes with the blood perfusion of the underlying cortex and causes damage to the bone directly beneath the plate, exhibited as bone necrosis and subsequent porosis [20] which are related with an increased risk of refractures after plate removal. This led to the development of plates with scalloped undersurfaces, designed to limit bone contact (limited-contact dynamic compression plates; LC-DCP). These new plates, however, failed to show the expected benefits and had negligible effects on improving the blood supply [21] and avoiding bone necrosis [22]. Finally, the stable conventional plate constructs induced stress shielding of the bone, porosis and reduced bone strength, in particular after plate removal [22]. The stress shielding effect with its biological consequences is most likely the reason why conventional plating of diaphyseal fractures is only indicated in specific situations such as for example simple forearm fractures [23].

LOCKED PLATING

The need for a more biological fixation led to the development of the internal fixator concept of locked plating. In locked plating, the screw head engages in the plate hole and the load transfer from the bone to the plate is provided by the locking mechanism of the screw within the plate hole (Fig. 3). The locked bone-plate constructs achieve angular and axial mechanical stability at the interface between the locking screw head and locking hole in the plate, creating a fixed angle device. The fixation principle is that of an external fixation with a minimized fixator bar (plate) to bone distance (Figs. 3 and 4). This fixation principle has major implications for the mechanical stability and the broad clinical application of locked plate constructs, where compression of the plate to the bone is no longer necessary and the plate can be kept elevated at a small distance off the bone, thus avoiding deterioration of blood perfusion and preventing stress shielding.

The stability does not depend on the tight fit of the plate on the bone surface and locking plates do not need to be individually contoured, but rather can be used in their manufactured pre-contoured shape. All locked screws act together and distribute the load more uniformly over the length of the plate in comparison to the screws in conventional plating. To counteract axial forces, locking screws experience a bending moment like a single beam construct [24]. Therefore, they need to have a larger diameter in order to withstand bending loads. Their primary mode of failure is either fatigue failure of the screw just beneath the locking head or loosening of the locking interface. Furthermore, there is no need for an exact anatomic reduction of the fracture, as load transfer between the fracture ends is completely obtained by the plate and does not necessarily require load transfer through cortical contact (Fig. 4). This allows a minimally invasive approach for indirect fracture reduction and application of locking plates. The plates can be inserted through a minimal skin incision and then slid along the bone surface without creating a large open approach. The technique evolved into the present generation of locking plates which include anatomical plate design and polyaxial locking screws. These features aim at rigid stability to allow early postoperative mobilization and early return to function as well as adequate stiffness to stimulate fracture healing of complex multifragmentary shaft and articular fractures in different anatomical locations (Fig. 5a–e). In this connection, poly-axial locking mechanism provides the option to fix even comminuted fracture patterns with multiple bone fragments sufficiently. With minimally invasive application of anatomical locking plates the blood supply to the periost and the fracture area is largely preserved thus constituting a biologic milieu for fracture healing, which allows for adequate osseous healing and decreased risk for infections, delayed union or non-union, and secondary loss of reduction [25]. The most important difference between conventional plating and locked plating is the mechanical environment that both fixation principles generate. For conventional

plating to result in successful osteonal bridging, fracture gaps need to be smaller than 0.5 mm and the resulting interfragmentary strain should remain below 2% [26]. Locked plating is indicated for fracture treatment in situations when the fragments are not in direct contact with each other. Although with larger gaps healing might take longer, even fracture gaps larger as 2 mm are still capable of healing [27,28]. In contrast to absolute stability in conventional plating, locked plating requires relative stability with interfragmentary movement in the fracture gap which can easily exceed 2% of interfragmentary strain [28,29].

DYNAMIC PLATING

Although locking plates are meant to be flexible fixation constructs that induce secondary healing and callus formation through interfragmentary motion, failures in healing in some types of fractures fixated with locking plates are not infrequent. Distal femur fractures are one example that may fail to demonstrate an periosteal callus formation under locked plating. In these fractures, considerably large locking plates are used because of the need to provide sufficient strength to withstand weight bearing (Fig.
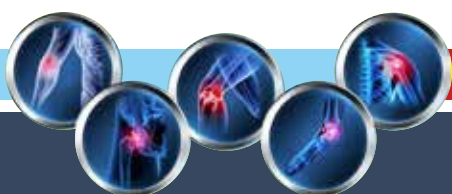

Fig. 3. Fracture healing with callus formation following bridged proximal lateral and distal medial locked plating for internal fixation of a multi-level tibial fracture.

6). The large strength of the distal femur plates comes along with large stiffness, so the resulting bending of these plates during weight bearing is rather small. Consequentially some patients experience healing disturbances, delayed unions, and hardware failure when fractures of the distal femur are treated with locking plates. Fractures that fail to heal have been reported to form less callus, suggesting callus inhibition due to inadequate (insufficient) interfragmentary movements [30].

The goals of adequate fracture fixation are to secure the reduction of the fracture, maintain alignment and induce an adequate mechanical and biologic environment for successful bone repair. Controlled dynamization of the fracture has been demonstrated to induce callus formation and resulting in a strong and fast healing response [31]. In their original research, Goodship and Kenwright demonstrated the beneficial effects of axial micromotion on bone formation in the fracture gap [32]. There are various strategies to induce dynamization in locked plating, which traditionally included variations in the placement of the locking screws in the plate, adjusting the working length of the plate across the site of the fracture and variation of the distance (elevation) of the plate to the bone [33–35]. More recently some engineering concepts have evolved, which enable a controlled adjustment of the amount and also direction of induced interfragmentary movement [36]. These concepts are either focused

Fig. 4. Comminuted multifragmentary intraarticular proximal tibia fracture fixed with medial antiglide plate and lateral locked plate.

on the design and placement of the locking screw or the design of the locking plate itself. The design of the so-called dynamic locking screw (DLS) enables the dynamization of the cortex underneath the plate and induces axial movement of the fracture during weight bearing [37]. While the DLS concept proved successful theoretically and in pre-clinical investigations [38,39], it has so far failed to demonstrate clinical benefit [40] and was eventually recalled from the market. Another design concept focusing on the dynamization through the locking screws is the concept of Far Cortical Locking (FCL) [41]. FCL screws are securely fixed in the plate and in the far cortex (opposite to the plate) while still allowing controlled motion at the near cortex via a flexible screw shaft with a reduced diameter. This design results in effective reduction of the stiffness of the locking plate construct and promotion of controlled axial movement at the fracture site while maintaining its construct strength. The concept of FCL to actively bring about fracture healing by inducing axial micromovement parallel to the plate has been demonstrated in pre-clinical studies [31]. Clinical benefits of FCL have been reported for fractures of the tibia [42] and the distal femur [43].

Instead of modifying the screw to induce controlled movement at the fracture site, it has been suggested to modify the plate or more specifically the plate screw interface to induce dynamization [44–46]. The concept of active plating has recently been refined by using screw holes that are integrated with individual sliding elements, which are elastically suspended in an elastomer envelope inside the plate [47] (Fig. 7). The elastic suspension of standard locking screws in the plate enables controlled interfragmentary dynamization and provides durable fixation. In pre-clinical investigations in an ovine osteotomy model the active plating concept was applied to bridged fractures [48] as well as for anatomically reduced fractures [49].

Both of these studies demonstrated the benefits of dynamization with active locked plating, which promoted early callus formation and yielded
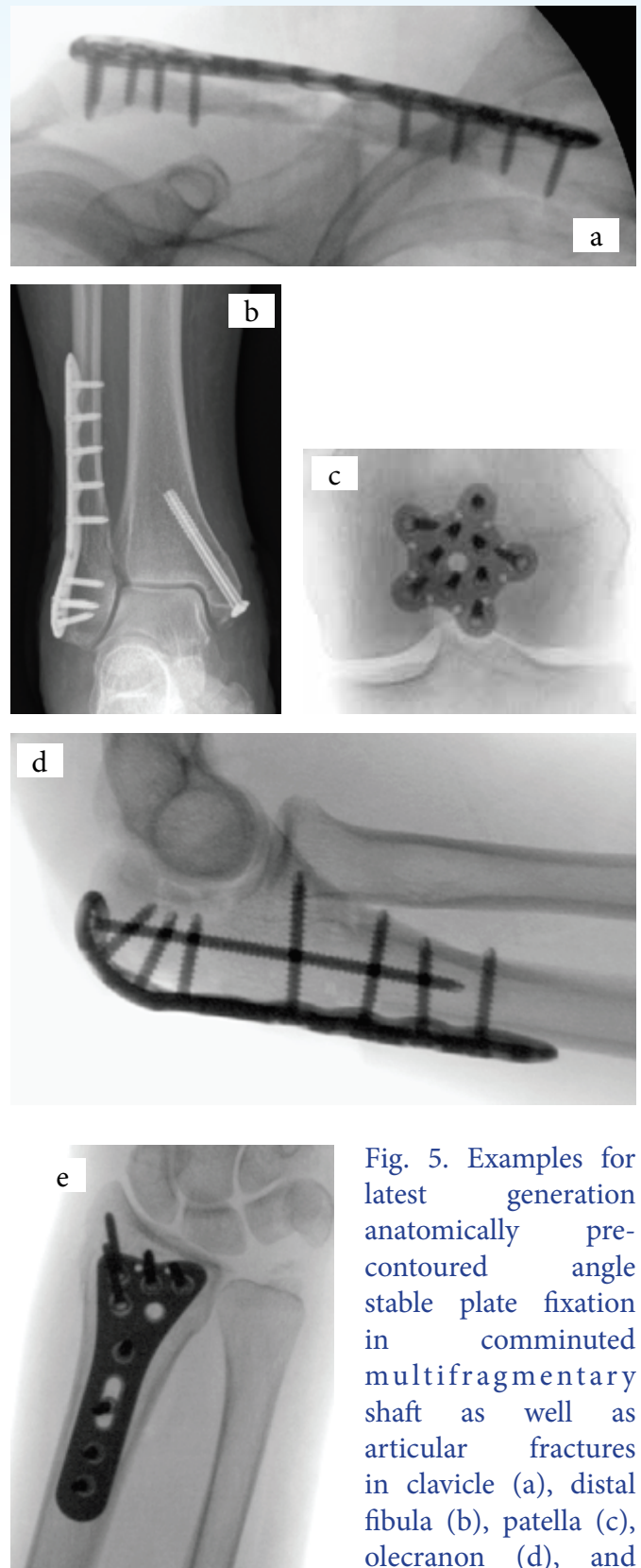
Fig. 5. Examples for latest generation anatomically pre-contoured angle stable plate fixation in comminuted multifragmentary shaft as well as articular fractures in clavicle (a), distal fibula (b), patella (c), olecranon (d), and distal radius (e).

faster and stronger healing than standard locked or compression plating. A recent prospective observational study on active plating of humeral shaft fractures [50] similarly confirmed early callus bridging and excellent functional outcome scores.

CONCLUSION

Plate osteosynthesis has continuously evolved over the past 200 years to deliver the three principal requirements of fracture management: durable fixation, preservation of biology, and promotion of fracture healing. The early quest was to develop biocompatible, inert, and durable implants, along with a fixation technique that minimized fixation failure. Anatomic open reduction and interfragmentary compression was successfully used to reduce fixation failure, but came at the cost of a highly invasive procedure. Modern locking plates are preferably anatomically pre-contoured and enable durable fixation in an environment of relative stability while allowing a less invasive approach that preserves the biology at the fracture site. However,

locked plating constructs may become too rigid at the cost of deficient interfragmentary motion, which is a key factor in promoting natural fracture healing by callus formation.

Subsequently, dynamic plating may have the potential to combine the benefits of locked plating with the ability to promote fracture healing by controlled interfragmentary motion. The clinical potential of dynamized plating, however, still has to be demonstrated in future clinical studies.

REFERENCES

1.   Lister J. On the antiseptic principle in the practice of surgery. Br Med J 1867;2:246–8.

2.   Lister J. An address on the treatment of fracture of the patella. Br Med J 1883;2:855–60.

3.   Hansmann C. Eine neue Methode der Fixierung der Fragmente bei komplizierten Frakturen. Verhandlungen der Deutschen Gesellschaft für Chirurgie 1886;15:134–37.

Fig. 6 (A) For dynamization, locking holes of active locking plates were integrated in individual sliding elements that are elastically suspended in a silicone envelope inside lateral plate pockets. (B) Lateral pockets are arranged in an alternating pattern from both plate sides, resulting in a staggered locking hole configuration. (C) Side view of plate showing the staggered silicone inserts

(Fig. 7). Absence of failure in the active locking plate and locking holes suggests that dynamic fixation with active locking plates provides safe and effective fixation. However, prospective randomized trials will be needed to quantify the clinical benefits provided by this active plating technology

4. Lane WA. Clinical remarks on the operative treatment of fractures. Br Med J 1907;1:10378.

5. Lambotte A. L'intervention opératoire dans les fractures récentes et anciennes envisagée particulièrement au point de vue de l'osteo-synthèse. Brussels, Belgium: Lamertin; 1907.

6. Lambotte A. Chirurgie operatoire des fractures. Paris, France: Masson & Cie; 1913.

7. Zierold AA. Reaction of bone to various metals. Archives of Surgery 1924;9:365–412.

8. Brettle J, Hughes AN. A metallurgical examination of surgical implants which have failed in service. Injury 1970;2:143–54.

9. Brettle J. A survey of the literature on metallic surgical implants. Injury 1970;2:26–39.

10. Danis R. Théorie et pratique de l'ostéosynthèse. Paris, France: Masson & Cie; 1949.

11. Venable CS. An impacting bone plate to attain closed cooptation. Ann Surg 1951;133:808–13.

12. Bagby GW, Janes JM. An impacting bone plate. Proc Staff Meet Mayo Clin 1957;32:55–7.

13. Hernigou P, Pariat J. History of internal fixation with plates (part 2): new developments after World War II; compressing plates and locked plates. Int Orthop 2017;41(7):1489–1500.

14. Hernigou P, Pariat J. History of internal fixation (part 1): early developments with wires and plates before World War II. Int Orthop 2016;41(6):1273–83.

15. Thakur AJ. The elements of fracture fixation. New-Dehli, India: Elsevier; 2007.

16. Rahn BA, Gallinaro P, Baltensperger A, Perren SM. Primary bone healing. An experimental study in the rabbit. J Bone Joint Surg Am 1971;53:783–6.

17. Schenk R, Willenegger H. [On the histological picture of so-called primary healing of pressure osteosynthesis in experimental osteotomies in the dog]. Experientia 1963;19:593–5.

18. Cordey J, Borgeaud M, Perren SM. Force transfer between the plate and the bone: relative importance of the bending stiffness of the screws friction between plate and bone. Injury 2000;31 Suppl 3:C21–8.

19. Bagby GW, Janes JM. The effect of compression on the rate of fracture healing using a special plate. Am J Surg 1958;95:761–71.

20. Perren SM. Fracture healing: fracture healing understood as the result of a fascinating cascade of physical and biological interactions. Part II. Acta Chir Orthop Traumatol Cech 2015;82:13–21.

21. Jain R, Podworny N, Hupel TM, Weinberg J, Schemitsch EH. Influence of plate design on cortical bone perfusion and fracture healing in canine segmental tibial fractures. J Orthop Trauma 1999;13:178–86.

[22] Uhthoff HK, Poitras P, Backman DS. Internal plate fixation of fractures: short history and recent developments. J Orthop Sci 2006;11:118–26.

23. Gardner MJ, Helfet DL, Lorich DG. Has locked plating completely replaced conventional plating? Am J Orthop (Belle Mead NJ) 2004;33:439–46.

24. Gautier E, Perren SM, Cordey J. Effect of plate position relative to bending direction on the rigidity of a plate osteosynthesis. A theoretical analysis. Injury 2000;31 Suppl 3:C14–20.

25. Egol KA, Kubiak EN, Fulkerson E, Kummer FJ, Koval KJ. Biomechanics of locked plates and screws. J Orthop Trauma 2004;18:488–93.

TREATMENT OF STABLE INTERTROCHANTERIC FRACTURES OF THE FEMUR WITH PROXIMAL FEMORAL NAIL VERSUS DYNAMIC HIP SCREW: A COMPARATIVE STUDY

Dr. Pancham Prasad[1] Dr. Dibyendu Shekhar[2] Dr. Shashikant Singh[3] Dr. Bijoy Kumar[4]

1. Senior Resident, Dept. of Orthopedic, Rajendra Institute of Medical Sciences, Ranchi
2. Junior Resident, Dept. of Orthopedic, Rajendra Institute of Medical Sciences, Ranchi
3. Assistant Professor Sheikh Bhikari Medical College, Hazaribagh, Jharkhand
4. Associate Professor, Dept. of Orthopedic, Rajendra Institute of Medical Sciences, Ranchi

ABSTRACT

Objective: To evaluate and compare the clinical and radiological outcomes of patients with stable intertrochanteric fractures treated with proximal femoral nail (PFN) vs. dynamic hip screw (DHS). **Methods:** Sixty patients with stable intertrochanteric fractures, aged over 18 years, were randomly divided into the PFN and DHS groups. DHS with a four-hole side-plate and an anti-rotation screw were used, as well as a modified ultra-short PFN for the smaller Asian population. The intra-operative, early and late complications were recorded, and the functional outcome of each group was assessed using the Harris Hip Score. **Results:** In the DHS group, the one-month mean Harris Hip Score was slightly lower than that of the PFN group. However, at the three- and six-month monthly follow-ups, the DHS group presented higher mean scores than the PFN group; at the one-year follow-up, both the groups attained similar scores. **Conclusion:** PFN provides a significantly shorter surgery with a smaller incision that leads to less wound-related complications. However, the incidence of technical errors was significantly higher in PFN when compared with DHS, as it is a technically more demanding surgery that leads to more implant failures and the consequent re-operations.

INTRODUCTION

The incidence of Intertrochanteric fractures has been increasing due to higher longetivity and rising incidence of road traffic accidents. Inter-trochanteric fractures account for approximately half of the hip fractures in elderly(1,2).The goal of treatment of any Intertrochanteric (IT) fracture is to restore early mobility so as to minimize the risk of medical complications and restore the patient to pre-operative status. The dynamic hip screw (DHS) is currently considered as the standard device for comparison of outcomes, especially for the stable intertrochanteric fractures(3) .The proximal femoral nail (PFN), introduced by the AO/ASIF group in 1998, has gained widespread popularity for treatment of trochanteric fractures in recent years. The advantage of Proximal Femur Nailing fixation is that it provides a more biomechanically stable construct by reducing the distance between hip joint and implant(4,5). Both most of the studies till date have evaluated the outcomes of PFN in unstable fractures and comparison with DHS in stable IT fractures is less studied. The present study was done to evaluate and compare the clinical and radiological outcomes of patients with stable Intertrochanteric fractures treated by PFN and DHS. The hypothesis of the study was that both PFN and DHS provide similar functional outcome in stable IT fractures.

MATERIALS AND METHODS

This was a prospective interventional study carried out between 2019 and 2021 at a govt. tertiary level hospital and included 60 cases of stable Intertrochanteric fractures above 18 years of age. Exclusion Criteria was any case with marrow cavity blocked by another implant, deformed femur/ abnormal bowing of femur, narrow marrow cavity (e.g. osteopetrosis), pathological fracture or old complicated fracture. The study was approved by
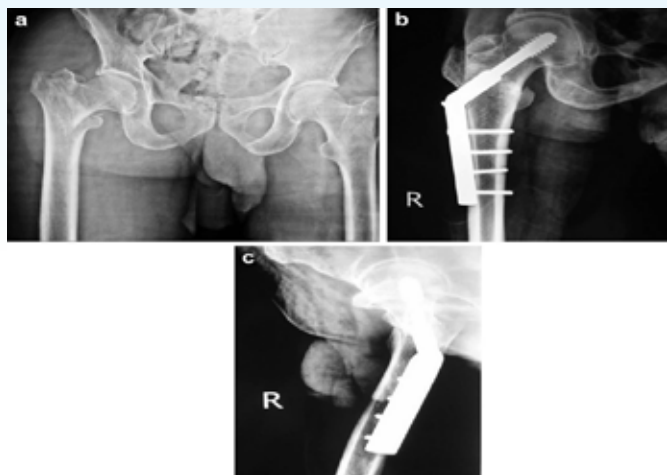
Figure 1. 63 Year-old male with fracture fixed with DHS. (a) Preoperative anteroposterior view. (b and c) Anteroposterior and lateral radiograph at 12 weeks follow up.
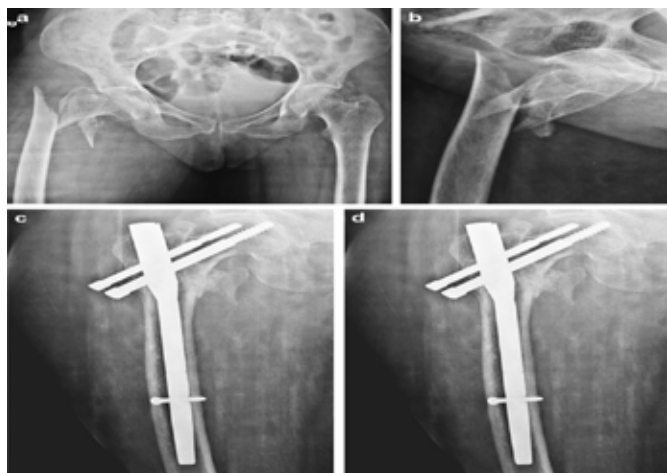

Figure 2.76 Year-old female patient with fracture fixed with PFN. (a and b) Preoperative anteroposterior and lateral view. (c and d) Anteroposterior and lateral radiograph at 12 week follow up.

the ethical committee of the hospital, and informed consent was obtained from each patient. Alternate patients who fulfilled the inclusion and exclusion criteria were treated with DHS or PFN respectively. No patient was lost to follow up. All patients were operated by the same surgeon in both the groups. Patients were taken up for surgery as early as possible after relevant investigations, radiographs, anaesthetic evaluation and physician clearance. A standard fracture table was used with the patient

in supine position. Since all fractures were of stable type, DHS with a side plate having 4 holes combined with an antirotation screw was used in all cases and in the other group, a modified ultra short PFN. (18 cm length, diameter of proximal part 14mm, anti-rotation screw of 6.5mm and hip screw of diameter 8.0mm) suited for the smaller Asian population was used. Closed reduction was attempted in all cases and if not achieved, indirect reduction using percutaneous or mini-open techniques was done before making entry for the PFN and DHS. Postoperatively, all patients underwent similar rehabilitation protocol with dynamic quadriceps and ankle pump exercises being started from the first day, early mobilization with walker as soon as possible with non weight bearing and later partial weight bearing was started depending on the patient's compliance. Patients were advised 1st follow up 4 weeks after discharge from the hospital and then every 6 weeks till the completion of 24 weeks postoperatively. Weight bearing was gradually increased as per the radiological evaluation of the fractured site. Further follow up was advised at 6 monthly intervals for 1 year and then annually. The intra operative, early (within first month after hip
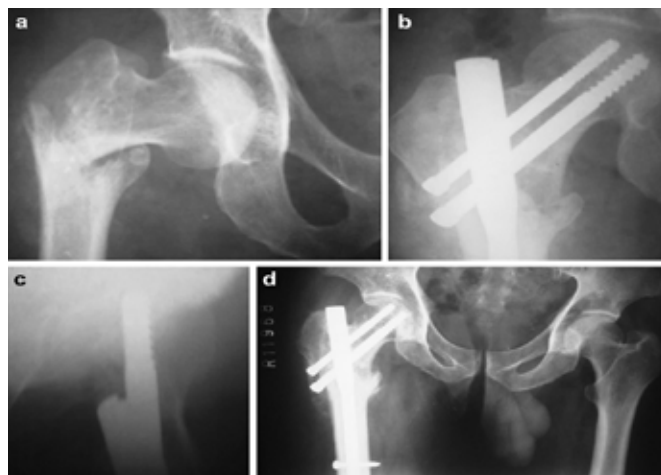

Figure 3.51 Year-old male patient with intertrochanteric fracture fixed with PFN. (a) Preoperative anteroposterior view. (b and c) Immediate post operative antero posterior and lateral view. (d) Anteroposterior view at 12 week follow up.

fracture repair), and late complications (after first month) were recorded and clinical outcome for each group was analyzed. Patients were followed up at regular intervals of 4 weeks, 8 week, 12 weeks, 6 months and annually thereafter and functional outcome was assessed with Harris Hip Scores.6 Data obtained was then assessed statistically using student's t-test for quantitative data like duration, blood loss, Harris hip scores and Z ratio for significance of the difference between two independent proportions for qualitative demographic data. Applying the null hypothesis the observed difference was considered to be significant if the p-value was < 0.05
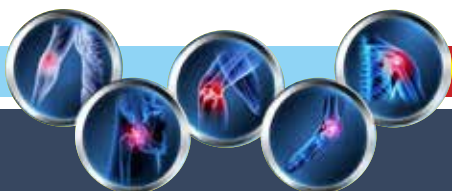
RESULTS

The present study involved 60 cases of stable intertrochanteric femur fracture of either sex from 2019 to 2021. Out of these, 29 were treated by Dynamic hip screw and 31 cases were treated by Proximal femoral nail. In our study, maximum age was 81 years and minimum was 40 years. Mean length of incision was smaller in PFN group (p < 0.01) but radiation exposures were significantly more in PFN group (p < 0.01). Duration of surgery was lesser in PFN group which was statistically significant (p < 0.01) (Table 1). Average blood was significantly more in DHS group (p < 0.01) with 2 patients requiring blood transfusion postoperatively as compared to nil in PFN group. Closed reduction was attempted and successful in all except one case out of the 60 cases in which reduction was achieved by indirect reduction techniques. Mean hospital stay was slightly more in DHS group but this was not found to be statistically significant (Table 1). Average cost of implant for DHS was approximately 55% of the cost of PFN. Mean duration of allowing full weight bearing was slightly longer in DHS group but it was not significant on statistical analysis. Early and late complications were noted and compared in both the groups. Incidence of technical errors was higher in PFN group (9.67% as compared to 3.48% in DHS group) but prolonged drainage and superficial infections were commoner in DHS group (Table 2); although the difference in incidence of

these complications was not statistically significant. No case of iatrogenic fracture, DVT, deep infections, nonunion or malunion was noted. Mortality rate was similar in both groups (one death in each group), was not related to any surgery related cause and occurred after three months post-operatively. Incidence of loss of reduction and implant failure and subsequently re-operation was higher in PFN group (Table 2), but not of significance when analyzed statistically. Mean shortening was similar in both the groups at final follow up. Functional results were assessed in all patients using Harris hip score at the one month, three months, six months & one yearly follow ups. In the D.H.S group, the one month mean hip score was slightly less than that of the P.F.N group, though not statistically significant (p value > 0.05) (Table 3). However at three monthly and six monthly follow up, the DHS group had higher mean scores than PFN group (p < 0.01), but at one year both the groups attained similar scores (p value > 0.05).

TABLE 1

Table 1 – Showing preoperative and introperative observations.			
Observations	DHS (n = 29)	PFN (n = 31)	p value
Mean age (range)	62.27 yrs (44–81)	60.67 yrs(40–80)	0.53
Sex ratio (M:F)	65.51% 4.5	60.67%	0.93
Mean age of fracture at surgery(in days)	7.9	4.9	<0.01
Mean length of incision (in cm)	48.7	71	<0.01
Mean radiation exposures (in no.)	69.7 min (39.5 + 30.2)	56.9 min (37.3 + 19.6)	<0.01
Mean duration of surgery (incision to	221 mL	109 mL	<0.01
fixation + fixation to closure)	1	0	0.29
Average blood loss (in mL)	0	1	0.29
Patients requiring blood transfusion	10.1	9.29	0.13
Failure to achieve	7.8 wks	7.2 wks	0.412

TABLE 2

Table 2 – Showing early and late complications.			
Complications	DHS (n = 29)	PFN (n = 31)	p value
Early			
Iatrogenic fracture	0	0	
Technical errors	1 (3.48%)	3 (9.67%)	0.33
Prolonged drainage	2 (6.89%)	0	0.13
Superficial infection	1 (3.48%)	0	0.29
DVT	0	0	
Late			
Loss of reduction	1 (3.48%)	2 (6.44%)	0.59
Implant failure	1 (3.48%)	3 (9.67%)	0.33
Second surgery	1 (3.48%)	3 (9.67%)	0.33
Mean shortening	5.5 mm	5.3 mm	0.60
Non union	0	0	
Mal union	0	0	
Deaths	1 (3.48%)	1 (3.22%)	0.96

TABLE 3

Table 3 – Showing mean Harris hip scores.			
Average Harris hip scores at	D.H.S group	P.F.N group	p value
1 month	24.8	26.1	0.10
3 month	53.4	47.6	<0.01
6 month	88.7	82.2	<0.01
2 years	94.2	94.0	0.79

DISCUSSION

In the last few decades treatment of intertrochanteric fractures has evolved significantly. Various methods of fixation devices have come and gone. The treatment still merits the type of fracture and quality of bone. DHS has been the considered the gold standard of intertrochanteric fracture fixation for a long time, especially for the stable fracture types.3 The PFN was designed to overcome implant-related complications of DHS and facilitate the surgical treatment of unstable intertrochanteric fractures as it, being an intramedullary implant, imparts a lower bending moment, compensates for the function of the medial column and acts as a buttress in preventing the medialization of the shaft.7 However, in stable IT fractures, whether all these characteristics aid in improving the outcome as compared to the DHS, is still a matter of debate.

In the present study, we compared intraoperative observations, complications and functional outcome of two groups of patients matched for demographic and preoperative variables and treated with DHS and PFN respectively. The mean length of incision 60% smaller in the PFN group compared to the DHS group. This was comparable to the findings in various other studies like those by Pan et al.8 and Zhao et al.9 Duration of surgery was shorter in PFN group by a mean of 12.8min; although the duration of implant fixation was almost similar in both the groups, time required for wound closer was significantly longer in DHS group probably due to larger incision and extensive dissection as compared to the percutaneous technique of PFN. Similar findings were noted by Pan et al.,8 Saudan et al.,10 Shen et al.11 and Zhao et al.9 Average blood was more in DHS group but was not so much clinically significant as to require blood transfusion as it was needed in only 1 patient in DHS group required blood transfusion. Mean duration of hospital stay and duration of allowing full weight bearing were both slightly less in PFN group. Early complications included superficial infections and prolonged discharge from wound in DHS group which were not noted in PFN group which resolved with regular dressings. These were probably due to the longer incision and extensive dissection in DHS cases, though no case of deep infection was noted. Incidence of technical errors was higher in PFN group (3 i.e. 9.67%) as compared to one case i.e. 3.48% in PFN group. These included varus angulation at fracture site (1 in each group), distal translation of the head and neck fragment due to it being pushed distally by the nail at entry point, opening up of the fracture site in one case after insertion of nail when fracture was located at the entry point it self and protrusion of the nail at the entry point due to mismatch between direction of neck screws and neck shaft angle. Thus these errors were typically related to the entry point and trajectory of the nail. These further led to higher incidence of loss of reduction, implant failure and re-operation rate in PFN group. This was comparable to the observations in various other studies(12,13). Implant failure included two

cases of superior cut out (one in each group) and two cases of Z-effect type of failure in PFN group. Loss of reduction was seen in the form of varus collapse in three of these cases of implant failure (one in DHS group, two in PFN group). Out of these three cases had to be re-operated and in one case (PFN), the laterally impinging screws were removed under local anaesthesia after fracture consolidation. Mean shortening at final follow up was comparable in both the groups. This was different from most other studies probably because in our study all cases were of stable type Intertrochanteric fractures which were reduced intraoperatively and thus not much scope was left for the sliding mechanism of DHS to take place to cause any shortening. Mean Harris hip scores were calculated at one month, three months, six months and yearly follow up and compared in both the groups. Initially these functional scores were slightly lower for the DHS group, but at three and six months follow ups, it was noted that the DHS patients fared slightly better than the PFN group. This was probably due to abductor lurch while walking and slightly decreased range of abduction in PFN group as compared to DHS patients. However, at annual follow ups, the scores in both the groups were similar, probably due to regaining of abductor strength with progressive physiotherapy. Thus a similar final clinical outcome could be achieved by the DHS at a much affordable price as compared to the PFN as noted by Giraud et al.14 A probable limitation of this study was smaller size of the study. Some observations like incidence of technical errors, implant failure, second surgery etc. which were not found to be statistically significant in our study, but are noted in many other studies is probably due to the smaller size of this study.

CONCLUSION

The PFN has recently gained tremendous popularity for the treatment of unstable intertrochanteric fractures. But controversy still remains whether, for stable fractures, it is better than DHS. Although advocates of PFN state that it provides the advantages of better biomechanical strength, shorter duration of surgery, lesser extensive surgery and earlier weight bearing, many recent studies have shown that there is an increased incidence of post-operative implant related complications and reoperation rate. In the present study we also obtained similar results that PFN provides a significantly shorter surgery with a smaller incision that leads to less wound related complications. But incidence of technical errors was slightly more with PFN as it is a technically more demanding surgery and this further leads to more implant failures and thus re-operations. The dual screws of PFN also do not provide any additional hold in the head as compared to the DHS as incidence of superior cut out was similar in both. The PFN is a significantly costlier implant than the DHS with almost similar final outcome. In stable IT fractures, the PFN also does not fair any better than the DHS in terms of shortening at final follow up. Though the final functional outcome is similar with both the implants, initial abductor lurch for many months is a significant drawback in PFN.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

REFERENCES

1. Leung K. Subtrochanteric fractures. In: Bucholz RW, Heckman JD, Court-Brown C, editors. Rockwood and Green's fractures in adults. 6th ed. Philadelphia, Lippincott: Williams & Wilkins; 2006. p. 1827–44.

2. David Lavelle G. Fractures and dislocations of the hip. In: Canale ST, editor. Campbell's operative orthopaedics. Philadelphia: Mosby; 2008. p. 3237–308

3. Jensen JS, Sonne-Holm S, Tøndevold E. Unstable trochanteric fractures. A comparative analysis of four methods of internal fixation. Acta Orthop Scand. 1980;51(6):949–62

4. Kish B, Sapir O, Carmel A, Regev A, Masrawa S. Full weight bearing after unstable per and subtrochanteric fracture using proximal femur

nail. J Bone Joint Surg Br. 2001;83:289.

5. Steinberg EL, Blumberg N, Dekel S. The fixion proximal femur nailing system: biomechanical properties of the nail and a cadaveric study. J Biomech. 2005;38(1):63–8.

6. Harris WH. Traumatic arthritis of the hip after dislocation and acetabular fractures: treatment by mold arthroplasty. An end-result study using a new method of result evaluation. J Bone Joint Surg Am. 1969;51(4):737–55

7. Kulkarni GS, Limaye R, Kulkarni M, Kulkarni S. Intertrochanteric fractures. Indian J Orthop. 2006;40(1):16–23.

8. Pan XH, Xiao DM, Lin BW. Dynamic hip screws (DHS) and proximal femoral nails (PFN) in treatment of intertrochanteric fractures of femur in elderly patients. Chin J Orthop Trauma. 2004;7:785–9.

9. Zhao C, Liu DY, Guo JJ, Li LP, Zheng YF, Yang HB, et al. Comparison of proximal femoral nail and dynamic hip screw for treating intertrochanteric fractures. Zhongguo Gu Shang. 2009;22(7):535–7.

10. Saudan M, Lübbeke A, Sadowski C, Riand N, Stern R, Hoffmeyer P. Pertrochanteric fractures: is there an advantage to an intramedullary nail? A randomized, prospective study of 206 patients comparing the dynamic hip screw and proximal femoral nail. J Orthop Trauma. 2002;16(6):386–93.

11. Shen HM, Liang CW, Fan YQ. The clinical study of the treatment of intertrochanteric fractures in the elderly with DHS, Gamma nail and PFN. Chin J Clin Med. 2007;2: 226–8.

12. Parker MJ, Handoll HH. Gamma and other cephalocondylic intramedullary nails versus extramedullary implants for extracapsular hip fractures in adults. Cochrane Database Syst Rev. 2010;(9):CD000093.

13. Hesse B, Gächter A. Complications following the treatment of trochanteric fractures with the gamma nail. Arch Orthop Trauma Surg. 2004;124(10):692–8.

14. Giraud B, Dehoux E, Jovenin N, Madi K, Harisboure A, Usandizaga G, et al. Pertrochanteric fractures: a randomized prospective study comparing dynamic screw plate and intramedullary fixation. Rev Chir Orthop Reparatrice Appar Mot. 2005;91(8):732–6.

COMPARISON BETWEEN INTERLOCK NAILING AND PLATTING FOR FRACTURESHAFT HUMERUS

Dr. Subhankar Mandal [1] Dr. Tapas Murmu[2] Dr. Shankar Niwas[3] Dr. Bijoy Kumar[4]

1. Junior Resident 2. Junior Resident 4. Associate Professor
Department of Orthopaedics, Rajendra Institute of Medical Sciences, Ranchi
3. Assistant Professor Sheikh Bhikari Medical College, Hazaribagh, Jharkhand

INTRODUCTION

Fractures of the humeral shaft are common and accounts for 1-3% of all fractures and have bimodal distribution. One group consists of mostly young males of 21 to 30 years age group and the other of older females of 60 to 80years. The predominant causes of humeral shaft fractures in young age group are high energy traumas and in case of second group mainly simple fall or rotational injuries.[1,2]

Fractures of humeral shaft have traditionally been regarded benign, with high percentage of primary healing with conservative methods, using either a hanging arm cast or a functional brace. Operative treatment for humerus fractures has usually been reserved for the treatment of non-union, unacceptable reduction of fractures, compound fractures, associated with forearm fractures, for polytrauma patients, fractures with neurovascular complications and patients with obesity who are at risk of developing varus angulations. The advantages of operative management are early mobilization and patient comfort. But, operative management carries the risk of technical errors and post-operative complications like infections, nerve injuries etc.[3,4]
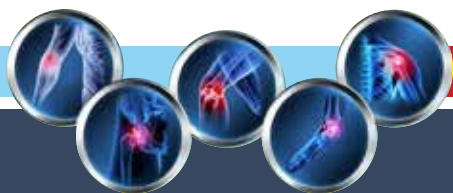
The optimal method of humeral shaft fracture fixation remains

in debate. Two techniques under study include intramedullary nailing and dynamic compression plate fixation. Open reduction and internal fixation (ORIF) with plates and screws continues to be considered the gold standard for surgical treatment. It is associated with a high union rate, low complication rate, and rapid return to function. It provides satisfactory results but requires extensive soft tissue dissection, and meticulous radial nerve protection. The plate may fail in osteoporotic bone.[2,4] Due to concerns about soft tissue dissection required for ORIF, a less invasive technique that allows indirect reduction and percutaneous plating of the anterior humerus has been developed. Anterior plating is a simple, safe, and effective treatment for humeral shaft non-union. It does not require radial nerve visualization or extensive soft tissue dissection, and the healing time is similar to that of other methods used for treating humeral shaft non-union. This is an alternative approach to osteosynthesis of humeral shaft non-union, in which the plate is placed on the anterior surface of the bone. The biological benefits of less damage to the soft tissues via an approach that uses a plane between nerves certainly contributed to good results.[5–7]

With the dynamic success of intramedullary fixation of fractures of the femur and tibia, there was speculation that intramedullary nailing might be more appropriate for humeral shaft fractures than dynamic compression plating. The theoretical advantage of intramedullary nailing included less invasive surgery, an undisturbed fracture hematoma and reaming can yield auto graft material. The biomechanics are improved, with higher amounts of inertia and load-sharing device support.[8,9]

With this background current study was planned to compare the outcomes of each method of fixation (dynamic compression plating and interlocking nailing) for the fracture shaft of humerus.

METERIAL AND METHODS

This randomized interventional study was conducted in the Department of Orthopedic Surgery at RAJENDRA INSTITUTE OF MEDICAL SCIENCES, RANCHI, JHARKHAND . Total 48 patients were surgically treated with either DCP or interlocking nailing between the above mentioned study period. Patients above 18 years having fractures of diaphysis of humerus indicated for surgical treatment and fractures less than 14 days were included in the study. Patients excluded from studies were fracture of upper and lower ends of humerus; patients with preexisting shoulder and elbow problems; Pathological fractures; Compound
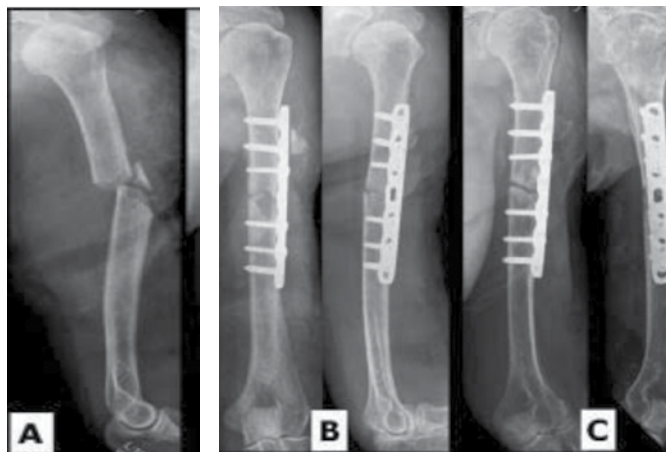

Figure 1. 50 Year-old male with fracture shaft of humerus fixed with DCP. (a) Preoperative lateral view. (b and c) Anteroposterior and lateral view radiograph at 12 weeks and 24 weeks follow up.

fracture. And who were lost to follow up or died before the fracture union.

The patients who met the inclusion and exclusion criteria were included in the study after taking informed consent. Ethical clearance was obtained. A thorough history and clinical examination was done. The fractures of humerus were classified according to the AO classification system. The status of radial nerve injury was recorded. Roentgenogram of the arm with shoulder and elbow was taken in both anteroposterior and lateral views. The humeral shaft

fracture was temporarily immobilized with a U-slab and arm pouch. We used either dynamic compression plate or interlocking nail for stabilization of fracture of the humeral diaphysis. Patients were prospectively randomized into two categories of dynamic compression plating (Group P) or interlocking nailing (Group N) by a computer generated list. In each group 24 patients were included. Once the patients were randomized, pre-operative planning and investigations (CBC, LFT/KFT, RBSL, BG, HIV, HBsAg and ECG) were done.

Anterolateral approach was used in patients with fractures of the upper and middle thirds of the shaft of the humerus. Posterior approach was used in
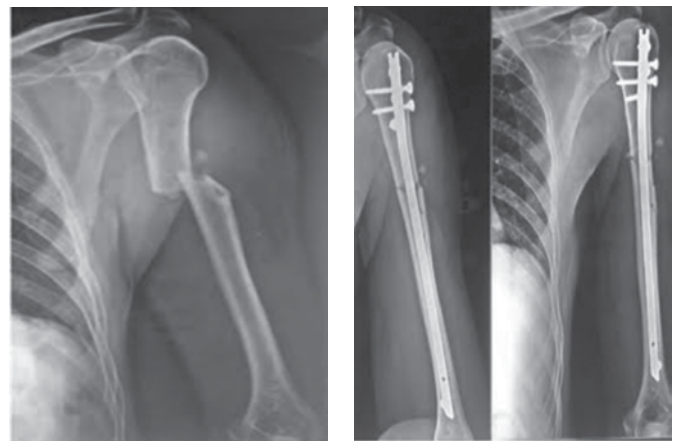

Figure 2. 60 Year-old male with fracture shaft of humerus fixed with ILN humerus. Preoperative Anteroposterior view and Anteroposterior and lateral view radiograph at 12 weeks follow up.

patients with fractures of the lower thirds of the shaft. Only ante grade nailing was done in case of interlocking nailing group. In the first group, 4.5 mm narrow DCP was used, and in second group standard intramedullary interlocking nail was used.

The patients were followed up every second week till radiological union was seen. At every follow up clinical examination was done to assess status of the surgical wound, pain, tenderness, range of motion of shoulder and elbow stability of the fracture and clinical union. Roentgenograms were taken in AP

and Lateral views to look for signs of radiological union. In the present study we concluded clinical union when the fracture site had become stable and pain free. The union is confirmed radiologically when plain X-ray showed bone trabacular cortical bone crossing fracture site on at least three surfaces on orthogonal radiograms. The time taken for clinical and radiological union was noted.

If there are nonclinical and radiological signs of union by 16 weeks, the fracture were categorized as delayed union and if absence of fracture union after 32 weeks after injury was categorized as non union. Return of 5/5 power was regarded as complete recovery.

The functional outcome was measured by the "Disabilities of Arm, Shoulder and Hand" (DASH) Questionnaire at nine months or at full recovery which ever was earlier. The Dash scoring system is a very useful tool to measure function of the upper limb developed by the American Academy of Orthopedic Surgeons (AAOS) & has been validated by various studies.[10]

During study 8 patients were lost to follow up and 2 patients expired. Of the 38 fractures, 18 were fixed with DCP and 20 were fixed by interlocking nail. Descriptive and inferential statistics were used to compare the outcome in both groups.

STATISTICAL ANALYSIS

Microsoft office 2007 was used for the statistical analysis. Mean and percentages were used to interpret the data. Comparison was made with the help of chi square test.

RESULTS

In the present study out of 48 patients 8 were lost to follow up and 2 patients expired leaving us with 38 patients with the distribution being 18 in DCP and 20 in interlocking group. The age of the patients in the DCP group ranged from 22 to 60 years with a mean of 37.28 years. The age in the interlocking group ranged from 23 to 70 years with a mean age

of 35.05 years. The most common mode of injury in both groups is RTA 27 (71.1%), with fall being the second most common cause 7 (18.4%).
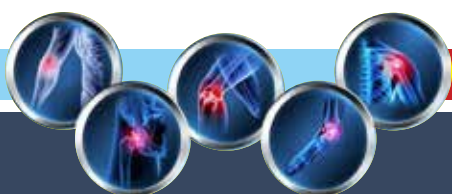
In the DCP group 7 associated injuries of which 4 were lower limb fractures, 1 upper limb fracture, 1 clavicular fracture and 1 abdominal injury. Of the 12 associated injuries in the interlocking group, 8 were lower limb fractures, 1 upper limb fracture, 1 rib fracture, 1 abdominal injury and 1 patient had paraplegia due to fracture dislocation of spine

Pre operative radial nerve palsy was present in 3 patients. All the 3 of them in the DCP group of which 2 recovered completely. The mean duration between trauma and surgery was in DCP group 4.15 days and in ILN group 2.95 days.

Average time taken for surgery was 82 minutes for DCP and 70 minutes interlocking nailing group. The average duration of follow up. In the present study was 11.4 months. Range (6 to 17 months).

Average time taken for radiological healing was 15.05 weeks. In the interlocking group 14.05 and DCP to 16.06. So the healing

Variable	ILN (n:20)	DCP (n:18)	Signifi-cance
Age (mean ± SD)	35.05 ± 11.44	37.28 ± 11.18	P value : 0.5 Non significant
Male: Female	14:6	13:5	P value 0.8 Non significant
Side Left: Right	8: 12	7: 11	P value 0.9 Non significant
Level of injury			
Lower 1/3	5 (25.0%)	4 (22.2%)	P value :0.62 Non significant
Middle 1/3	11 (55%)	10(55.6%)	
Upper 1/3	2 (10.0%)	1(5.6%)	
Junction M3/L3	1 (5%)	2 (11.1%)	
Junction U3/L3	1 (5%)	0	
Junction U3/M3	0	1 (5.6%)	

Variable	ILN (n:20)	DCP (n:18)	Signifi-cance
AO classification			
A1	1 (5%)	2 (11.1%)	p=0.294, Non Significant
A2	1 (5%)	4 (22.2%)	
A3	9 (45.0%)	3 (16.7%)	
B1	1 (5%)	3 (16.7%)	
B2	4 (20.0%)	3 (16.7%)	
B3	1 (5%)	0	
C1	1 (5%)	0	
C2	1 (5%)	2 (11.1%)	
C3	1 (5%)	1 (5.6%)	

Table-1: Baseline variables in both groups

rate was relatively faster in the interlocking group as compared to the DCP group. Two fractures treated with DCP remained ununited. Among the 38 patients 10 had excellent results, 12 had good results, 10had fair results, 6 had poor results.

Intraoperatively the interlocking group had 4 complications and the DCP group had only 2 complications. Postoperatively in the DCP group there were 6 complications and in the interlocking group there were 13 cases with complications. Complications were more in the interlocking group, which was statistically significant (p=0.009).

DISCUSSION

Most surgeons agree that intramedullary nailing is the best internal fixation for femoral and tibia shaft fractures, but there is no agreement about the ideal procedure for fractures of the humeral shaft. Plate osteosynthesis requires extensive soft tissue dissection with the risk of radial nerve damage. In the present study, 38 patients were included, out of which 20 were treated with interlocking nail and 18 with DCP.

The indications for open reduction and internal fixation of acute fractures of the humeral shaft have been described as: fracturesin patients with multiple injuries, open fractures, fractures associated with vascular or neural injuries or with lesions of the shoulder, elbow or forearm in the same limb; bilateral upper extremity injuries, fractures for which closed methods

Variable	ILN (n:20)	DCP (n:18)	Significance
Time taken forradio-logical healing (mean ± SD)	14.05 ± 3.18	16.06 ± 3.10	P value : 0.06Non Significant
DASH score			
Excellent	2 (10%)	8 (44.4%)	P value :0.04 Significant
Good	6 (30%)	6 (33.3%)	
Fair	8 (40%)	2 (11%)	
Poor	4 (20%)	2 (11%)	
(mean ± SD)	43.1 ± 28.1	24.05 ± 19.44	P value 0.02; Significant

Table-2: Comparison of outcome in both groups

of treatment have failed and pathological fracture. In several reported series, the presence of associated multiple injuries was the most frequent indication for internal fixation of the humeral shaft.[1-3] In the present study failed closed reduction andassociated injuries were the most common indications.

In the Present Study, there was no significant difference in the time taken for union. No difference in union rates has been found in some prospective studies whereas plate fixation shows fewer non-unions than nailing in others. In M Changulani etal study union time was found to be significantly lower with interlocking as compared to DCP but there was no significant difference between the union rate.[11] In H Raghavendra et al[12] and Chaudhari et al[1] study also no significant difference was found. In K Singisetti and M Ambedkar study[2] there was a significant difference between the two groups with tendency forearlier union in plating group.

In the present study, the incidence of non-union in DCP group was 11.11%.In previous reports the incidence of non-union after plating has ranged from 2% to 4%. In McCormack et al[13] study the incidence of non-union in plating group was 4.4%. In K Singisetti and M Ambedkar study[2] it was 6.25%, in M Changulani et al[11] study 12% and in Subhash Puri et al[14] study 6.7%.In present study, the incidence of non-union in the interlocking nail group is 0%. In McCormack et al study the incidence of non-union in interlocking group was 9.5%. In K Singisetti and M Ambedkar[2] study it was 5%, in M Changulaniet al study[11] 14.3% and in Subhash Puri et al[14] study 13.3%.

In the present study, excellent to good results were seen in eight patients in interlocking group and fourteen patients in DCP group. There were fairer and poor results in the interlocking nailing group compared to DCP group. With the P value, less than 0.05 there was a statistically significant difference betweenthe two groups. In K Singisetti and M Ambedkar[2] study thirteen out of 20 patients of the interlocking nail group had good to excellent results while 15 out of 16 patients ofthe plating group had similar results at the final follow-up for the study. This difference was found to be statistically significant. In S Raghavendra et al[12] studied patients operated with plating faredsignificantly better than those operated with interlock nailing when the overall results were analyzed. Whereas in McCormacket al study[13] and Chaudhari et al[1] study non statistically significant difference was noted in both groups.

CONCLUSION

There were fairer and poor results in the interlocking nailing group compared to DCP group. The complications were more in the interlocking nailing group with most of them pertaining to poor shoulder function or pain and this differencein the complications was significant. Though interlocking intramedullary nailing is good for specific conditions like pathological fractures, segmental fractures or with associated lower limb fractures which require early weight bearing with crutch walking, we still consider DCP fixation is better than interlocking nailing in treating fractures of the diaphysis of the humerus.

REFERENCES

1. Chaudhuri A, Dasgupta S, Datta S, Ghosh S, Halder T, Mitra U. Comparative study of operative treatment of mid shaft fracture of humerus by locking plate versus intramedullary interlocking nail. Med J Dr DY Patil Univ. 2013;6:390.

2. Singisetti K, Ambedkar M. Nailing versus plating in humerus shaft fractures: A prospective comparative study. Int Orthop. 2010;34:571–6.

3. Denies E, Nijs S, Sermon A, Broos P. Operative treatment of humeral shaft fractures. Comparison of plating and intramedullary nailing. Acta Orthop Belg. 2010;76:735–42.

4. Hwang Y-S, Kim K-Y, Kim H-C, Ahn S-H, Lee D-E. Polarus Intramedullary Nail for Proximal Humeral and Humeral Shaft Fractures in Elderly Patients with Osteoporosis. J Korean Fract Soc. 2013;26:14.

5. Tyllianakis M, Tsoumpos P, Anagnostou K, Konstantopoulou A, Panagopoulos A. Intramedullary nailing of humeral diaphyseal fractures. Is distal locking really necessary? Int J Shoulder Surg. 2013;7:65–9.

6. An Z, Zeng B, He X, Chen Q, Hu S. Plating osteosynthesis of mid-distal humeral shaft fractures: Minimally invasive versus conventional open reduction technique. Int Orthop. 2010;34:131–5.

7. Rommens PM, Kuechle R, Bord T, Lewens T, Engelmann R, Blum J. Humeral nailing revisited. Injury. 2008;39: 1319–28.

8. Crolla RMPH, de Vries LS, Clevers GJ. Locked intramedullary nailing of humeral fractures. Injury. 1993;24:403–6.

9. Habernek H, Orthner E. A locking nail for fractures of the humerus. J Bone Joint Surg Br. 1991;73:651–3.

10. Hudak PL, Amadio PC, Bombardier C. Development of an upper extremity outcome measure: The DASH (disabilities of the arm, shoulder, and head). Am J Ind Med. 1996;29:602–8.

11. Changulani M, Jain UK, Keswani T. Comparison of the use of the humerus intramedullary nail and dynamic compression plate for the management of diaphyseal fractures of the humerus. A randomised controlled study. Int Orthop. 2007;31:391–5.

12. Raghavendra S, Bhalodiya HP, Wali MGR, Baba AN, Latoo I a, Bhat N a., et al. Internal fixation of fractures of the shaft of the humerus by dynamic compression plate or intramedullary nail: A prospective study. Indian J Orthop. 2007;41:214.

13. McCormack RG, Brien D, Buckley RE, McKee MD, Powell J, Schemitsch EH. Fixation of fractures of the shaft of the humerus by dynamic compression plate or intramedullary nail. A prospective, randomised trial. J Bone Joint Surg Br. 2000;82:336–9.

14. Puri S, Biswas S, Salgia A, Sanghi S, Aggarwal T, Kohli A. Operative management of fracture of shaft humerus by dynamic compression plate versus interlocking intramedullary nailing: A comparative prospective study of 30 cases. Med J Dr DY Patil Univ. 2013;6:49.

A COMPARATIVE STUDY BETWEEN PLATING VERSUS TITANIUM ELASTIC NAIL SYSTEM IN MID-SHAFT CLAVICLE FRACTURE MANAGEMENT

Dr. Subhajit Halder[1] Dr. Rohit Lal[2] Dr. D.P. Bhushan[3]

1. Junior Resident, Dept of Orthopedics, Rajendra institute of Medical Sciences, Ranchi, Jharkhand
2. Senior Consultant, Dept of Orthopaedics, Samford Hospital, Ranchi
3. Professsor, Dept. Of Orthopaedics, SNMMCH, Dhanbad, Jharkhand

ABSTRACT

Background: Clavicle fracture is one of most common bony injuries. Despite of high frequency, choice of proper treatment is still a challenge. So a comparative randomized study was planned to compare Plating verses TENS for clavicle fractures management.

Methods: Study was conducted in Department of Orthopedics, Rajendra Institute of Medical Sciences, Ranchi , Jharkhand...Patients aged from 20-55 years with closed displaced were included in study. Patients were randomized in two groups- One group (25 pateints) treated with TENS and second group (25) with plate. Outcome assessed by pain VAS score, Constant & Murley score, DASH score, cosmetic result, radiological fracture healing time.

Results: Mean fracture union time in TENS group was 11.4±2.12 weeks and in plate group 13.4±3.46 weeks (difference was significant p=0.016). Mean pain VAS score in TENS group was 2.56±0.91 and in plating group 3.12±0.8 (p=0.023). Tens group were cosmetically more satisfied (mean score 4.48±0.7) than plate group (mean score 3.8±1.0, p=0.009). Mean DASH and Constant Shoulder Score in TENS group were 1.87±3.4, 9.36±7.04 and plate group 4.8±9.0 and 15.08±9.4 respectively. Both were significant (p=0.039, p=0.000).

Conclusions: Our study found that patients treated with TENS showed excellent outcome in 84% cases while 60% in plating group for displaces mid-shaft clavicle fracture. Patients in TENS group better in terms of Constant & Murley score and DASH score than treated with plate.

Keywords: Clavicle, Randomized trial, Constant and Murley score, Fracture healing

INTRODUCTION

Clavicle fracture is one of the most common bony injuries. Approximately 2% to 5% of all fractures in adults and 10% to 15% in children involve the clavicle.[1] Studies indicate that 29 to 64 per 1, 00000 suffer from a clavicle fracture each year.[1,2] A weak spot in mid clavicular region accounts for most of fractures. Despite of high frequency, choice of proper treatment is still a challenge for orthopedic surgeon.[3] In particular it is not clear whether surgery produces better outcomes than non-surgical management. In this scenario, a comparative randomized study was planned to compare Plating verses Titanium Elastic nail System (TENS) for clavicle fractures and compare with respect to incidence of nonunion, shortening, functional outcome, cosmetic aspects and complication. The aim of the study is toanalyze the result of TENS management and surgical treatment by plating of displaced midshaft clavicle fracture. It also aimed to compare the functional outcome of displaced fracture of the middle third of clavicle treated with TENS and Plating management.

METHODS

The Study was conducted in department of orthopedics,

Rajendra Institute of medical sciences, Ranchi, Jharkhand... Patients aged from 20-55 years with closed displaced and isolated fracture of middle third clavicle were included in this study. Those who were
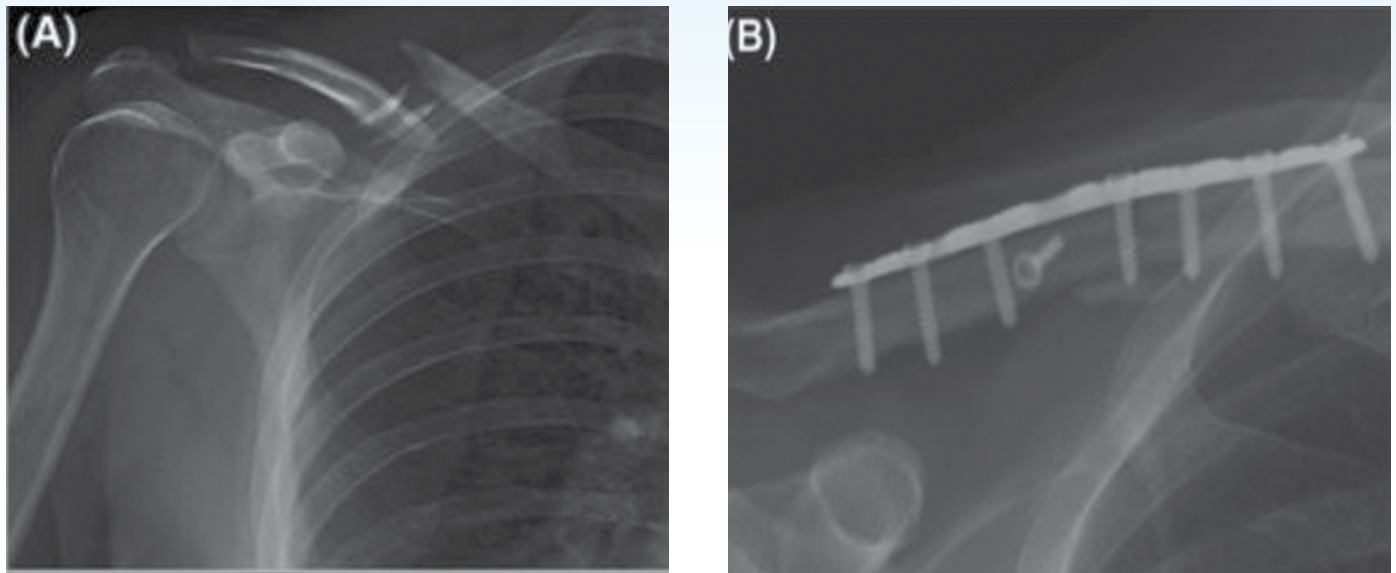
Figure 1. 32 Year-old female with fracture right clavicle fixed with LCP. (a) Preoperative view. (b) Anteroposterior view radiograph at 12 weeks follow up.

not medically fit for surgery, not gave consent, have pathological fracture, with neurovascular deficits, with concomitant injury, with previous fracture clavicle non-union were excluded. Patients coming to the emergency department of orthopedics OPD of the within the study period and who (Rajendra Institute of medical sciences, ranchi, Jharkhand) qualified the inclusion criteria were randomized in two groups- One group were treated with TENS and second group with plate. Simple randomization was used for patient's allocation to groups. During the study period 78 clavicle fractures, which require surgical treatment were analyzed.Out of which only 50 cases of mid clavicle fracture were included in this study

Patient on admission to emergency unit or OPD was initially resuscitated and stabilized (if required. All the cases were initially investigated with radiograph to asses fracture type and post traumatic clavicular shortening and routine hematological investigation, urine and stool examination, ECG and caridiological check up. Fractures were classified as per AO/OTA Classification. In both cases patients were operated under general anesthesia.

SURGICAL TECHNIQUE FOR PLATING

After pre operative dose of prophylactic antibiotics, patient was placed in the supine position with a large bump placed between the scapula, allowing injured shoulder girdle to fall posteriorly, helping to restore length and exposed to the clavicle. Reduction was done and a 3.5 mm Recon plate, LCP, one third tubular plate was contoured with bending for application to the superior surface of the clavicle or antero-inferior surface. In case of long oblique fractures or wedge communated fractures, l ag screw were used where possible with care taken to preserve soft tissue attachment. For communated fractures sufficiently long plate with nine or twelve hole was used to bridge the fracture and obtain at least six cortex fixation on each side of fractures.

SURGICAL TECHNIQUE FOR TENS

Patients were placed in supine position. A small incision was made approximately 1 cm lateral to the sternoclavicular joint. A TEN (Titanium elastic stable intramedullary nial) was inserted (the diameter varied from 2 to 3 mm depending on the width of the bone). Before introduction, the original curvature of the small and flattened nail tip
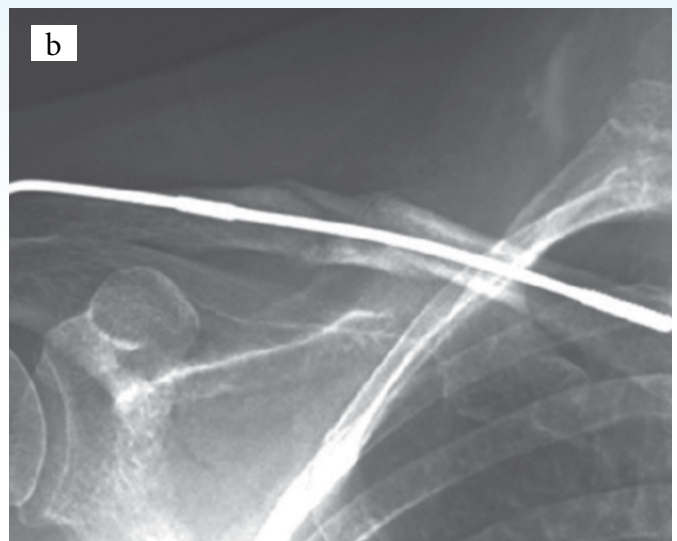
Figure 2. 25 Year-old female with fracture right clavicle fixed with Titanium Elastic Nail System. (a) Preoperative view. (b) Anteroposterior view radiograph at 12 weeks follow up.

was straightened slightly to allow better gliding in the small medullary canal. Closed reduction was performed under fluoroscopic control using two percutaneously introduced pointed reduction clamps. The nail was then advanced manually until it was just medial to the acromioclavicular joint. Accurate maneuvering of the nail tip was necessary under fluoroscopic control to avoid penetration of the thin dorsal cortex. After reaching the end point, the fracture was compressed and the nail was cut close to the entry point to minimize soft tissue irritation, at the same time leaving sufficient length behind for easy extraction later on. The fascia and skin were closed in layers.

POSTOPERATIVE PROTOCOL AND FOLLOW UP

For both the groups Intravenous Antibiotics was given for 3 days and changed to oral antibiotics for 7 days. Operated limb was immobilized in an arm sling. Thewound was inspected at 3rd post operative day and x ray was taken to study the alignment of fracture fragments. Suture removal was done on 10th postoperative day. Patients were discharged with the arm sling. Rehabilitation of the affected arm was started at the end of 2 weeks. A gentle pendulum exercise of the shoulderin the arm sling

was allowed. At 4 to 6 wks gentle range of motion of the shoulder was allowed but abduction in limited to 80 to 90 degree. At 6 to 8 wks active range of motion in all planes were allowed.

All patients were assessed on day 3, then every 3 weekly, till radiological signs of union, then at 6 month, 9 month, and 12 month after surgery. X-ray

Figure 3. 25 Year-old female with fracture right clavicle fixed with Titanium Elastic Nail System. Anteroposterior view radiograph after nail removal.

was taken for all patients at each follow up for evaluation of fracture healing and implant position.

OUTCOME ASSESSMENT

Radiographic healing was defined as evidence of bridging callus across the fracture site or obliteration of fracture line. Clinically fracture healing is defines as the absence of tenderness with firm palpation over the fracture site, full range of motion and the presence of normal strength of upper extremity. Time to achieve union was recorded. After union, shortening of clavicular length was measured clinically as the linear difference of clavicle lengths from sternal end to acromial end between operated and normal side.

We measured subjective pain with a visual analogue scale (VAS) 1 day before and 3 days months after conservative and surgical management. The VAS ranged from 0-10, 0=no pain, to 10=worst pain imaginable. The functional outcomes were assessed by Constant and Murley score and DASH score. In Constant and Murley scoring subjective variables are pain and ADL (sleep, work, recreation, sports) which gives a total 35 points. The objective variables are range of motion and strength which give a total of 65 points. Patients were graded as below with a maximum of 100 points. DASH outcome measure is a 30-item, self-report questionnaire designed to measure physical function and symptoms in patients with any or several musculoskeletal disorders of the upper limb. More severely disabled individuals have a higher score on a scale of 0 to 100. Cosmetic results after 6 month is assessed by patient satisfaction score from1=very unsatisfactory to 5=very satisfactory. All data were analysed in SPSS version 16. The Mann- Whitney U test was used to compare the means of variables between two groups as the variables were not normally distributed across two group. P value below 0.05 was considered to be statistically significant.

Secondary outcome measures include perioperative data like operative time, amount of blood loss and size of the surgical wound; complications such as neurovascular injury, wound infection, nonunion, malunion, implant migration, implant failure, soft tissue irritation, refracture after implant removal and cosmetic outcome with regardsto visible deformity, hypertrophic scars and hardware prominence under the skin. Implant removal was not done routinely in our study. It was done as per need and will of the patient after fracture union. The number of days to return to normal activities after implant removal was noted.

RESULTS

Total 50 patients were studied among whom 25 belonged to TENS group and rest belonged to plating group. The demographic and clinical profiles of patients were depicted in Table 1. There was no significant difference between two groups in respect to these demographic and clinical profiles. The age range of the patient was from 18 to 55 years. The mean age for TENS group was 33.28±10.73 and plate group 34.76±11.87 (p=0.646). The injury being a result of trauma was commonly found in male population compared to female in both the groups. Male to female ratio 2.5:1. The mode of injury was uniformly distributed in both the groups. 56% of cases are due to road traffic accident, 16% cases were due to fall from height and sports activity and due to fall on outstretched hand on 12% cases. In both the group the dominant side of the patient was more affected (64%). In respect to type of fracture as per OTA classification, 50% cases were simple (B1) type and 50% cases were wedge (B2) type.

In our study 13 patients (52%) were used locking compression plate, 6 patients (24%) recon plate and 6 patients (24%) semi tubular plate. As per OTA classification for type B1 simple fracture locking compression plates were used in 8 patients (32%), recon plates in 3 patients (12%) and semi tubular plates in 1 patient (4%). For type B2 both LCP and STP were used in 20% cases each. Recon plates were used in 3 patients (12%) (Table 1).

In our study the fractures in the TENS group were united with an average time of 11.4±2.12 weeks and

in plate group one case non united but rest cases united with an average time of 13.4±3.46 weeks and the difference was significant (p=0.016).

TABLE 1: DEMOGRAPHIC AND CLINICAL PROFILE OF STUDY PARTICIPANTS (N=50).

Character	TENS group (n=25)	Plating group(n=25)
Mean age (in years)	33.28±10.7	34.76±11.8
Gender (in number (%))		
Male	18 (72)	18 (72)
Female	7 (28)	7 (28)
Mode of injury (in number (%))		
RTA	12 (48)	16 (64)
Fall on outstretched Hand	5 (20)	1 (4)
Fall from height	2 (8)	6 (24)
Sports	6 (24)	2 (8)
Side of affection (in number (%))		
Dominant	19 (76)	13 (52)
Non dominant	6 (24)	12 (48)
Type of fracture as per OTA (%)		
B_1	13 (52)	12 (48)
B_2	12 (48)	13 (52)

Table 2: Pain as per vas score on day 3 among study participants (n=50).

PainVAS score	TENS group (n=25)		PLATE group(n=25)	
	No. of cases	%	No. of cases	%
0	0	0	0	0
1	2	8	0	0
2	11	44	6	24
3	9	36	11	44
4	2	16	7	28
5	1	4	1	4
6 to 10	0	0	0	0

Table 2 showed the pain VAS score on day 3 among study participants. The mean pain VAS score in TENS group was 2.56±0.91 and in plating group was 3.12±0.83 and the difference was significant (p=0.023) (Table 2).

No clavicular shortening was seen in 32% (8 patients) and less than 5 mm shortening in 28% (7 patients) plate cases. 6 patients (24%) in plate group shows 6 to 10 mm shortening. Majority of the patients (60%) in TENS group shows no shortening. 8 patients (32%) in TENS group shows less than 5 mm shortening. Mean shorteningin TENS group was 1.84±2.88 mm and plate group was 4.5±4.12 mm and the difference was significant (p=0.011)

Table 3 showed the functional outcome in terms of shortening among study participants. Those having shortening <15mm had excellent result in 100%. 16.7% had good result and 33.3% (Table 3).

TABLE 3: FUNCTIONAL OUTCOME IN TERMS OF SHORTENINGAMONG STUDY PARTICIPANTS (N=50).

Shortening	Excellent (%)	Good(%)	Fair (%)	Poor(%)
<15 mm	36 (100)	1 (16.7)	2 (33.3)	0 (0)
≥15 mm	0 (0)	5 (83.3)	4 (66.6)	2 (100)
Total	36	6	6	2

TABLE 4: COSMETIC SCORING AMONG STUDY PARTICIPANTS (N=50).

Cosmetic scoring	Tens group (n=25)		Plate group (n=25)	
	No. of cases	%	No. of cases	%
1	0	0	0	0
2	1	4	3	12
3	1	4	6	24
4	8	32	9	36
5	15	60	7	28

In our study, the TENS group were cosmetically more satisfied with mean score 4.48±0.77 than the plate group with mean score 3.8±1.0 (p=0.009). Table 4 showed cosmetic scoring among study participants (Table 4).
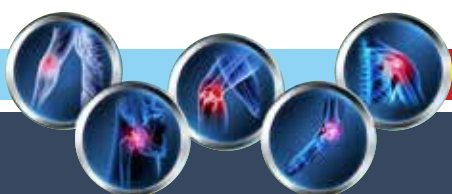
Functional outcome was measured according to Constant Shoulder score and DASH score. In TENS group 21 (84%) patients showed excellent result, 2 patients (8%) showed good result. But in plate group about 15patients (60%) showed excellent result while 16% cases showed good result.

COMPARISON OF DIFFERENT SCORES IN OUR STUDY

In our prospective study mean DASH and Constant shoulder score in TENS group were 1.87±3.4, 9.36±7.04 and plate group 4.8±9.0 and 15.08±9.4 respectively. P value for mean DASH score=0.039 and p value for mean constant score=0.000 which were significant. Table 5 depicted comparison of different scores among study participants (Table 5).

TABLE 5: COMPARISON OF DIFFERENT SCORES AMONG STUDY PARTICIPANTS.

Sl no	Constant score in tensgroup	DASH score in tensgroup	Constant score inplate group	DASH score in plategroup
1	10	4.5	10	1
2	10	3.0	10	1.8
3	9	13	10	1.3
4	6	3.8	10	1.4
5	7	2.7	10	2.0
6	5	3.4	9	1.10
7	9	3.9	8	1.02.5
8	10	37.4	10	3.8.8
9	10	5.0	10	1.5
10	6	2.2	10	1.2
11	8	1.9	10	0.8
12	6	2.4	10	00
13	8	3.4	8	00
14	7	2.0	9	10.5
15	6	3.8	10	25
16	5	4.7	12	40
17	4	15.9	14	1.0
18	6	14.6	18	2.5
19	3	3.1	19	0.8
20	6	3.9	26	1
21	5	2.2	27	8
22	16	2.9	25	8
23	13	3.4	23	00
24	22	10.8	28	4.2
25	37	2.8	49	4.2

In TENS group we found the complications are delayed union in 4%, infection in 4%. In TENS group, majority of the cases (68%) had radiological union within 9-12 weeks & 7 patients (28%) had union at 13-15 weeks. But plate group majority (60%) had it in about 9-12 weeks with mean union time 13.4 weeks with 4% having non union, 4% having delayed union and 4% having mal-union. In addition to it in plate group, hypertrophic scar was found in 12% cases, plates loosening due to infection in 8% cases, 8% patient showed superficial infection and 4% showed re-fracture. TENS group is better in terms of infection, plate loosening, hypertrophic scar and plate prominence, refracture or neurovascular injury as no such complication was found in TENS group.

DISCUSSION

The clavicle has an integral role not only in the mechanics of the pectoral girdle but also in the function of upper extremity. Clavicle fractures accounts for approximately 2.6% of all fracture.[1,4-7] The majority of clavicle fractures (80-85%) occur in midshaft of bone where the typical compressive forces applied to the shoulder and narrow cross section of the bone combine and result in the bony failure.[3,4,8,9] Most of the(97%) in this group are mild to moderate displaced and can be treated conservatively. However 3% of middle third clavicle fractures are completely displaced and shortened. This small group of fractures accounts for 90% of nonunion of the middle third fractures and therefore may warrant early open reduction and internal fixation. Our study was done to compare the rate of union and functional outcome in displaced middle third clavicle fractures by surgical management using TENS vs plating. This study was conducted in the post graduate department of Orthopaedics, M.K.C.G Medical college, Berhampur from November 2015 to October 2017.

In our study mean age of the patients with displaced mid shaft clavicle fracture in TENS group was 33.28 years and in plate group was 34.76 years. Nordquist et al. reported mean age to be 29.3 years and the incidence appears to decrease significantly after second decade of life.[1] Study conducted by Bostman et al Showed the average age was 33.4 years.[10] Nordquist et al. and Bostman et al in their studies found that males outnumber the females. Our study also found 72% of participants were males.[1,10]

Plate osteosynthesis is the gold standard method for surgical treatment of clavicular fracture. Plate fixation can provide immediate rigid fixation. The convenient 3.5 mm DCP, RP, STP are usually used routinely. New type such as LCP, Precounter LCP, LC-DCP have been developed to decrease the hard wire irritation, and implant failure. In our study we use 3.5 mm LCP in 52% patients and RP in 24% and STP in 24% cases. According to our study the mean radiological union time in TENS group was 11.4±2.12 weeks and plate group 13.4±3.46 weeks. TENS was found to be superior in terms of radiological union for the fracture of middle third of the clavicle than plate fixation as the mean difference was significant. In our study we use Titanium elastic nail in TENS group and 3.5 mm LCP, RP or STP in plate group. In TENS group we found the complications are delayed union (4%), infection (4%). In TENS group, majority of the cases (68%) had radiological union within 9-12 weeks and 7 patients (28%) had union at 13-15 weeks. But plate group majority of the plates 60% (15 patients) had it in about 9-12 weeks with mean union time 13.4 weeks with 1 (4%) having non union, 1 (4%) having delayed union and 1 (4%) having mal-union. In addition to it in plate group, hypertrophic scar was found in 12% cases, plates loosening due to infection in 8% cases, 8% patient showed superficial infection and 4% showed re-fracture. TENS group is better in terms of infection, plate loosening, hypertrophic scar and plate prominence, refracture or neurovascular injury as no such complication was found in TENS group.

Although plating of the clavicle spares the original fracture site it rarely involves fixation along its entire length. Refracture secondary to additional trauma either medial and lateral to original occurs and reported at a rate between 1% to 2% by Mckee et

al.9 Poigenfurst et al reported in 4 patients out of 122 patients refracture occurs.11 Refracture needs revision surgery. Our study shows refracture rate 4% (one patient) in plate group.

In our study mean constant score in TENS group was 9.36±7.04 and plate group 15.08±9.0. Patients treated by plating showed excellent outcome in 60% cases while 84% in TENS group. The mean DASH score was found to be 1.87±3.4 in TENS group and 4.8±5.9 in plate group. Patients treated with TENS were found to be better in terms of CONSTANT and DASH score than treated with plate. TENS group had significantly higher mean cosmetic score than the plate group (p=0.039). Saha et al reported that patients treated by plating of displaced mid shaft clavicle fracture, the mean constant score was 95.2 and mean DASH score was 5.12 Mckee et al found that mean constant score in CONS group 91.6±14.1 and in plate group 97±4.5 and mean Dash score 4.1±7.0 and 11.49±7 respectively.13

CONCLUSION

Our study found that patients treated by plating showed excellent outcome in 60% cases while 84% in TENS group. Patients treated with TENS were found to be better in terms of Constant and DASH score than treated with plate. TENS group had significantly higher mean cosmetic score than the plate group. So in the management of acute displaced midshaft clavicular fractures, TENS is superior to plating for management of clavicular fracture. Surgery with TENS results good functional outcome compared with surgical plating treatment.

ACKNOWLEDGEMENTS

REFERENCES

1. Nordqvist A, Petersson C. The incidence of fractures of the clavicle. Clin Orthop. 1994;3:127- 32.

2. Robinson C M. Fractures of the clavicle in the adult. J Bone Joint Surg Br. 1998;80:476-84.

3. Rowe CR. An atlas of anatomy and treatment of midclavicular fractures. Clin Orthop. 1968;58:29- 42.

4. Neer CS. Nonunion of the clavicle. JAMA. 1960;17:1006-11.

5. Lenza M, Belloti JC, Andriolo RB, Gomes Dos Santos JB, Faloppa F. Conservative interventions for treating middle third clavicle fractures in adolescents and adults. Cochrane Database of Systematic Rev. 2009;2:CD007121.

6. Neviaser JS. The treatment of fractures of the clavicle. Surg Clin North Am. 1963;43:1555-63.

7. Nowak J, Holgersson M, Larsson S. Can we predict long-term sequelae after fractures of the clavicle based on initial findings? A prospective study with 9 to 10 years follow-up. J Shoulder Elbow Surg 2004;13:479-86.

8. Allman FL. Fractures and ligamentous injuries of the clavicle and its articulation. J Bone Joint Surg Am. 1967;49:774-84.

9. McKee MD. Optimal treatment of displaced midshaft fractures of the clavicle. Philidelphia, Saunders. 2009;1:126-32.

10. Bostman O, Manninen M, Pihlajamaki H. Complications of plate fixation in fresh displaced midclavicular fractures. J Trauma. 1997;43:778-83.

11. Poigenfurst J, Reiler T, Fischer W. Plating of fresh clavicular fractures,Experience with 60 operations. Unfallchirurgie. 1988;14:26-37.

12. Saha P, Datta P, Ayan S, Garg AK, Bandyopadhyay U, Kundu S. A comparative study- Plate versus titanium elastic nail in treatment of displaced midshaft clavicle fractures. Indian J Orthop. 2014;48(6):587–93.

13. McKee MD, Wild LM, Schemitsch EH. Midshaft malunion of the clavicle.Surgical technique. J Bone Joint Surg Am. 2004;86:37-44.

A COMPARATIVE STUDY OF THE MANAGEMENT OF FRACTURE NECK FEMUR BY DYNAMIC HIP COMPRESSION SCREW WITH DEROTATION SCREW VERSUS THREE CANCELLOUS SCREWS

Dr. Tapash Murmu[1] Dr. Manibhushan Prasad[2] Dr. G.S.Baraik[3]

1. Junior Resident, 2. Ex-Associate Professor
Dept of Orthopedics.. Rajendra Institute of Medical Sciences, Ranchi, Jharkhand
3. Professor and Head of Department, Dept of Orthopedics. MGM Medical College and Hospital, Jamshedpur, Jharkhand

ABSTRACT

BACKGROUND

Intra capsular fractures of neck femur have always presented a great challenge to orthopaedics surgeons and remain in many ways the unsolved fracture as far as treatment and results are concerned.

Methods: Cases included in this study are transcervical and subcapital fracture neck femur in patients less than 60 yrs of age managed in Rajendra Institute of Medical Sciences, Ranchi, Jharkhand

Results: Fracture type, anatomical reduction and proper implant selection are the most important factor affecting the out come of management of fracture neck femur where as age, time interval, method of reduction, and capsulo to my playa less important role.

Conclusion: Dynamic Hip Screw (DHS) is a better implant in management of most of the cases of fracture neck femur. High sub capital fractures are an exception to this rule.

Keywords: Fracture neck femur, transcervical/sub capital fracture, canulated cancellous screw, dynamic hip screw, avascular necrosis, nonunion.

THESIS SUMMARY

INTRODUCTION

Fractures of the femoral neck are devastating injuries that most often affects the elderly and have a tremendous impact on the health Care system and society in general. The worldwide incidence of femoral neck fractures has continued to increase. From an estimated 1.3 million hip fractures in 1990. This number is predicted to rise to 2.5 million by 2025 and 4.5 million by 2050, assuming there is no age specific increase. Amongst these the fractures occurring in young patients are particularly trouble some. The fracture is regarded as a vascular injury to the bone's blood supply [3-8]. The degree of vascular compromise is thought to directly correlate with the displacement of the fracture which affects fracture union and leading to complications. Hence intracapsular fracture neck of femur is regarded as an orthopaedic emergency [9] and needs to be reduced with rigid internal fixation which is believed to improve the circulation off emoral head and prevent the non union and avascular necrosis.

Internal fixation with cannulated cancellous screws after good anatomic al reduction has the advantages of decreased blood loss and operative time, lower transfusion requirements and decreased length of hospital stay [9].

Richards et al has quoted basic advantages of using sliding hip screws in terms of strength greater than multiple cancellous screws, minimization of risk of sub sequent sub trochante ricfracture secondary to a stress riser effect, and placement of compression across the fracture at the time of reduction. Disadvantages of the sliding hip screw for femoral neck fracture stabilization include alarger surgical exposure and the potential to create rotational mal alignment of the femoral head at the time of screw

insertion[10].

However inspite of available modalties and techniques there is high rate of compliations particularly in young patients suffering from fracture neck femur.

We have undertaken this comparative study to assess the outcome of both fixation modalities as well as factors influencing the results ofthese fixations in our population and attempt to fill in the lacunae in our understanding of management off racture neck femur.

METHODS

Cases included in this study are transcervical and sub capital fracture neck femur in patients less than 60 yrs of age. The cases studied for this dissertation were managed in Rajendra institute of medical science, Ranchi.

The total number of cases studied were 62

The total patients were divided into two subgroups

Patients treated with multiple cancellous screws (31)

Patients treated with dynamic hip screw and derotation screw (31).

All the patients were followed up with radiological and functional assesement.

DISCUSSION

Age, sex and laterality offracture: We have found no studies suggesting the role oft hese variables in the outcome offracture treatment.In our study as well, we have not found these factors to play any role in the out come of fracture treatment.

Modality of treatment: On assessment of patients on follow up with Harris hip score, we found excellent result in 61.3 % of our patients managed with DHS while only 25.8 % of patients managed with CC screw showed excellent result. On the other hand 9.7 % patients managed with CC screw showed poor results while none of the patients managed with DHS

showed poor result. This difference is statistically significant with p value of 0.024 as calculated by Chi-square test. Also overall Harris hip score of patients managed with DHS was higher as compared tothescoreinpatientsmanagedwithCCscrew.We have found DHS not only to be to be more stable but also allows better compression across the fracture, allowing early mobilization and early union. There was no complication of non-union in patients managed with DHS while 3 patients managed with CC screw progressed tonon-union. Average time for union in our study was 14 weeks for patients managed with DHS while it was 18 weeks for patients managed with CC screw. We recommend use of DHS
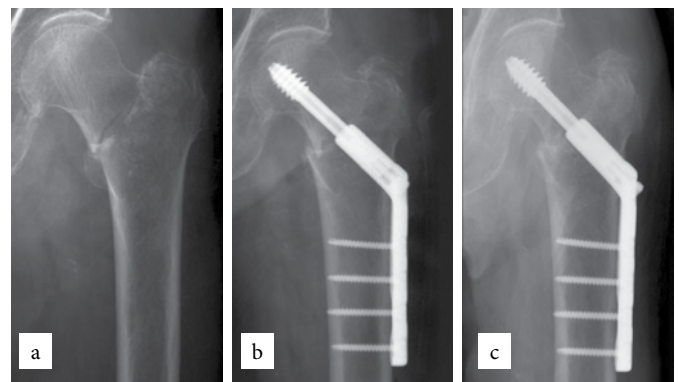

Figure 1. 60 Year-old female with left basi cervical neck femur fracture fixed with DHS. (a) Preoperative anteroposterior view. (b and c) Anteroposterior radiograph at 12 weeks and 24 weeks follow up.

with derotation screw for managing all the patients offracture neck femuri/v/o early mobilization, early unionandreduced risk of non-union.

Fracturetype: Pauwel's type-3 femoral neck fractures are problematic to treat, with non-union rates higher than those reported for historical controls. In one of the studies on Pauwel's type III fractures[11] non-union rate of 16% was reported with cannulated screws and 8 % with fixed angle device and supports the theory that these type-3 fractures experience shear and may demonstrate a high errate of varus, shortening, andnon-union. Inour study, 8 patients had Pauwel's type III fracture of which 5 patients were managed with DHS while 3 patients were
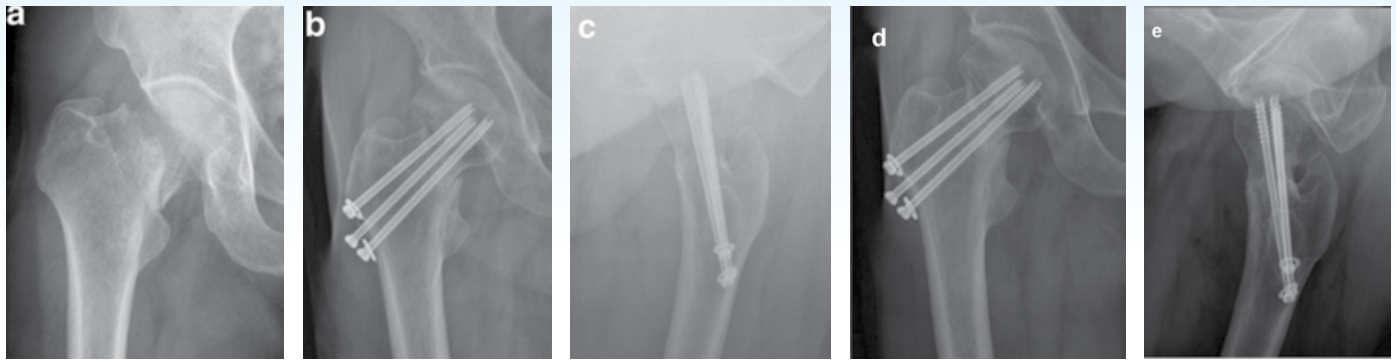
Figure 1. 30 Year-old male with fracture right neck of femur fixed with 3 CC screws. (a) Preoperative anteroposterior view. (b,c d and e) Anteroposterior radiograph and lateral radiographs at 12 weeks and 24 weeks follow up.
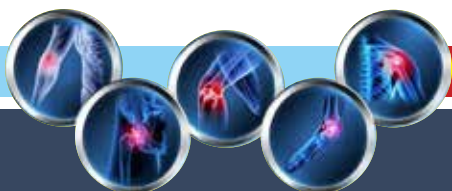
managed with CC screw. Complications like delayed union and varus were seen in patients managed with CC screw. However no patients with type III fracture ended up in non-union. Biomechanically, it has been shown that a sliding hip screw deviceis stronger than three parallel cancellous screws for the treatment of Pauwel's type III intracapsular neck femur fractures. Stability and thequality of reduction appeared to influence the rates of adverse out comes in our series. We recommend use of DHS with derotation screw in Pauwel's type III fractures as adequate compression is achieved intraoperatively by placing 5 mm shorter lag screw in inferior quadrant of the neck and placing the derotation screw wide rapartin superior quadrant. We have found limitation of this constructin high subcapital fracture where DHS threads won't have enough purchase in femoral head[12]. Time interval between injury and surgery: Advocates of earlysurgery suggest that the main advantages ofprompt reduction of a displaced femoral neck fracture are unkin king of the vessels and performance of anintra capsular decompression to remove the hematoma that increase sintra capsular pressure [13,14,15]. This improves and restores blood flow to the femoral head, minimizing the risk offemoral head osteonecrosis. Inour study majority of our patients were treated within twenty-four hours after the injury. However, the exact time to treatment is difficult to as certain. In our study however higher risk of non-union was seen in patients managed with CC screw who under

wentsurgery more than 72 hrs after trauma.The probable reason is that when surgery is delayed for more than 72 hrs there is resorption at fracture ends and compression across the fracture site is poor, more so with CC screw as compared to DHS. [16]

Method of reduction (open vs. closed): In our study only 13 % (8 patients) required open reduction of which 1 patient developed Avascular Necrosis. Hence we donot consider open reduction as a risk factor for AVN.

Role of Capsulotomy: The role of capsulotomy in the treatment of femoral neck fractures remains controversial, and the practice varies by trauma program, region, and country. Clinical studies [17-21] have shown that decompressing the intra capsular hematoma by means of a capsulotomy or aspiration reduces the intra capsular pressure. This decrease in the intra capsular pressure results in improved blood flow to the femoral head and may reduce femoral head Ischemia [17-23]. In our study the difference in the rate of osteonecrosis between those who had and those who had not received a capsulotomy was small; however, our sample size was too small for us to make definitive conclusions about the value of capsulotomy. Capsulotomy was not done inpatients managed with DHS as reaming for lag screw placement was considered to decompress the femoral head.

Post-operative radiological reduction : Portzmann R Retal [24]and Lee ch et al [25] and several others have found increased complications like non-union and AVN in patients with non-anatomical post operative reduction. Complications like non-union, AVN, shortening and post operative poor functional out come were seen more commonly in patients who were fixed in malalignment. Hence it is recommended by us to reduce the fractures anatomically or in valgus impacted position.

Positioning of Lag screw and type of barrel: Screw position[26] can beassessed with implant-cortical bone purchase by evaluating the distance from the implant to the cortex. Baumgaertneretal. [27] proposed what has become the well-known concept of the tip-apex distance (TAD). In our study the exact distance was not measured due to variable magnification of available x-rays and lack of proper scaling of the x rays and hence the stability of reduction and the relation of TAD with the outcome could not becom mented. Similarly, we have found that placement of DHS lag screw in the inferior quadrant along the calcar and use of long barrel plate increases the stability of fixation and henceis recommended by us. We have also found Dynamic Hip Screw with derotation screw to have greater ability to compress across the fracture site as compared to Canulated Cancellous screw. However, further biomechanical studies are recommended for confirmation.

Duration of surgery and blood loss: Average duration of surgery in patients managed with CC screw was 50 mins while that in DHS group was 90 mins. Incision for CC screw group was smaller as compared to DHS group. Average blood loss for CC group was 50 cc while that of DHS group was 150cc.

Complications: In this study, the risk factors for fracture non-union after internal fixation of intra capsular femoral neck fractures, we found that a displaced fracture, border line and un acceptable reduction, and more centralized screw position were risk factors for non-union and implant failure. The factors that have been most consistently found to be predictive of non-union after fixation of intra capsular femoral neck fractures are poor reduction and fracture displacement. Age and sex are not risk factors for non-union in most studies, including our study. Fracture site, fracture level, and bone densitywere not found to bere lated. Of the 3 patients managed with CC screw that went in to non-union, 2 patients were fixed in borderline retroversion and 1was fixed in varus. [28] In our study we have achieved union rateof 100 percent with DHS while it is 90 % in patients managed with CC screw. High rate of union in DHS group was due to significant compression and impact ion achieved across the fracture site.

Avascular Necrosis: AVN was seen in 6 cases (9.7%) inourseries. Of this 4 cases were managed with DHS while 2 patients were managed with CC screw. Of the patients who developed AVN,none of the patients required further surgical management in the form of hip replacement till follow-up. Further collapse was prevented in these patients with the use of bi sphosphonates. Union was confirmed radiologically by corticalization across the fracture site in AP and lateral views and filling of earlier bone defects with remodelling of bone.

Minor complications like superficial infection and bursitis were encountered but these complications were managed with oral/ IV medications. None of these minor complications were found to affect the over all functional outcome.

CLINICAL MESSAGE

The aim of this study was to study various factors related to the anatomical and functional out come in the management of fracture neck femur. With the increasing incidence of fracture neck femur in young adults this study aims in providing precise management protocols and thereby reducing the incidence of complication sinyoung patients.

Anatomical reduction is of prime importance for any fracture neck femur to unite. All cases of fracture neck femur in patientsless than 60 years of

age should be managed with DHS with Derotation screw with the exception of high sub capital fracture which should be managed with Canulated cancellous screws.

BIBLIOGRAPHY

Davidglavelle, fractures and dis locations of the hipin : campbellsoperative or thopaedics. Terry canalles, beaty JH: editors. Pennsylvania. 2008; mosby Elsevier. 11th edition,volume-3:p3237-308

1. Rossk Leighton, fractures of neck of femurin rock wood and greens fractures in adults. Bucholz R Wheckman JD, courtbrownCM. Editors Philadelphia.2006, lippincot Williams and Wilkins, 6th edition, vol2, p1753-92

2. Protzman RR, Burkhalter WE. Femoral-neck fractures inyoungadults. J Bone Joint Surg Am. 1976;58:689-95.

3. Thuan V. Ly and Marc F. Swiontkowski. Treatment of Femoral Neck Fractures in Young Adults. J Bone Joint Surg Am.2008;90:2254-2266.

4. Dedrick DK, Mackenzie JR, Burney RE. Complications of femoral neck fracture in young adults. J Trauma.1986;26:932-7.

5. Zetterberg CH, Irstam L, Andersson GB. Femoral neck fractures in young adults. Acta Orthop Scand. 1982;53:427-35.

6. Swiontkowski MF, Winquist RA, Hansen ST. Fractures of the femoral neck in patients between the age soft welve and forty-nine years. J Bone Joint Surg Am.1984;66:837-46.

7. Luice RS, Fuller, Stephen, Burdick D C and Johnston RM,: Early prediction of avascular necrosis of the femoral head following femoral neck fractures. Clinical Orthopaedics.1981;161:p207-14.9. Ross K Leighton. Fractures of the Neck of Femur. In: Rockwood and Green's Fractures in Adults. Bucholz RW, Heckman JD, Court-brown CM: editors. Philadelphia. 2006; Lippincott Williams &Wilkins. 6th ed,vol-2;p1753-92.

10. Behr JT, Dobozi WR, Badrinath K. Thetreatment of pathologic and impending pathologic fractures of the proximal femurintheelderly. Clin Orthop1985;198:173â€—178.

11. Liporace F, Gaines R, Collinge C, Haidukewych GJ.: Results of internal fixation of Pauwel stype-3vertical femoral neck fractures.: J Bone Joint Surg Am. 2008 Aug;90(8):1654-9. doi:10.2106/JBJS

12. M P Singh, Aditya N Aggarwal, Anil Arora, Ish K Dhammi, and Jagjit Singh: Unstablerecent intracapsular femoral neck fractures in young adults: Osteosynthesis and primary valgusosteo to my using broad dynamic compression plate: Indian JOrthop.2008Jan Mar;42(1):43-48.

13. Swiontkowski MF, Winquist RA, Hansen S T Jr. Fractures of the femoral neck in patients between the age softwelve and forty-nine years. J Bone Joint Surg Am. 1984;66:837-46.

14. Claffey TJ. Avascular necrosis of the femoral head. Ananatomicalstudy. JBoneJointSurgBr.1960;42:802-9.

15. Swiontkowski MF,Tepic S, Rahn BA, Cordey J, Perren SM. The effect of fracture on femoral head blood flow. Osteonecrosis and revascularization studied in miniature swine. Acta Orthop Scand.1993;64:196-202.

16. George J. Haidukewych, Walter S. Rothwell, David J. Jacofsky, Michael E. Torchia and Daniel J.Berry: Operative Treatment of Femoral Neck Fracturesin Patients Between the Ages of Fifteen and Fifty Years: J Bone Joint Surg Am.2004;86:1711-1716.

17. Bonnaire F, Schaefer DJ, Kuner EH. Hemarthrosis and hip joint pressure in femoral neck fractures. Clin Orthop Relat Res.1998;353:148-55.

18. Harper WM, Barnes MR, Gregg PJ. Femoral head blood flow in femoral neck fractures. An analysis using intra-osseous pressure measurement. J Bone Joint Surg Br.1991;73:73-5.

19. Holmberg S, Dalen N. Intra capsular pressure and caput circulation in non displaced femoral neck fractures. Cl in Orthop Relat Res. 1987;219:124-6.

20. Crawfurd EJ, Emery RJ, Hansell DM, Phelan-M,Andrews BG. Capsular distension and intracapsular pressure in sub capital fractures of the femur. JBone Joint Surg Br.1988;70:195-8.

21. Str¨omqvist B, Nilsson L T, Egund N, Thorngren K G, Wingstrand H. Intracapsular pressures in undisplaced fractures of the femoral neck. J Bone Joint Surg Br.1988;70:192-4.

22. Swiontkowski MF, Tepic S, Perren SM, Moor R, Ganz R, Rahn BA. Laser Doppler flowmetry for bone blood flow measurement: correlation with micro sphere estimates and evaluation of the effect of intracapsular pressure on femoral head blood flow.J Orthop Res.1986;4:362-71.

23. Wood house CF. Dynamic influences of vascular occlusion affecting the development of a vascular necrosis of the femoral head. Clin Orthop Relat Res.1964;32:119-29.

24. Protzman RR, Burkhalter WE. Femoral-neck fractures in young adults.J Bone Joint Surg Am.1976;58:689-95.

25. Lee CH, Huang GS, Chao KH, Jean JL, Wu SS. Surgical treatment of displaced stress fractures of the femoral neck inmilitary recruits: are port of 42 cases. Arch Orthop Trauma Surg. 2003;123:527-33.

26. Aminian A, Gao F, Fedoriw WW, Zhang LQ, Kalainov DM, Merk BR. Vertically oriented femoral neck fractures: mechanicalanalysis of four fixation techniques. J OrthopTrauma. 2007;21:544-8

27. Baumgaertner MR, Curtin SL, Lindskog DM, Keggi JM. The value of the tip-apex distance in predicting failure of fixation of peritrochanteric fractures of the hip. J Bone Joint Surg Am. 1995 Jul;77(7):1058-64.

28. Bonnaire FA, Weber AT. Analysis of fracture gap changes, dynamic and static stability of different osteosynthetic procedures in the femoral neck. Injury. 2002; 33 Suppl3: C24-32.

TIBIOTALARCALCANEAL ARTHRODESIS USING AN INTRAMEDULLARY NAIL IN PATIENTS WITH ANKLE ARTHRITIS

Dr. Ankit Kumar Bhalotiya[1] Dr. Abhishek Gudia[2] Dr. G K Gupta[3]

1. Junior Resident 3. Associate. Professor
Department of Orthopaedics, Rajendra Institute of Medical Sciences, Ranchi
2.Assistant Professor, Department of Orthopaedics, MGM Medical College, Jamshedpur, Jharkhand

INTRODUCTION

Ankle arthritis is a physically disabling condition, and its treatment can be both challenging and rewarding for the patient and the treating physician. Gait derangement is common in patients with ankle arthritis, and associated pain in the knee, hip, or back often contributes to general health problems. Arthrodesis, although not always perfect in outcome, can obtain a stable, mostly pain-free ankle and an often dramatic improvement in the function and quality of life in appropriate patients.

Ankle arthrodesis has been reliably used and improved since 1951 when Charnley reported his method of compression arthrodesis with the use of external fixation [1]. Damage to the ankle can be due to a variety of reasons such as trauma or pathology which causes progressive loss and damage to the articular surface. Arthrodesis is used for symptomatic, persistent, disabling ankle pain refractory to nonoperative management to include NSAIDs, shoe modifications, or bracing.

In certain circumstances, arthrodesis of both the ankle and subtalar joints is necessary or advantageous.

Indications for arthrodesis of the ankle and subtalar joint are disease involving both joints or complex pathologic features in either joint, example several failed fusions or reduced bone stock with soft tissue problems. In the latter scenario, tibio-talocalcaneal arthrodesis is used more often as a salvage procedure.

Tibio-talocalcaneal arthrodesis ideally should be performed using a technique that is straightforward, gives excellent stability and a high union rate, spares the soft tissue, results in few complications, and has a high patient satisfaction rate. Intramedullary fixation for tibio-talocalcaneal arthrodesis is not a new technique but has become increasingly popular during the last few years, resulting in numerous recent publications. Nailing systems are becoming more sophisticated and are purposely designed for tibio-talocalcaneal arthrodesis. The possible advantages of retrograde nailing are the use of a load-sharing device in combination with preservation of the soft tissues.
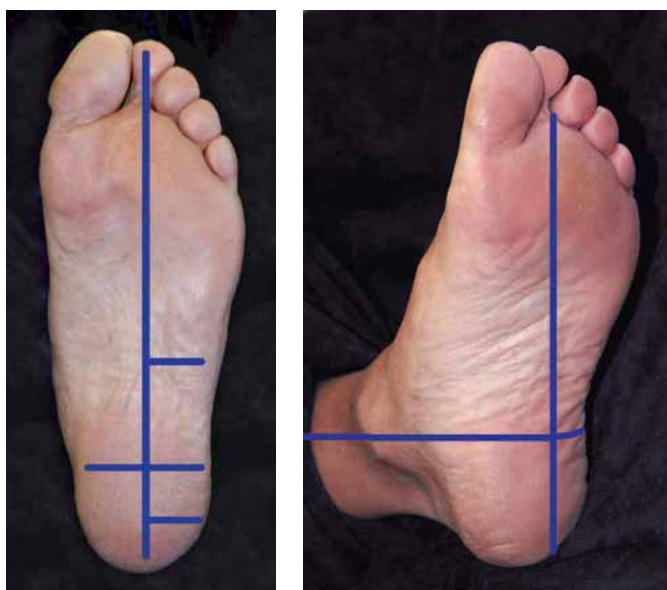

Figure 1 : Diagram representing the ideal entry point for the TTC nail

MATERIALS AND METHODS

This is a retrospective study done in the department of Orthopaedics , RIMS , RANCHI from 2019- 2021. The indications for surgery included posttraumatic

Figure 2. 40 Year-old male with arthritic changes at right ankle joint treated with TTC nail. (a) Preoperative anteroposterior and lateral view. (b) Anteroposterior and lateral radiograph at 12 weeks follow up.

osteoarthritis after ankle fracture, fracture dislocation, or necrosis of the talus in 10 patients. No patients in this series responded to conservative treatment All retrograde nailing were performed in a standardized way as described by Mader et al The retrograde locking (TTC) nail was used in all cases.

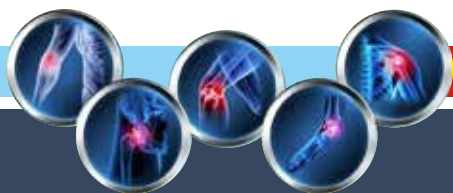The surgical procedure was performed in a standardized way in which the patient is prepped and draped in the supine or prone position on a radiolucent operating table. We aim for a neutral fusion position with a neutral to 5° heel valgus angulation and 10° to 15° external rotation with the foot plantigrade.[6] A fibula osteotomy, with removal of a 15-mm–segment of bone, is performed routinely approximately 10 to 12 cm proximal to the tip of the fibula to allow for adequate bone contact between the tibia and talus after debridement of the ankle. Debridement of the ankle is done to remove residual cartilage. This can be performed in an open or percutaneous manner. We used an open procedure ,in which , the cartilage is removed with an osteotome. The subtalar joint is not formally debrided because the process of reaming as much as

12 mm yields a joint that is sufficiently destroyed and grafted with bone debris to achieve fusion. A small longitudinal incision is made over the sole of the foot and blunt dissection follows to reach the ridge on the under surface of the calcaneus. The ankle is brought into the fusion position and with the help of the image intensifier, the entry point on the calcaneus is chosen carefully to provide good alignment with the middle of the tibial shaft in two directions. The lateral plantar neurovascular bundle is protected with Langenbeck retractors and a 5-mm Steinmann pin is driven through the os-calcis and talus into the tibia; the subsequent position is confirmed radiographically. In some cases, soft tissue release or an osteotomy had to be performed to align the hindfoot correctly. In those cases, an external fixator may be required to maintain position. The type and level of osteotomy depend on the deformity and are case-specific (Figs 1 and 2). Reaming is done as much as 12 mm (distally 14 mm) and a 10-mm straight nail of appropriate length (140, 160, or 180 mm) is inserted over a guide wire. The holes in the nail are lined up radiographically in such a way that

Figure 3. 35 Year-old female with arthritic changes at right ankle joint after being diagnosed with TB of right ankle treated with TTC nail. (a) Preoperative anteroposterior and lateral view. (b) Anteroposterior and lateral radiograph at 12 weeks follow up.

one screw can be inserted into the os calcis and one into the talus. With the help of a guide bar, the posterior to anterior locking screws for the talus and os calcis are drilled and filled through stab incisions in the Achilles tendon. The locking screws have threads at their most proximal ends, which are used for fixation in the nearby cortex. The proximal tibial

locking screw is drilled from posterior to anterior but is inserted through a stab incision from the front to facilitate later removal.

All patients completed a questionnaire and had physical and radiographic examinations. Patient satisfaction was measured on a scale of 1 to 10 (7 or greater indicating patient satisfaction). The AOFAS ankle/hindfoot score also was completed for every patient. This score transforms subjective and objective factors into numeric scales to describe pain, function, and alignment. The maximum possible AOFAS score in hindfoot arthrodesis is 86 points (100 points minus 14 as a result of expected absence of hindfoot motion). Physical examination involved evaluation of the hindfoot for tenderness, position, and mobility. Radiographs were taken of the surgically treated ankle in anteroposterior and lateral planes. Consolidation was assessed postoperatively by radiographs (6 and 12 weeks postoperatively, thereafter when necessary). Radiographic fusion was determined by the presence of bridging bone in two directions for the ankle and in only one direction (lateral view) for the subtalar joint. Union of the ankle and subtalar joint were considered separately.

RESULTS

All of the ankles , which continued follow up , successfully fused . There was a loss in follow up of 3 patients.

The minimum consolidation time for the ankle was 14 weeks , and it also was 14 weeks for the subtalar joint.

In one patient (10%), the varus deformity was under corrected.

We did not found any case with following complications: sensory loss to the dorsum of the foot, arterial bleeding at the entry point of the nail, pain and radiologic lucency around the proximal tip of the nail , and ulceration around the proximal locking screw within 3 months.

Ninety-two percent of the patients were satisfied with their outcome.

The mean postoperative AOFAS ankle/hindfoot score at follow up was 70 (range, 32–86). At follow up, no patients reported having severe pain; 5 patients had no pain, 1 had mild pain, and 1 had moderate pain. 4 patients had no limitations of daily or recreational activities, 3 had limitations in recreational activities, 2 had some limitations in daily and recreational activities, and 1 had severe limitations in daily and recreational activities. 5 patients walked without a visible limp but 2 had an obvious when assessed while walking in their daily footwear. All patients walked easily on any surface, but had some difficulty walking on uneven terrain or climbing ladders. The maximum walking distance at follow up varied among patients and was widely influenced by comorbidity. None of the patients had hindfoot instability.

DISCUSSION

Tibio-talocalcaneal arthrodesis by intramedullary nail fixation combines high biomechanical stability with the possibility of soft tissue preservation. In this study, we did not formally debride the subtalar joint and slightly more than $\frac{1}{2}$ of the ankles were debrided percutaneously. The purpose of this study was to evaluate the union rates of tibio-talocalcaneal arthrodesis using an intramedullary nail without formal debridement of the subtalar joint and a choice between open or percutaneous debridement of the ankle joint.

REFERENCES

1. Aktaş Ş, Baktıroğlu S, Demir L, Kılıçoğlu Ö, Topalan M, Güven E, Mirasoğlu B, Yanar F. Intralesional application of epidermal growth factor in limb-threatening ischemic diabetic foot ulcers. Acta Orthop Traumatol Turc 2016; 50(3): 277–83.

2. Alvarez R G, Barbour T M, Perkins T D. Tibiocalcaneal arthrodesis for nonbraceable

neuropathic ankle deformity. Foot Ankle Int 1994; 15(7): 354–9.

3. Bennett G L, Cameron B, Njus G, Saunders M, Kay D B. Tibiotalocalcaneal arthrodesis: a biomechanical assessment of stability. Foot Ankle Int 2005; 26(7): 530–6.

4. Caravaggi C, Cimmino M, Caruso S, Dalla Noce S. Intramedullary compressive nail fixation for the treatment of severe Charcot deformity of the ankle and rear foot. J Foot Ankle Surg 2006; 45(1): 20–4.

5. Caravaggi C M, Sganzaroli A B, Galenda P, Balaudo M, Gherardi P, Simonetti D, Ferraresi R, Farnetti A, Morandi A. Long-term follow-up of tibiocalcaneal arthrodesis in diabetic patients with early chronic Charcot osteoarthropathy. J Foot Ankle Surg 2012; 51(4): 408–11.

6. Chahal J, Stephen D J, Bulmer B, Daniels T, Kreder H J. Factors associated with outcome after subtalar arthrodesis. J Orthop Trauma 2006; 20(8): 555–61.