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Orthopedic & Musculoskeletal System



Affordance-Based Assessment

Unstable Thoracolumbar Fractures

Highlights

Fixation of Trimalleolar Fracture

Unstable Hip Fracture Management

Discovering Thoughts, Inventing Future

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Comparative Analysis of Peri-Operative Parameters in Unstable Hip Fracture Management by PFNA: Hip Fracture Needs Early Care during Covid-19

By Tomar Lavindra, Govil Gaurav & Dhawan Pawan

Abstract- Unstable peri-trochanteric fracture presents management challenges, more so during the Covid-19 pandemic.

Aim of the study was to evaluateperi-operative parameters during proximal femoral anti-rotation (PFNA) nailing in the early lockdown period of Covid-19 pandemic (Post-C group) and compare them to a cohort of demographically matched unstable peri-trochanteric fracture group from thepre-lockdown period (Pre-C group) to ascertain any significant change in clinical, radiological and functional outcomes.

We retrospectively analysed matched groups with respect to median age, ASA grading and comorbidities. Intraoperative parameters assessed were duration of operation theatre and surgical time for PFNA. In Post-C group, personal protection equipment (PPE) use by Health Care Worker (HCW)was evaluated.

Keywords: orthopaedics covid-19; peri-trochanter fracture; cephalo-medullary nails; pfna fixation; hip fracture.

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Comparative Analysis of Peri-Operative Parameters in Unstable Hip Fracture Management by PFNA: Hip Fracture Needs Early Care during Covid-19

Tomar Lavindra [α], Govil Gaurav [σ] & Dhawan Pawan [ρ]

Abstract- Unstable peri-trochanteric fracture presents management challenges, more so during the Covid-19 pandemic.

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Study included ten patients each in both groups. Average operation theatre duration in Post-C group was significantly high (p value 0.041). PFNA surgery time was comparable (p value 0.572) even with a cautious surgical approach. Radiographic parameters showed similar outcomes in both groups with no significant change in quality of reduction and fixation. Comparable functional recovery in both groups. Reliable outcomes with PFNA in unstable fractures. No mortality in immediate 30-day postoperative period.

Equivocal reliable outcomes obtained irrespective of pandemic though PPE used in Post-C group. There was increased operation theatre time with implementation of re-established safety protocol guidelines. Peri-operative parameters remain unaffected. Early hip fracture management ensured better functional outcomes.

Keywords: orthopaedics covid-19; peri-trochanter fracture; cephalo-medullary nails; pfna fixation; hip fracture.

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I. Introduction

The Covid-19 pandemic is an unprecedented crisis [1]. Orthopaedics during an evolving contagious pandemic faces new challenges for trauma management [2-5]. Guidelines for hip fracture management were ill-defined during initial phase of lockdown and subsequently guidelines were issued by national associations for safe surgical practices during Covid-19 [1,2,5,6,7]. In lockdown, the dictum was "stay home stay safe". However social isolation policy cannot prevent falls at home. Hip injury remains a common concern in elderly osteoporotic individuals. High energy trauma causing proximal hip fracture may occur in young individuals [5]. Decision making in surgical management of peri-trochanteric unstable injuries was a challenge with reallocated hospital resources. The preponderance of similar fractures in elderlyhave associated comorbid conditionscompounding the mangement [4]. Recumbency with either conservative ordelayed surgical management of a hip fracture was associated with increased complications and mortality especially in elderly patients [8-11]. Surgical fixation remains the standard of management in such fractures to attain acceptable reduction and early mobilization[8]. An extramedullary dynamic hip screw or intramedullary cephalo-medullary nailing are fixation options [8]. PFNA allow better stability in osteoporotic fracture in elderlies as lever arm is short and medial collapse of the distal fragment can be further managed [8,11,12].

We analysed and compared the intraoperative and postoperative parameters associated with PFNA fixation in unstable peri-trochanter fracture management. In Covid-19, there were challenges in securing a safe environment for HCW and patient alike. Our study evaluated the effectiveness and reliability of fixation in the unstable fractures while following institutional protocols for safety of HCW's and patients. The patient with hip fracture requires an early intervention for better functional outcomes, irrespective of pandemic.

II. Material & Methods

The study was a retrospective study of unstable peri-trochanteric fracture presenting to emergency from March 2020 till June 2020. The study was done in an

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orthopaedic unit at a tertiary care-centre in an Indian metropolitan city. We operated ten cases after the lockdown was initiated in March 2020 in our country (Post-C group). They were compared with a group of demographically matched patients operated prior to lockdown with a standard operating protocol (Pre-C group). Patients operated for unstable peri-trochanteric femur fractures (AO 31.A2 and 31.A3) were included in the study. However, those with stable 31.A1 type fractures, immobile or bed-ridden prior to injury, triaged for conservative management and those who were advised hospitalization but did not consent were excluded. We did a follow up evaluation at four weeks and assessed functional outcomes, complications and mortality.

We retrospectively evaluated the hospitalization records for twenty patients. The demographic profile including age, sex, site of fracture, mode of injury, American association of anaesthesiologists (ASA) grading and associated comorbidities were recorded. A pre-operative radiograph including an anteroposterior view of the pelvis with both hips and a lateral view of the affected hip were taken. The AO/OTA classification was used to classify the fractures[13,14].

All the patients were operated by senior author. All patients received standard preoperative antibiotic prophylaxis. The use of protective masks such as powered air purifying respirator (PAPR), N-95 with impermeable gowns, eye protection and covered shoes for safety in operation theatres were followed in Post -C group while a standard operating protocol without PPE were followed in Pre-C group. The duration from shifting patient to operation theatre to surgery start time (in minutes), actual duration of surgery for PFNA (in minutes) and duration of operation theatre time excluding surgery time (in minutes) was noted. Reduction and internal fixation were performed with the patients in supine position under fluoroscopic guidance in both the groups. We took additional measures to minimise aerosol generating procedures (AGP) by avoiding cautery, reaming and drilling where-ever possible in Post-C group. Postoperatively, patients were given standard thromboprophylaxis in both groups. Postoperative Visual Analog Score (VAS) for pain were recorded. Preoperative and postoperative haemoglobin and units of blood transfused were recorded for both groups. The duration of stay in hospital was noted and patients were discharged early in Post-C group and further guided for rehabilitation at home.

The quality of reduction was assessed by comparing the neck-shaft angle of the operated hip, to that of the normal hip on the antero-posterior view. A variation of less than 5 degrees from the normal side was considered a good reduction. Between 5 and 10 degrees of variation was considered acceptable and more than 10 degrees variation was considered poor. The quality of fixation was assessed using the tip-apex distance (TAD) and the Cleveland index[15,16].

The TAD was determined by measuring the distance from the tip of the helical blade to the apex of the femoral head on both anteroposterior (AP) and lateral radiographs. A tip apex distance less than 25 mm is protective of the helical blade cutting out of the femoral head and considered adequately optimal[15]. The tip apex distance was measured using the Picture Archiving and Communication System (PACS) tool on the immediate postoperative radiographs.

The Cleveland index was used to assess the position of the helical blade in PFNA. A centre-centre or centre-inferior placement of the helical blade was considered optimal.

Functional outcomes at the time of discharge and at four weeks were noted from physiotherapy record sheet. Functional outcome including hip pain, ability to stand with walker support, ability to walk with walker support and ability to do bed to chair transfer were assessed at the time of discharge. Complications namely early infection, deep vein thrombosis, blade migration or loosening especially in osteoporotic fracture if encountered were documented for both groups. Any mortality or symptoms suggestive of Covid-19 infection, if any within 30 days of surgery were noted.

Statistical analysis was done and variables were compared using independent t-test. A p-value of less than 0.05 was considered significant. The data was entered in MS Excel spreadsheet and statistical analysis was done using Statistical Package for Social Sciences (SPSS) version 24.

III. Results

Of twenty patients, Pre-C group had four31.A2 and six 31.A3 fracture cases and Post-C group had five 31.A2 and five 31.A3 fractures. Cohorts were age and sex matched. All patients were managed with PFNA. Median age was 75 years in Pre-C group and 72 years in Post-C group. Commonest mechanism of injury was slip and fall at home in both groups accounting for 80% of patients. The associated medical conditions included hypertension, valvular heart disease, diabetes, chronic obstructive lung disease, delirium and hypothyroidism. Demographic data for both groups is presented in Table I.

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Table I: Demographic data and patient distribution of the two groups

Variables		Pre- C group	Post-C group	p-value
Median Age (in years)		75	72	0.512
Sex	Male	6	5	
	Female	4	5	
Mechanism of injury Fall at home		80%	80%	
RTA		20%	20%	
ASA	Grade 3	60%	80%	
	Grade 4	40%	20%	

Mean number of days between admission and surgery was 2.4 days in Pre-C group and 2.8 days in Post-C group. Patients were either ASA grade III or IV in both groups. Time spent in operation theatre was significantly higher in Post-C group than in Pre-C group (p value 0.041). The increased time was attributed mainly to implementation of safety precautions, use of PPE and cautious learning approach of HCW's during evolving pandemic. The mean duration of surgery in Pre-C group was less than in Post-C group but statistically insignificant (p value 0.128). Mean duration of hospital stay in Pre-C group was 6.2 days and in Post-C group was 5.8 days. In Post-C group, preoperative assessment took longer time due to reallocated hospital resources, however it was statistically insignificant. Though an early discharge was planned postoperatively in Post-C group, it did not significantly decrease the total hospital stay.

Mean pre-operative haemoglobin and mean post-operative haemoglobin in both groups on comparison showed no significant changes (p0.544). Mean intraoperative fall in haemoglobin in Pre-C group was 2.18 gm % and in Post-C group was 1.36 gm %. Six patients from each group underwent packed red blood cell transfusion.

The quality of reduction was good to acceptable in both groups as illustrated with Figure 1 and Figure 2.The average TAD for both groups was less than 25 mm. It was 15.78 mm for the Pre-C group (range 12.66 to 19.20mm) and 17.80 mm for the Post-C group (range 15.38 to 20.70 mm). In both groups, a post-operative Cleveland index of 5,6,8 or 9 was noted implying a centre-centre or inferior-central implant position. Results have been summarized in Table II.

Table II: Intraoperative and postoperative parameter assessment of the two groups

Variables	Pre-C group	Post-C group	p value
Mean waittime for surgery (in days)	2.4 ± 1.34	2.8 ± 0.84	0.428
Total time spent in OR (in minutes)	101 ± 20.04	151 ± 17.25	**0.041**
Time taken for nailing (in minutes)	56 ± 8.21	65 ± 16.20	0.572
Mean duration of hospital stays (in days)	6.4 ± 1.90	5.8 ± 1.48	0.213
Pre-op Hb (in gm%)	10.78 ± 0.80	9.88 ± 1.96	0.186
Post-op Hb (in gm%)	8.88 ± 1.45	8.52 ± 1.53	0.978
Intra-operative fall in Hb (in gm%)	1.78 ± 1.62	1.36 ± 0.92	0.544
Patient requiring transfusion (in %)	60	60	
Tip apex distance (in mm)	15.78	17.8	0.561
Cleveland index (5,6,8,9)	100%	100%	-
Angulation of fracture < 5 degree 5-10 degree	7 good 3 acceptable	6 good 4 acceptable	-
Complications in early post-operative period	None	None	
30-day mortality post surgery	None	None	

In both groups rehabilitation and physiotherapy was initiated in immediate post-operative period till discharge. Postoperative VAS score in both groups were comparable. The ability to stand and walk with walker support, to do bed to chair transfer were found to be similar in both groups.

No signs of early infection, deep vein thrombosis, implant related complications were encountered within four weeks of assessment. There were no in-hospital or 30-day mortality in either groups.

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IV. Discussion

Management of an unstable peri-trochanteric fracture pose management challenges to the surgeon [11,17]. This was compounded by the evolving Covid-19 pandemic [4,18]. The national associations during the pandemic set guidelines that one should operate the unstable hip fractures not amenable to conservative management [2]. This was to avoid complications associated with recumbency and reduce the high morbidity and mortality of hip fractures in elderlies [11,17]. The management of a late presenting and/or a malunited or non-united peri-trochanter fracture was considered a far more challenging proposition for surgeon and patient alike [4,5].

Most hip fractures in elderly occur due to slip and fall at home, and the social distancing policy will not be able to prevent them in Covid-19 pandemic [5]. An unstable hip fracture will likely require surgery and it may be one of the most common orthopaedic operation undertaken during the coronavirus pandemic [5].In this developing scenario, added safety protocols of using PPE and guidelines for protection of patient and HCW as pernational association guidelines need to be implemented [2]. Safe operating room protection protocols must be respected and an early discharge must be sought[4]. There will be a fear of Covid-19 infection which may affect the outcomes during care of a hip fracture in an elderly in an emergency situation [19].

The protocol for unstable hip fracture management in elderlyin Pre-C period was to surgically fix them early [17,19]. Studies suggested to optimise medical comorbidities and treat hip fracture early to reduce complication rates[5,19,20]. The susceptibility to pulmonary infection and deep vein thrombosis, especially in patients with limited ambulatory capacity is a concern [20]. With relocation of available hospital resources for management of Covid-19 patients, there were institutional limitations which delayed the implementation of pre-existing protocols for surgical management [5]. Measures included staff redeployment, repurposing of operation theatre affecting hip fracture care [5,19]. Implementing screening of patient's Covid-19 status prior to orthopaedic surgery also increased the preoperative wait time. Knowledge of a patient's Covid-19 status preoperatively allowed the institution to put in place full protective measures for conduction of surgery safely [3]. We experienced psychological concern during Covid-19 period, a fear of infecting self, team members, patient and their relatives, along with HCW's during the operative procedure. Hence, during the peri pandemic times, operative treatments which required minimal invasion and shorter surgical times were preferred, over any complex and long orthopaedic surgeries likely to generate more significant amounts of aerosols [2]. Almost all fragility fracture surgery which required an element of bone drilling and aerosol generation were conducted with more cautious approach [2,5]. Even positioning of the patient prior to the surgical procedure and use of reduction techniques for proximal hip fracture with or without traction required more time [7].

There was an increase in operation theatre time for the procedure as the protocols of PPE were implemented. We experienced PPE use involved learning curve for HCW to conduct the procedure with constrained visual field, occasional obscured clear vision and associated mental exhaustion. This may impact the reduction, fixation and duration outcomes of the nailing procedure. The surgeon's focus required for applying his surgical experience and expertise to manage this complex fracture, needed to be monitored by evaluating the quality of reduction and fixation [11,21]. The varus angulation, tip-apex distance and Cleveland index are reliable indices for radiological assessment [15,16,22,23]. The stability with an IM device was better for an early functional recovery in unstable fractures [17,24,25]. A significantly better social function scores, mobility scores and complication rates was suggested between plates and nails [24].

Knowledge and best practices about Covid-19 are evolving rapidly. The new research and experiences will further broaden the understanding and practices. In the study, though we had no positive Covid-19 infected patient however our experience of conducting the procedure in Covid-19 pandemic gave us considerable insights. We as surgeons should not drop our guard and we must reinforce the implementation of mandatory effective safety protocols for HCW and patients. The evaluation of intraoperative and postoperative parameters to manage hip fracture showed similar clinical and functional outcomes. Hip fracture care needs early intervention irrespective of pandemic.

V. Limitation

It is a small study group. Being a single centre retrospective study, it is susceptible to bias in selection. The long-term impact on functional recovery will need further observation. The large cohort study group will help in further validation.

VI. Conclusions

Unstable peri-trochanteric fracture fixation can be accomplished with a standard operating protocol combined with appropriate use of PPE and Covid-19 required safety protocols. It allowed stable fixation and an early rehabilitation. The duration of surgery time, quality of reduction and early functional outcomes were not compromised during the pandemic. An increased duration of operation theatre was noted with a more cautious surgical practice.

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PFNA gave an optimal early functional recovery with a good reduction and implant placement in these unstable fractures. In pandemic, an early care of hip fracture needs to be prioritized.

Abbreviations:
Proximal Femoral Nail Anti-rotation: PFNA
Pre-Covid: Pre-C
Post-Covid: Post-C
Personal Protective Equipment: PPE
Health Care Worker: HCW
Proximal Femoral Nail: PFN
Body Mass Index: BMI
American Society of Anaesthesiologists: ASA
Visual Analog Score: VAS
TAD: Tip-apex distance
Picture Archiving and Communication System: PACS
Analysis of Variance: ANOVA
Statistical Package for Social Sciences: SPSS
Road Traffic Accident: RTA
Aerosol Generating Procedures: AGP
Intramedullary: IM
Powered Air Purifying Respirator: PAPR

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Lavindra Tomarand Gaurav Govil conceptualised the study design.
Gaurav Govil and Pawan Dhawan collected data for the study and did data interpretation.
Gaurav Govil did literature search and prepared the first manuscript.
Pawan Dhawan did statistical analysis.
All authors read and approved the final manuscript.

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Figures

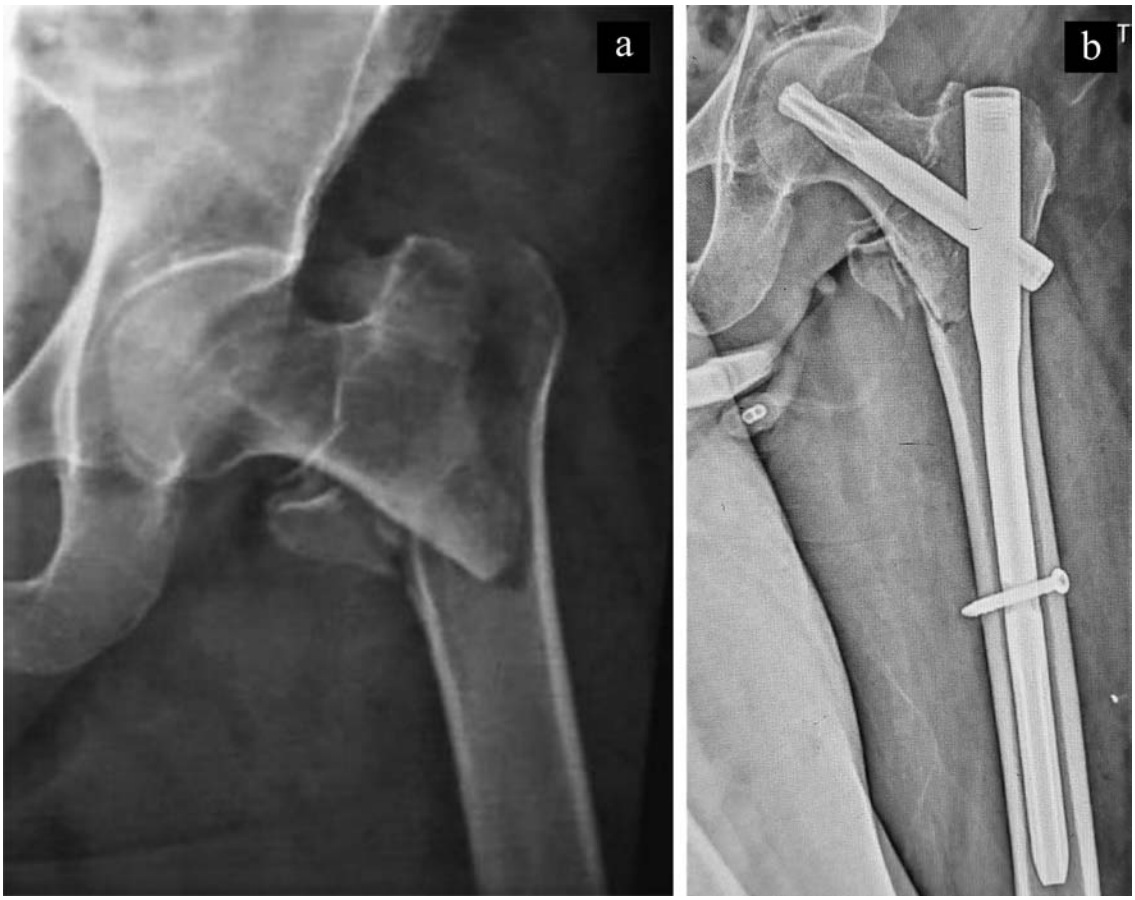


Figure 1: Show a 31.A2.2 fracture in 85-year female from Pre-C group with acceptable reduction

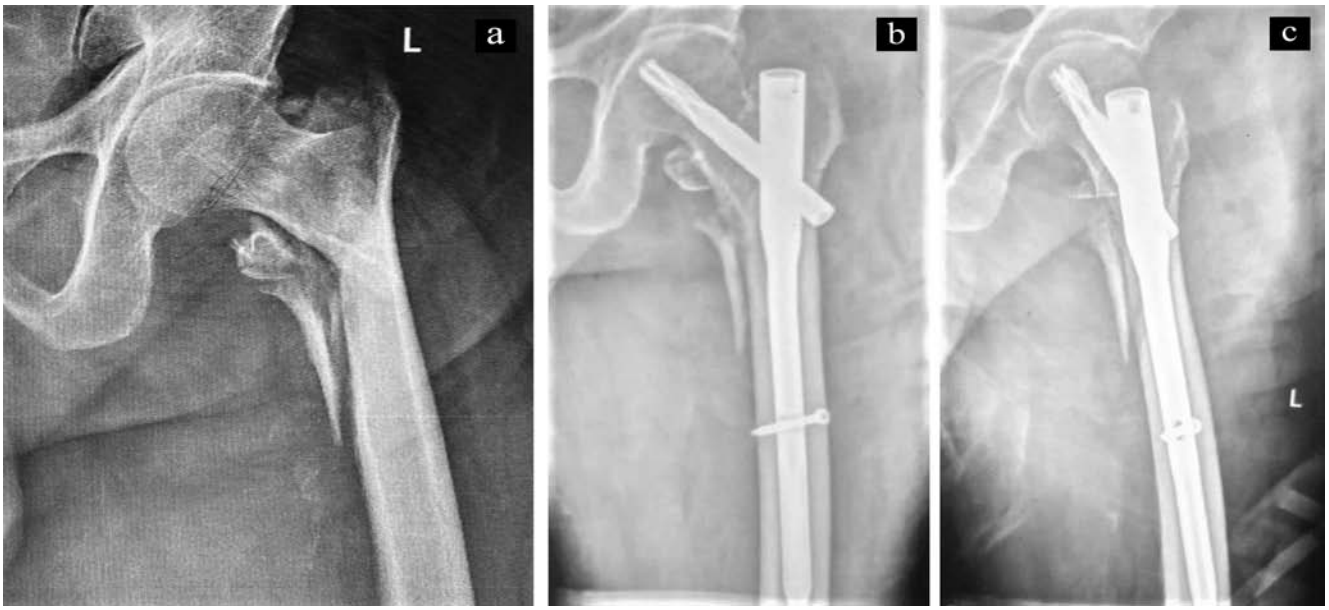


Figure 2: Show a 31.A2.3 fracture in 84-year male from Post-C group with acceptable reduction

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By Dharmesh Patel, Avtar Singh, Rajeev Vohra & Babaji Thorat

Abstract- *Background:* Ipsilateral fractures of the distal radius and scaphoid are rare, with few reports describing mechanisms of injury, fracture patterns, and treatment approaches.

Case presentation: A patient with Ipsilateral comminuted, displaced distal fracture of the radius and fracture of the scaphoid was treated via internal fixation of the scaphoid fracture with Herbert screw and internal fixation of the distal radius fracture with locked volar & dorsal plating.

Conclusions: Rigid internal fixation of the distal radius and scaphoid fracture is mandatory to start early active rehabilitation of the wrist without the need for wrist immobilization with plaster or external skeletal fixation.

Keywords: *distal radius fracture, scaphoid fracture, ipsilateral fractures, dual plating.*

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I. Background

Simultaneous fractures of the ipsilateral scaphoid and distal radius are rare. We have found only one case reported in the English language medical literature; the patient had been treated using plaster immobilization [1]. In this paper, we report the case of a young man who sustained high-energy, unstable, displaced comminuted distal radius fractures along with scaphoid fracture. The latter were treated with Herbert screw fixation and locking volar & dorsal plates. The purpose of this paper is to report the operative technique used to ensure that an early wrist rehabilitation program could be started in this unusual case.

Although the distal radial fracture can be diagnosed without too much difficulty, but the scaphoid fracture can be missed initially and leading to a delay in diagnosis and adequate treatment. The distal radius fracture is often intra-articular, while the scaphoid fracture occurs at the waist in most cases. Treatment of combined fractures of the distal radius and scaphoid can vary from closed reduction and cast immobilization to open reduction and internal fixation (ORIF) with bone grafting. Arthroscopically assisted fixation has also been reported recently [2].

The sequelae of an untreated or inadequately treated fracture of the distal radius can be significant and functionally disabling [3]. Unrecognized or untreated fractures of the scaphoid can also lead to non-union and can be accompanied by avascularity of the proximal pole, both of which can seriously compromise wrist function [4].

In this study, we report our experience of patients with combined fractures of the distal radius and scaphoid to increase the awareness of this combined injury and suggest an algorithm for its management.

II. Case Presentation

A 26-year-old man alleged history of the road traffic accident. He was came to the emergency department, and done Roentgenogram and CT scan that displayed combined ipsilateral fractures of the scaphoid and comminuted distal end radius fracture. The scaphoid fractures were typed A according to the Herbert classification system, and the distal radial fractures were type C (23-C3) according to the AO classification system (Figure 1 & 2). Open reduction of the intra-articular distal radius fracture and the scaphoid fracture was performed under regional anesthesia.

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Figure-1: Preoperative AP / LAT roentgenogram of the right distal radius and scaphoid fractures.



Figure-2: Pre-operative CT Scan showing comminuted fracture distal end radius (AO - 23C3) and fracture scaphoid (Herbert Classification Type A)

Initially, we fixed the distal end radius from the dorsal side using locking plate via the dorsal approach then dissection was made between the flexor carpi radialis and palmaris longus tendons, and it was extended 3 cm distal to the wrist flexion crease to expose the scaphoid. The flexor pollicis longus tendon was retracted in the direction of the radius, while the median nerve and other tendons were retracted in the direction of the ulna, revealing the pronator quadratus. Next the distal end radial borders of the pronator quadratus were raised and retracted in the direction of the ulna to expose the distal radius. First, the scaphoid fracture was fixed with a Herbert screw next open reduction and internal fixation of the distal end radius was performed with volar approach with the locking plate (Figures 3). No cast immobilization or bracing was used after the surgery. The patient began a passive and active range of motion exercises immediately.

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Figure-3: Postoperative AP / LAT roentgenogram of the right distal radius and scaphoid

III. Discussion

Ipsilateral fractures of the distal radius and scaphoid are uncommon injuries, however, thus far there is only one reported case of ipsilateral fractures of the distal radius and scaphoid, and in that case the patient was treated using a plaster immobilization. Conservative management like cast immobilization may be applied in children but reduction maneuvers for distal radial fractures should bedone carefully to avoid displacement of the scaphoid fracture [5,6]. Although the presence of displaced scaphoid and radius fractures in adults as in our case is an indication for operative treatment, keeping in mind that traction would be applied to the carpus to treat an unstable distal radial fracture, the presence of even an un-displaced scaphoid fracture with a displaced distal radius fracture is an indication for internal fixation of the scaphoid [7]. The three main management methods for unstable distal radial fractures are external fixation, dorsal plating, and volar plating [8]. The volar approach is advantageous to dorsal dissection, which may lead to the inadequate blood supply to the dorsal meta-physeal area of the radius, can be avoided further this approach causes fewer problems related to the soft-tissue and tendons [8, 9]. The locked compression plate uses threaded screws that lock into the plate holes when tightened; this provides angular and axial stability with minimal possibility of screw loosening. Also these volar locking compression plates have significant strength advantages over those used in dorsal plating [8-10].

IV. Conclusions

Ipsilateral fractures of the distal radius and scaphoid are rare and are usually the result of High-energy mechanisms. The scaphoid fracture is usually a non-displaced fracture at the waist. The distal radius fracture pattern varies but most are displaced and comminuted. The union rate of the scaphoid is high, even if subjected to radio-carpal distraction required for distal radius management.

High- energy trauma to the hand and wrist can result in ipsilateral fractures of the radius and scaphoid and initiation of an early rehabilitation program requires rigid fixation of both these fractures. Volar and dorsal locking plating of distal radius fracture and Herbert screw fixation of scaphoid fracture allows this rigid fixation allow to start early active rehabilitation of the wrist without the need for wrist immobilization with plaster or external skeletal fixation.

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Affordance-Based Assessment is Neither Subjective nor Objective Outcome Measure

By Wangdo Kim

Universidad de Ingenieria y Tecnologia UTEC

Abstract- There is increasing awareness of the need to include patient-reported outcome (PRO) instruments in evaluatingthe measurement of clinical outcomes, withan increasing focus placed on the patients'perspective.Scientists have tried to link PROs with objective outcomes, providing unique information formanaging patient care. Traditionally, objective and patient-reportedoutcomes (such as the Knee Injury and Osteoarthritis OutcomeScore (KOOS)) are considered two distinct constructs, which cannotserve as a direct proxy for each other.

Gibson´s affordances are properties taken with reference to the patient. They are neither objective nor subjective.The present article develops a theoretical framework called entrainment of touch and posturethat advocates the vis viva (living force) as the proper gauge for the dynamical action of a force, and that could explain "possibilities for action or affordance" during outcome measurement.

Keywords: gibson´s affordance; entrainment of touch and posture; affordance-based-assessment; knee synergy; instantaneous knee screw (IKS); patient-reported outcome (PRO).

GJMR-H Classification: NLMC Code: WE 168



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We found that active touch and posture refer to what is ordinarily called touching—variations in skin stimulation caused by surfaces are altered together by motor activity variations. This affordance of "walk-on-able" is worth noting because it is often neglected that locomotion and its surfaces form an inseparable pair. The assessment process can be viewed in terms of action possibilities provided by the active sets of organs residing that can obtain and utilize information about the tissue environments in which the grafts are to be located.

Keywords: gibson´s affordance; entrainment of touch and posture; affordance-based-assessment; knee synergy; instantaneous knee screw (IKS); patient-reported outcome (PRO).

I. Anterior Crucial Ligament Reconstruction and its Assessment

The anterior cruciate ligament (ACL) is a critical knee joint, bone-to-bone connected, stability ligament that is attached from an anterior location of the proximal tibia to a posterior location of the distal femur. The ACL is highly susceptible to failure during athletic activities and slip-fall events (Howell 1998). The goal of ACL reconstruction surgery is to rebuild the ligament attachments as closely as possible to the native anatomy in order to restore pre-injury knee function and normal proprioception in the affected knee (Behrend, Giesinger et al. 2017). Personalized medicine in surgery allows the customization of insertion sites, graft size, tunnel placement, and graft tension for each individual patient (Karlsson, Hirschmann et al. 2015). A critical pre-operative decision concerns the placement of a tibial-femoral tunnel mimicking the native orientation of the ACL attachment (Karlsson, Hirschmann et al. 2015). Surgeons need to consider particular aspects of the local anatomy and, by extension, the biomechanical artifacts introduced during surgery.

Considering the importance of the sensory function of the joint structure, it would seem sensible to minimize the sensory damage of the joint whenever operative treatment is necessary (Johansson, Sjölander et al. 1991). The joints are exploratory sense organs, but they are also performatory motor organs; that is to say, the equipment for *feeling* is anatomically the same as the equipment for *doing* (Gibson 1966). Here, we report an alternative approach based on the understanding of knee affordances to guide surgeons in the design/assessment of knee reconstruction strategies.

To our knowledge, this is the first study to use psychological theory to address this surgical assessment concept (Niama Natta, Thienpont et al. 2019). Traditional rating systems to assess clinical outcomes after joint arthroplasty are often based on the surgeon'sobjective ratings, such as range ofmotion and strength, or clinical ratingsof function and pain. However, the patient's perceptions after arthroplasty may differ significantly from those of their clinician. Moreover, surgeonsoften under appreciate the needs and views of their patients (Kinnaman, Farrell et al. 2006). There is, therefore, increasing awareness of the need to include patient-reported outcome (PRO) instruments in the evaluation of surgical procedures. Indeed, these patient-centered assessments of treatment outcomes are becoming today's standard (Rolfson, Eresian Chenok et al. 2016).

Patient-reported outcome metrics (PROMs) can be simply described as a patient's health status self-report. A 'forgotten joint score,' corresponding to when a patient forgets the artifact in their everyday life, was introduced in PROM as the ultimate goal in joint reconstruction (Behrend, Giesinger et al. 2012). 'Forgotten joint scores' are often observed in patients after surgery (Hamilton, Giesinger et al. 2017). Nevertheless, these ratings do not replace the need to understand the general role of artifacts and affordances in reconstruction surgery. This study aims to identify

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measurable invariants using a (positive) affordance-based assessment strategy for the structural function of the joint during ACL reconstruction. The term `affordance' is conventionally traced to James J. Gibson, and his programmatic approach to perception and action, Ecological Psychology (Gibson, 1979). The notion appears simple at its core, and yet upon closer examination, it has the potential to reveal a radically altered view of the relation between an organism and its environment (Cummins 2009).

The fundamental hypothesis of the ecological approach and this work is that active organisms of the knee that can obtain and utilize information about persisting properties of their tissue environments in which the grafts are to be located will have a definite advantage over organisms that cannot do this.

II. The Affordance of the Knee

Gibson demonstrated how animal perception and action is continuous, with interactions with inanimate objects or surfaces (Gibson 1979). The affordances of a product are what it provides, offers, or furnishes to a user. Gibson's 'system theory' of perception corresponds to an open system, which is rather different from the view of isolated artifacts (Gibson 1966). The resources encountered by an animal or thinking humans are the affordances of the environment. Affordances are opportunities for action, not causes or stimuli (Reed 1996). The impetus for any knee surgery project can be understood in terms of creating and changing affordances. The design process is the construction of an artifact that offers specific affordances but not certain undesired affordances. An artifact with more positive affordances is considered better, while an artifact with more negative affordances is considered worse. The ecological approach demonstrates how humans (and other animals) perception and action are continuous with interactions between animate and inanimate physical systems (Kelso 1995, Kim, Araujo et al. 2020). However, the fact that interactions between the inanimate graft and animate patient are continuous precludes the need to identify the patient-reported outcome (PRO) as a distinct category, which can then be incorporated within the larger theory.

III. Entrainment of Touch and Posture

Entrainment refers to an individual's chronobiological, physical, and behavioral relationship with their environment. Specifically, this refers to the coupling of two independent oscillatory systems in such a way that their periods of oscillation become related by virtue of phase alignment (Cummins 2009).Contrasting the established idea of senses, Gibson considered separate anatomical units as perceptual systems (Gibson 1966). In the present case, a joint yields spatial information, a skin-nerve conveys contact information, and in certain dynamic combinations, joint and skin-nerve yield synchronization or entrainment specifying information about the layout of external surfaces during locomotion.

Behavioral dynamics in a consistent approach havebeen proposed to account for the dynamics of perception and action (Warren 2006). This approach followed Gibson's idea that rather than being localized in an internal (or external) structure, control is distributed over the agent-environment system, in the present case, the user-artifact-surface system. Therefore, Warren's behavioral dynamics argues for a one-to-one correspondence between the internal structure IKS (Instantaneous knee screw)(Kim, Araujo et al. 2020), constituted by the internal forces formed by the distal end of the femur and the proximal end of the tibia, and the external structure, represented by the ground reaction forces (GRFs) on foot (Beer 2010).

To test such an ecological approach to perception and action during the stance phase of a gait, we compared previously published experimental data sets (Fregly, Besier et al. 2012) with our predicted datasets (Kim, Veloso et al. 2013) in terms of medial and lateral contact forces. Available data included limb motion capture, fluoroscopy images, GRFs, electromyographical readings determining muscle forces, as well as medial and lateral knee contact forces derived from GRFs. Data were collected from an adult male with a right knee reconstruction (65 kg mass and 1.7 m height).

In this study, the IKS was determined by a linear combination of two separate instantaneous screw axes of the shank (S) and thigh (T) (Figure 1(a)). Let the motions of (S,T) referred to their respective axes, the instantaneous shank axis (ISS) and the instantaneous thigh axis (ITS) respectively (Figure 1(a)); the motion of the shank referred to the same system of coordinates as the thigh, is obtained by the transformation of coordinates. The motion of the shank then takes the form (Figure 1(b)). This follows from the well-known result that a pair of (S, T) have the IKS in common velocity (Ball, 1900). Then, the motion of the shank at the IKS has to be momentarily at rest and stay within the thigh. We can introduce a reference system that moves with the thigh, and we can observe the shank in that system. The criterion for the equilibrium of an arbitrary system of forces at the given knee is that the total virtual work of all forces vanishes (Lanczos 2012). This criterion involves virtual, not actual displacements, and at that instant, the actual motions of the T and S enter into account as the invariant ISS and ITS (Figure 1(a)). Since the virtual displacement, the variation of the IKS, involves a possible but purely mathematical experiment, it can be applied at a certain definite time (even if such a displacement would involve physiologically infinite velocities). As an affordance of the knee for a patient,

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however, the IKS's have to be measured relative to the patient. They have unity relative to the posture and touch of the patient being considered (Gibson 1979).

Coupling introduces a constraint on the behavior of each limb. The motion of the shank is no longer completely independent of the phase and velocity of the thigh. In relative coordination, there is a tensegrity structure between the intrinsic dynamic structure of each of the two systems and the coupling force that links them. Behavioral dynamics control laws indicate that the entrainment or coordination of the shank and thigh (S, T) follows the same physical laws as the entrainment between the knee and ground (IKS, GRF). In order to tease out the implications of this claim, it will be necessary to introduce and clarify the notions of both affordance and entrainment. Coupling of (S, T) introduces a constraint on the behavior of each limb. The motion of one limb is no longer completely independent of the phase and velocity of the other. This very important characteristic of coupled systems generally has as a consequence that the resulting composite system is effectively of a lower dimension than the aggregate of the components (Cummins 2009). Therefore, the cross-ratio (Semple and Kneebone 1960) of the ordered pair (IKS, GRF) with respect to the ordered pair (S, T) is

$$\{(IKS, GRF);(S, T)\} = -1 \quad (1)$$

In particular, if $\{(IKS, GRF);(ISS, ITS)\} = -1$, then *(IKS, GRF)* divide a pair of (ISS, ITS) harmonically (Courant and Robbins 1941). The fundamental hypothesis of this work is that affordances of the knee create selection pressure on the behavior of individual limbs, as perceived by its invariant, ISS, and ITS; hence is regulated with respect to the affordances of the environment for a given patient. One of most profound is that a pair of invariant (ISS, ITS) can be so selected with reference to the other pair of invariant belonging to the knee system (IKS, GRF) that the IKS nearly coincides with a reciprocal screw of the GRF, as indicated in a magnified inset image in Figure 1(b). The motion of one limb is no longer completely independent of the phase and velocity of the other. The IKS is perceived as an affordance for the entrainment of movement of (S, T).

A perceptual system of the knee can come to equilibrium since twists of amplitudes S and T neutralize. We thus see that the two kinds of action: actual motion at the knee joint (S, T),can be selected with reference to the virtual work function of (IKS, GRF) as also categorized as the performatory and exploratory action during human walking (Gibson 1979). Active organisms of the knee that can obtain and utilize information about persisting properties of their tissue environments in which the grafts are to be located will have a definite advantage over organisms that cannot do this.

When the variations in the ground contact (magnitudes and direction) were shown along with the variations of knee movement in terms of IKS, an invariant was determined uniquely by the two corresponding pairs, see equation (1) (Figure 1(b)).

For a given IKS (when an observer perceives the affordance of the surface) and the location of the center of pressure (COP) on the axis of the GRF is known, then the GRF vector is limited to a plane in the screw system of the first order (Kim, Veloso et al. 2013) (Figure 1(a)). The muscle synergy η and GRF φ are then compounded into an invariant, limited to the plane of the COP in reciprocity with the IKS. This theorem was originally proposed by Möbius, who showed that forces from six lines could be equilibrated, and also, if five of the lines are given along with a point on the sixth line, then the sixth line is limited to a polar plane (Ball 1900).

Thus, the affordance of the knee has the potential to diagnose pathologies. The last decade has seen a paradigm shift in the measurement of clinical outcomes, with an increasing focus on the user's perspective, PROMs. Many clinicians, though, are less confident in self-reported PROMs, than in 'objective measurements' (Hamilton, Giesinger et al. 2017). Recent studies identified several sensations, activities, and psychological factors such as feelings of instability and knee-related fears that make the patients aware of their artificial knee joint (Loth, Liebensteiner et al. 2018). They concluded that joint awareness might work as an overarching parameter. This is aligned with Gibson's statement that an affordance cuts across the dichotomy of subjective-objective and helps us to understand its inadequacy (Gibson 1979). Affordances have to be designed in relation to the uniqueness of each patient, and thus posture and movement need to be measured in terms of a specific patient-environment system, not in patient-centered terms.

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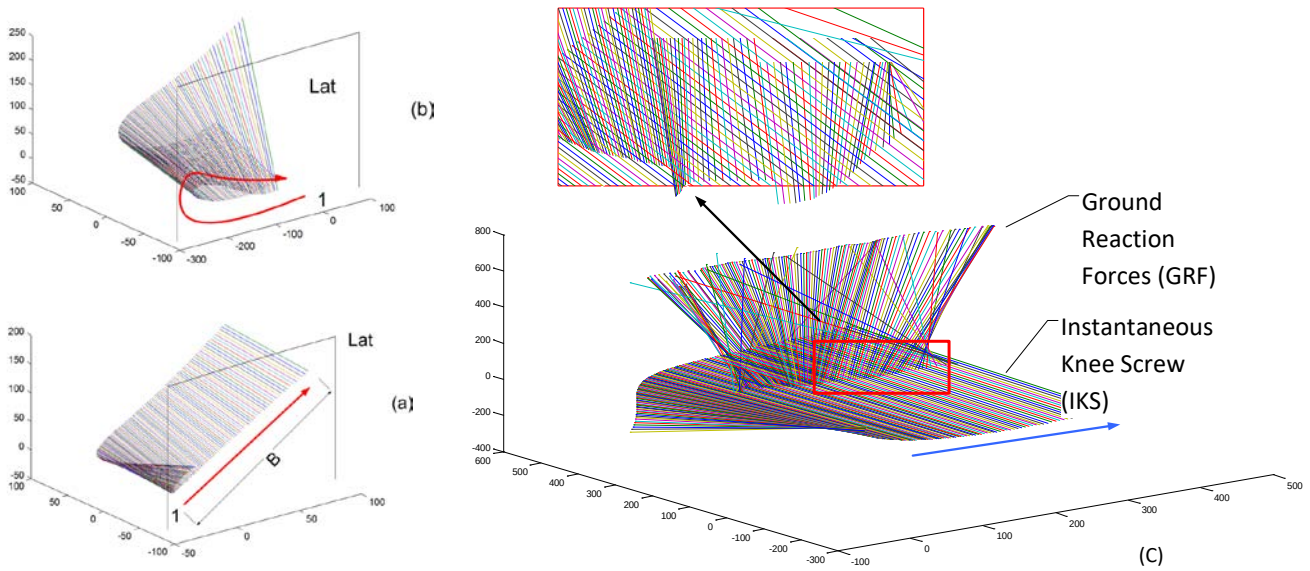


Figure 1(a) (b): An actual displacement by performatory actions on the instantaneous screw axes (ISA) from the posteromedial side of the shank (a) and the thigh(b). The endpoints of axes are at the intersections with medial and lateral sagittal planes, which are located -60 mm to 60 mm off the origin of the global frame. The first axis, indicated by 1, represents the first step of IKS. The arrow indicates where the subsequent axes are migrated at every subsequent 0.05 sec time increment (units in mm).

Figure 1(c): A virtual displacement by exploratory actions of perception and action during the stance phase of gait entrain the knee joint rotation with the touch pattern (GRF) of the foot. The invariant knee-manifolds demonstrates that an affordance for postural stability is measured relative to the posture of the patient, as represented by the entrainment of the GRF with the IKS at any point in the gait pathway.

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The Functional and Radiographic Outcome of Fixation of Trimalleolar Fracture: A Prospective Study

By Dharmesh Patel, Avtar Singh, Rajeev Vohra, Sandeep Chauhan & Babaji Thorat

Abstract- *Background:* Ankle injuries gain importance because body weight is transmitted through it and locomotion depends upon thestability of this joint. Trimalleolar fractures are one of the most complex fractures around ankle. As with all intra articular fractures, Trimalleolar fractures necessitate reduction and stable internal fixation. The purpose of this study is to assess the functional and radiographic outcome and results of surgical treatment of Trimalleolar fractures by specific modalities. To attain a proper anatomical alignment and stability of ankle joint and further applying a syndesmotic screw if needed.

Materials and Methods: A Prospective review was conducted for 28 patients between January 2018 to December 2019 with a closed trimalleolar fracture. Open reduction and internal fixation was done with specific modalities. Patients were evaluated with Subjective and objective assessments of the patient's ankles were done using a modification of the scoring system proposed by Olerud and Molander and radiologically by Kristenson criteria.

Keywords: *Trimalleolar fracture, posterior malleolus fracture, plating, tension band wiring.*

GJMR-H Classification: *NLMC Code: WE 185*



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The Functional and Radiographic Outcome of Fixation of Trimalleolar Fracture: A Prospective Study

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Abstract- Background: Ankle injuries gain importance because body weight is transmitted through it and locomotion depends upon thestability of this joint. Trimalleolar fractures are one of the most complex fractures around ankle. As with all intra articular fractures, Trimalleolar fractures necessitate reduction and stable internal fixation. The purpose of this study is to assess the functional and radiographic outcome and results of surgical treatment of Trimalleolar fractures by specific modalities. To attain a proper anatomical alignment and stability of ankle joint and further applying a syndesmotic screw if needed.

Materials and Methods: A Prospective review was conducted for 28 patients between January 2018 to December 2019 with a closed trimalleolar fracture. Open reduction and internal fixation was done with specific modalities. Patients were evaluated with Subjective and objective assessments of the patient's ankles were done using a modification of the scoring system proposed by Olerud and Molander and radiologically by Kristenson criteria. The functional and radiographic outcome of ORIF and advantages of the procedures were recorded. Functional and radiographic evaluations were performed at immediate post- op, six weeks, three months and sixmonths, one year after surgery. At each follow-up, patients were assessed for syndesmotic reduction, loss of fixation, implant failure and any arthritis changes. The reduction in quality was evaluated on immediate postoperative radiography.

Results: In the present study of 28 patients with trimalleolar fractures treated by open reduction internal fixation. Excellent results were achieved in 23 (82.1%) patients, good in 4 (14.3%), and poor in 1 (3.6%) patient. The patient with poor results had mild pain with activities of daily living, diminution in the abilities to run and to do work, the reduced motion of ankle, and narrowing of joint space.

Conclusions: Operative treatment for trimalleolar fractures results in good functional and radiographic outcomes postoperatively. Anatomical reduction of the fracture is associated with better functional outcomes. Early treatment without delay, anatomic reduction, and fracture fixation, stringent postoperative mobilization, and rehabilitation should help improve outcomes in an trimalleolar fracture.

Keywords: trimalleolar fracture, posterior malleolus fracture, plating, tension band wiring.

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I. Introduction

Sir Robert Jones said, "Ankle is the most injured joint of the body but the least well treated [1]. As with all intra articular fractures, Trimalleolar fractures necessitate reduction, and stable internal fixation [2, 3, 4]. Ankle fracture is one of the most common lower limb fractures [5] for they account for 9% of all fractures representing a significant portion of the trauma workload [6]. Ankle fractures usually affect young men and older women; however, below the age of 50 [7]; ankle fractures are the commonest in men. Two commonly used classification systems for ankle fractures include the Danis Weber AO classification and the Lauge-Hansen classification. There are several different methods of ankle fracture fixation; however, the goal of treatment remains a stable anatomic reduction of talus in the ankle mortise and correction of the fibula length as a one mm lateral shift of the talus in the ankle mortise reduces the contact area by 42%, and displacement (or shortening) of the fibula more than 2 mm will lead to significant increases in joint contact pressures. Further research both biomechanically and clinically needs to be under taken in order to clarify preferable choice of fixation. Many of the fractures which are stable are reduced by conservative treatment and have given good results. The other unstable displaced and open fractures require open reduction internal fixation. The superiority of ORIF over closed treatment has been thoroughly demonstrated in literature. However, all studies have not obtained good results incases of Trimalleolar fractures. The purpose of this study is to assess the functional and radiographic outcome and results of surgical treatment of Trimalleolar fractures by specific modalities of tension band wiring of medial malleoli or screw fixation of medial malleolus, plating of lateral malleoli, and screw or plate fixation of

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posterior malleoli, to attain a proper anatomical alignment, and stability of ankle joint and further applying asyndesmotic screw if needed.

II. Materials and Methods

From January 2018 to December 2019, 28 trimalleolar fractures fixation was performed using specific modalities implant. The study was conducted at Amandeep Hospital, Amritsar, Punjab after obtaining the ethical clearance from institutional ethical committee. Initial management was done in the orthopedic emergency area, which included getting standard AP and lateral radiographs of the ankle joint. Distal neurovascular status and clinical signs to exclude compartment syndrome were assessed and documented. Patients with gross ankle dislocation were attempted to be reduced in the emergency itself under sedation after prior consent from the patient and relatives. A below-knee plaster slab was applied to immobilize the joint, and analgesics were instituted. The limb was kept elevated to prevent excessive swelling. After routine blood investigations and anesthesia clearance, patients were posted for surgery. An ankle CT scan was conducted in all cases as part of the preoperative planning. Intravenous 1 g cefazolin was administered 30 min before skin incision in the operating room after prior antibiotic sensitivity testing. Patient's age between 18 to 85 years with close trimalleolar fractures was included in this study. Patients with open fractures, active infection at site of injury, or other associated fractures in the body elsewhere were excluded. Patients with severe preexisting arthritis in the affected ankle joint, limp, or assisted walk due to some previous or ongoing pathology in the hip or knee joint either in ipsilateral or contralateral limb were excluded from the study.

a) *Operative methods*

There are several different methods of ankle fracture fixation. However, the goal of Treatment remains a stable anatomic reduction of talus in the ankle mortise and correction of the fibula length as a one mmlateral shift of the talus in the ankle mortise reduces the contact area by 42% [3], and displacement (or shortening) of the fibula more than two mm will lead to significant increases in joint contact pressures. The choice of fixing the medial or lateral side first may be guided by the surgeon's preference, but the ankle joint in these fractures is often very unstable.

We have followed the following sequence:

1. The fibular shaft is brought out to length and fixed.
2. The Volkmann's fragment (posterior malleolus) is reduced and fixed.
3. The medial fracture is fixed.
4. The integrity of the syndesmosis is restored.

After the induction of appropriate anesthesia, the patient was first made to lie in a Semi-prone position on a radiolucent operating table. All bony prominences were well padded. The knees were slightly flexed by positioning a bolster underneath the ankles to obtain good ankle dorsiflexion for fracture reduction. A Postero-lateral approach was used by making an incision midway between the medial border of the fibula and the lateral border of tendon Achilles (Figure 1). The use of a pneumatic tourniquet in the initial part of our surgery was done to identify and isolate the sural nerve and lesser saphenous vein away from the surgical field. The sural nerve courses from medial to lateral part. At a point 7 cm proximal to the tip of the lateral malleolus, the nerve is on an average 26 mm posterior to the edge of the fibula[8].Careful soft- tissue dissection and protection of the sural nerve is a must to prevent the formation of painful neuromas. The peroneal tendons were retracted further laterally and anteriorly to expose the fibula. The fibular fixation was carried out first. We provisionally fixed the fracture with K-wires and applied a 3.5-mm reconstruction plate, fibularprebend plate or one-third tubular plate in an anti-glide fashion over the posterior or lateral surface of the fibula. Anatomical reduction of the lateral malleolus usually made the ankle stable and posterior malleolus reduced by itself due to ligamentotaxis by posterior inferior tibio-fibular ligament. The ankle stability was checked intra-operatively by performing a posterior drawer or posterior loading test of the foot with one hand and by stabilizing the distal leg with the other hand. In inadequate reductions or stabilization of the posterior malleolus, a talar subluxation under the distal articular surface was appreciated.

Fixation of posterior malleolus was carried out next. Adeep interval between the peroneal tendons laterally and flexor hallucis longus medially (Figure 2) was made, and soft tissue and periosteum were incised from a medial to lateral fashion to avoid injuring the posterior inferior tibio-fibular ligament(PITFL). Also, care was taken not to injure posterior malleolar vessels, thereby preventing devascularization of the posterior malleolar fragments. The soft tissue, soft callus, and hematomainter posing in the fractured surfaces of the posterior malleolus were cleared with curette and saline irrigation. This was possible by a slight book opening technique in a cranio-caudal direction of the posterior malleolus. This is achieved before fixation of the lateral malleolus since once stabilized by PITFL in its place the posterior malleolusis comparatively difficult to maneuver. The posterior malleolus was buttressed with a 3.5-mm recon plate, distalradius T-pate, or one-third tubular plate. The fibular translation test was then performed to check for the stability of the syndesmosis and, in none of the cases, we found syndesmosis to be unstable. No syndesmotic fixation was carried out in any of our cases. The postero-lateral wound was irrigated,

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adequate hemostasis was achieved, and closure was performed. The second part of the surgery included fixation of the medial malleolus. An antero-medial approach was used to expose the medial malleolus, carefully protecting the great saphenous vein. The interposing periosteum was excised and fixation achieved with two 4-mm partially threaded cannulated screws or tension band wiring. The patient was subsequently discharged after a dressing change at 48 hrs post-surgery. A below-knee plaster was maintained until two weeks postoperatively till Stitch removal. A strict nonweight-bearing and ankle range of motion (ROM) exercises protocol was maintained until six weeks post-surgery. Follow-up at six weeks was done when radiographs of the ankle joint were repeated and partial weight-bearing with the help of walking aids was initiated. Regular monthly follow-ups was conducted. Full weight bearing was started once the clinical and radiological union was achieved. Ankle score, according to Olerud and Molander (Table 1), and ankle arthritis with weight bearing X-rays at 12 months of follow-up were documented in all cases [9, 10].

Post-operative antibiotics were continued for a period ranging from 3 to 5 days depending on the presence of other injuries and therapy was prolonged if there were signs of infection. Once pain-free, patient was trained in non-weight bearing crutch walking and advised dorsiflexion and plantar-flexion exercises.

Postoperative, assessment was done immediately then six weeks, three months, six months and one year according to Olerud and Molander functional scoring. Fractures were classified according to the Lauge-Hansen system and operated within 24hrs of presentation. Subjective and objective assessments of the patient's ankles were done using a modification of the scoring system proposed by Olerud and Molander [9]. Patients were evaluated radiologically by Kristenson criteria [11] (Table 2).

Postoperatively complications, including Non-union, Delayed union, infection, implant failure, per-implant fracture, and Post-traumatic arthritis were recorded.

III. Results

In our series, most of the patient affected by the fracture belongs to age group of 20- 50 years, which were Fifteen (53.6%). The commonest mode of injury is road traffic accident (67.9%) and fall (32.1%). 12 were male patients (42.9%) and 16 were female patients (57.1%). 15 cases involved the right ankle and 13 cases involved the left ankle. The most common injury pattern seen was supination external rotation in19 patients (67.9%). In the present study group, 19 cases (67.9%) had a stay of more than five days while 9 cases (32.1%) had a stay of less than or equal to five days. The mean duration of stay was 4.9 days. Surgical technique used were open reduction and internal fixation of the lateral malleolus with semi tubular plate or recon plate; medial malleolus with cancellous screws or tension band wiring; posterior malleolus with cancellous screws or plate.

In the present study out of 28 patients, two patients presented with persistent swelling, five patients presented with residual pain while seven patients presented with both of the complaints. In our study of 28 cases, 23 cases (82.1%) achieved excellent results, and 4 cases (14.3%) achieved good results at 12 months follow up. No significant wound complications were noted. Operative treatment for ankle fractures results in good functional outcome post-operatively. Anatomical reduction of the fracture was associated with better functional and radiological outcomes. Early management with guided weight- bearing ensures good functional outcomes.

The average time to union and full weight-bearing was 12.85 weeks (range 10–16 weeks). The average percentage of the restoration of ROM as compared to the contralateral ankle at the time of union was 90.2% of dorsiflexion, 91.8% of plantar flexion, 88.1% of inversion, and 85.1% of eversion. An excellent outcomes in 23 patients and good outcomes in 4 patients at the end of 12 months follow-up were concluded according to the Olerud and Molendar scoring system[9](Table 1). Bargon criteria[10] for grading post-traumatic arthritis of the ankle joint at the end of 12 months with the help of weight- bearing ankle X-rays were assessed. Only one patient had grade 2 arthritis, four patients had grade 1, while the rest had grade 0 arthritis. No complications related to soft tissue healing, pain, or hardware impingement or breakages were encountered.

IV. Discussion

In the present study, the most common fracture pattern seen was supination-external rotation type of injury 19 cases (67.9%) followed by pronation external rotation type of injury five cases (17.9%).Studies by weening *et al*.[12] in 2005, of about 425 ankle fractures demonstrated 30% of fractures to be due to supination external rotation type of injury. The least common being pronation dorsiflexion type of injury. The most common modality of fixation for the lateral malleolus and posterior malleolus were recon plate and for the medial malleolus was with 4 mm cannulated cancellous screws or tension band wiring. Syndesmotic screws were not used in any of the cases. Kortekangas et al in 2014 in their study compared the functional and radiologic results of syndesmotic trans-fixation with no fixation in supination external rotation ankle fractures and found no significant difference in functional outcomes or radiologic findings after a minimum follow up of 4 years [13].

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On follow-up at six weeks, 7 out of 28 patients had persistent swelling and residual pain, 5 patients had only residual pain and 2 patients had only persistent swelling. This is in concordance with a similar study done by Hong *et al*.[14] in 2014 in which he reported residual pain, swelling and ankle stiffness as the most common complications at one year follow-up. The mean Olerud and Molendar score at three month post-op was 46.60, six months post-op was 80.17 and at one year post-op was 94.82. There was a statistically significant improvement in the scores from 3rd- month to 6th- month post-op (p- value 0.001). In our study total 23 patients had total score between 90- 100, four patients had score between 75-89 and only one patient had score less than 75 which is comparable to previous study. Hong et al. in 2013 evaluated the functional outcomes, and limitation of sporting activities after trimalleolar ankle fractures. At one year follow -up most patients gained good function and had good to excellent Olerud and Molander scores. However, out of the 47 patients, 26(55.3%) had residual pain, 29(61.7%) complained of stiffness and 21(44.7%) had ankle swelling. Of the 33(70.2%) patients who were involved in sporting activities before the ankle injury, 9(27.3%) were able to return to the pre-injury level of sporting activities with no difficulties[15].

According to Kristenson's Radiological criteria out of 28; 23 (82.1%) patients have good result, 4 (14.3%) patients have fair result and 1 (3.6%) patient has poor result. Similarly Khandelwal h. *et al*.[16] in their study recorded Good result in 85% patients & Fair result in 15% patients who were treated operatively.

There are several limitations of our study. The results of this study may be limited by measurement error. The physical measurements may be subject to both, observer's errors and patient variability. Observer's errors can arise from inconsistencies during the recording and reporting of measurements, including; variations in the placement of equipment. The study was conducted by a single observer hence there was no inter-observer bias. Patient variations however, may arise from the patient altering their effort or position when performing the physical assessments, or by reporting a better or worse functional score in response to external influences unrelated to their ankle at the time of completing the score.

The study is also limited to patients having surgical fixation for their fracture. These results therefore, cannot necessarily be compared to the outcomes achieved with non-operative Management or other modalities of treatment.

V. Conclusion

Operative treatment for trimalleolar fractures results in good functional, and radiographic outcomes postoperatively. Anatomical reduction of the fracture is associated with better functional outcomes. Early treatment without delay, anatomic reduction, and fracture fixation, stringent post-operative mobilization, and rehabilitation should help improve outcomes in a trimalleolar fracture.

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(Figure-1): Skin marking showing the incision for the posterolateral approach in between the tendon of tendoachilles and the posterior border of the fibula.



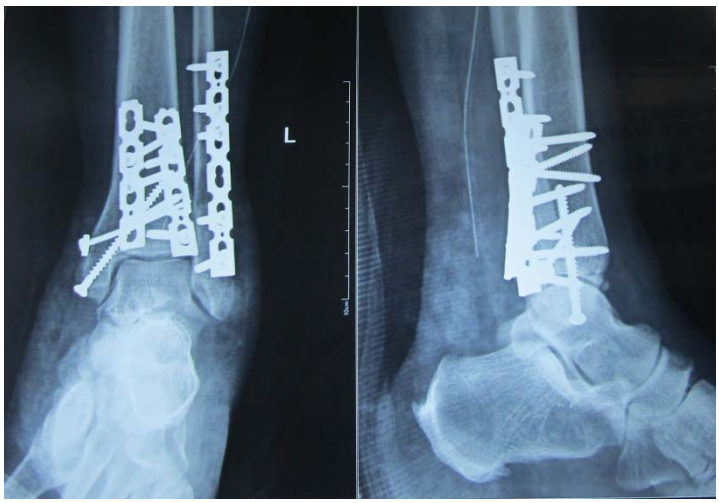
(Figure 2): Deep soft tissue interval for posterior malleolus exposure in between peroneus muscles laterally (broad white arrow) and the flexor hallucis longus (narrow white arrow).

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Case 1



Pre-op X-Ray CT-Scan



Post- op X- ray



Functional Outcome

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Case 2



Pre-op X-Ray



CT-Scan



Post- op X- ray



Functional Outcome

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(Table 1)

Table I: Scoring system devised by Olerud and Molendar (maximum 100 points)

PARAMETER	DEGREE	SCORE
1. Pain	None	25
	While walking on uneven surface	20
	While walking on even surface outdoors	10
	While walking indoors Constant and severe	5
		0
2. Stiffness	None	10
	Stiffness	0
3. Swelling	None	10
	Only in evenings	5
	Constant	0
4. Stair-climbing	No problems	10
	Impaired	5
	Impossible	0
5. Running	Possible	5
	Impossible	0
6. Jumping	Possible	5
	Impossible	0
7. Squatting	No problems	5
	Impossible	0
8. Supports	None	10
	Taping, Wrapping	5
	Stick or crutch	0
9. Work, activities of daily life	Same as before injury	20
	Loss of tempo	15
	Change to simpler job	15
	Severely impaired work capacity	0

A score of 90 to 100 is considered Excellent; 70 to 89 - Good; 50 to 69 points - Fair and less than 50 is considered Poor.

Table 2: Kristenson's criteria[11].

S.N	GOOD
1.	Talus- Correctly Placed
2.	Medial malleolus – No displacement or fracture gap of less than 2mm
3.	Lateral malleolus- negligible lateral displacement and up to 2mm of posterior displacement
4.	Posterior malleolus -upward displacement of less than 2mm
	FAIR
1.	Talus- Correctly Placed
2.	Medial malleolus – No displacement or fracture gap of less than 2mm
3.	Lateral malleolus- negligible lateral displacement and up to 2mm of posterior displacement
4.	Posterior malleolus -upward displacement of less than 2mm
	POOR
1.	Talus- Correctly Placed
2.	Medial malleolus – No displacement or fracture gap of less than 2mm
3.	Lateral malleolus- negligible lateral displacement and up to 2mm of posterior displacement
4.	Posterior malleolus -upward displacement of less than 2mm

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Posterior Instrumentation with Transpedicular Screw and Connecting Rods in the Management of Unstable Thoracolumbar Fractures

By Clevio Desouza & Amit Kale

Abstract- *Aim:* To evaluate the use of posterior instrumentation with transpedicular screw and connecting rods in management of post-traumatic unstable thoracolumbar spine fractures.

Methods: 20 patients with post-traumatic instability of thoracolumbar spine were included in our study. The spinal stability was assessed by the thoracolumbar injury severity scoring. All patients underwent an open reduction internal fixation by the posterior approach. The localisation of pedicles was done using intraoperative imaging. The assessment of neurological status of the patients was done using the ASIA grading scale and other complications were assessed and noted up to 6 months.

Results: 20 patients with unstable thoracolumbar injuries were managed with pedicle screws and rods. Males were affected more than Females. The most common type was AO Type A and L1 was the level most affected. None of the patients deteriorated after surgery. 15 patients with incomplete cord injury showed at least one frankel grade improvement. 4 patients with complete cord injury showed no improvement.

Keywords: *pedicle screws, thoracolumbar injuries.*

GJMR-H Classification: *NLMC Code: WE 168*



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Posterior Instrumentation with Transpedicular Screw and Connecting Rods in the Management of Unstable Thoracolumbar Fractures

Clevio Desouza [α] & Amit Kale [σ]

Abstract- ***Aim:*** To evaluate the use of posterior instrumentation with transpedicular screw and connecting rods in management of post-traumatic unstable thoracolumbar spine fractures.

Methods: 20 patients with post-traumatic instability of thoracolumbar spine were included in our study. The spinal stability was assessed by the thoracolumbar injury severity scoring. All patients underwent an open reduction internal fixation by the posterior approach. The localisation of pedicles was done using intraoperative imaging. The assessment of neurological status of the patients was done using the ASIA grading scale and other complications were assessed and noted up to 6 months.

Results: 20 patients with unstable thoracolumbar injuries were managed with pedicle screws and rods. Males were affected more than Females. The most common type was AO Type A and L1 was the level most affected. None of the patients deteriorated after surgery. 15 patients with incomplete cord injury showed at least one frankel grade improvement. 4 patients with complete cord injury showed no improvement. The mean kyphotic angle by Cobb's method was 20.8 degree on admission, 4.6 degree post-operatively and 6.1 degree at latest follow-up. Average anterior vertebral body height at the time of admission was 52%, post-operatively it was 85% and at final follow-up it was 80%. There was 1 case of screw mal-positioning and 3 patients developed bed sores.

Conclusion: Pedicle screw fixation with connecting rods is a useful choice for thoracolumbar injuries for achieving reduction and stability, without affecting extra motion of segments.

Keywords: pedicle screws, thoracolumbar injuries.

I. Introduction

Spinal trauma is one of the leading problems in orthopaedic practice, more so in the modern era where the individuals are more at risk due to high energy trauma [1]. Thoracolumbar spinal segment is the second most common involved segment after cervical segment in spinal injuries [2]. There is concentration of these injuries at the thoracolumbar junction, with its occurrence being such that 60 % is between T12 and L2 [3]. 15 to 20% patients with fracture at thoracolumbar level have associated neurological injury [4].

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The treatment options available for unstable thoracolumbar spine fractures and fracture dislocations of the spine have long been controversial. Many authors according to their understanding, advised non-operative treatment, but later their studies emphasized the advantage of Open reduction internal fixation with posterior instrumentation [2, 5, 6]. Historically, thoracolumbar fractures have been treated with immobilization for a period of 8-12 weeks [6].This mode of treatment is accompanied with complication due to recumbence. It is very labour intensive, cost of therapy in terms of hospital hours used, bed occupancy and care by trained personnel is very high. In a country like India, where there is acute shortage of hospital facilities and trained manpower, conservative management, more often than not, end up as benign neglect, so there is an urgent need for exploring possibilities of surgical stabilization, early mobilizations and rehabilitation of patients.

Internal fixation and stabilization of spinal lesion allows early mobilization of all patients, regardless of neurological deficit, while protecting the neurological structures from further injury and enhancing their recovery [7]. Surgical treatment can be anterior, posterior or combined approach. As most orthopaedic and spinal surgeons are more experienced in posterior approach and at the same time this approach requires less operative time with less blood loss, hence a safe alternative [8]. If an incomplete neurological deficit exists, significant residual neural compression is documented and when treatment is carried out 3 weeks later anterior approach can be considered [9,10]. Historically, Harrington hook rod construct or its modifications have been extensively studied [11]. The main disadvantage of these instruments is that it spans 5-6 spinal segments [12]. Hence, newer options, especially pedicle screw plate or rod constructs which provide short segment immobilization have gained popularity [13].

The goal of surgery is to achieve stability, to correct deformity, early mobilization, to expedite post-operative recovery and to decrease pseudo-arthrosis [14]. The pedicle screw plate or rod construct helps to

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achieve all these [15]. In this study, we have stabilized cases of thoraco-lumbar unstable spinal lesions with pedicular screw and rod fixation. Pedicle screw system has gained much popularity in recent times.

II. Objectives

1. To study the efficacy of pedicular screw and rod fixation system in achieving stabilization in thoracolumbar fractures of spine.
2. To determine the commonest mechanism, level, and type of fracture and to study radiological and clinical outcome.
3. To facilitate early mobilization of patients and thus help in easy nursing care of the patient, in order to recreate a stable, pain free spinal column.

III. Material and Methods

20 cases were assessed during the study period of 12 months between June 2019 to June 2020. All the patients underwent treatment according to protocol. The patients were assessed in the emergency department and after initial investigations, and haemodynamic stabilization patients were assessed neurologically in detail. All the patients had their routine radiographs done along with MRI and CT scans. The pre-operative neurological status was graded on the basis of ASIA scale grading. It was also used to assess post-operative recovery and follow-up. The indication for the surgery was instability for which instrumentation was needed to restore spinal stability or to protect neurological elements.

a) Inclusion criteria

1. Age group >18yrs.
2. Traumatic thoracolumbar fractures.
3. Unstable fractures with or without neurological deficits.

b) Exclusion criteria

1. Age < 18 yrs.
2. Traumatic cervical spine fractures and sacral spinal fracture.
3. Spinal instability due to congenital spinal abnormality.
4. Patients not willing for surgery.
5. Medically unfit for surgery.

c) Preoperative work up

1. Plain radiograph (static and dynamic wherever necessary)
   i. Anteroposterior views.
   ii. Lateral views.

To assess extent of degeneration, instability, mechanism of injury, fracture pattern and its severity and canal compromise or deformity.

2. Magnetic resonance imaging (MRI) was useful in determining
   i. The condition of the spinal cord following trauma
   ii. Any soft tissue encroachment (intervertebral disc) of the spinal Cord.

d) Instruments

- General spinal instruments.
- Mastoid retractors.
- Cobb's elevator.
- Trocar with stopper.
- Pedicle Centralizers.
- Pedicle probe.
- Tap 5.5 mm and 6.25 mm.
- Pedicle sound.
- Rod contouring template.
- Cam action bending device.
- Rod cutter.
- Rod holder, rod pusher.
- Combined insertion device for inner screw and outer nut.
- Rod stabilizer.
- Distractor self-holding.
- Hex screw driver,
- Socket wrench for outer nut, cannulated with T-Handle.

e) Procedure

Prophylactic intravenous antibiotics were given preoperatively. In supineposition general anaesthesia with endotracheal intubation was administered. The patient was put in prone position on a 4 poster frame encouraging morelordosis. Care being taken to keep the nipples in females and the scrotum in males from free from pressure. This position avoids venous stasis and decreases intra-abdominal pressure, thus reducing venous bleeding. All bony prominences were padded. The skin, subcutaneous tissues, and paraspinal muscles down to the level of lamina were infiltrated with 1:50000 epinephrine solution to minimize bleeding. A posterior midline incision was made centering over the involved spinal unit and extending 2 levels above and below. The incision was deepened to expose posterior elements of the vertebrae one level above and one below the injury. The dissection was carried laterally to the tips of the transverse processes, maintaining meticulous homeostasis. The pedicles were identified, by identifying the point of convergence of a horizontal line along centre of transverse process and vertical line along centre of superior facet. Using a rongeur cortical bone was removed around the pedicle entry point. Pilot hole is made with use of sharp Trocar with stopper. Centralizers or Blunt Kirschner wires were placed into the pedicle and their position was confirmed under image intensifier on both anteroposterior and lateral views. Pedicle probe was passed with rotating it over 30

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degrees clockwise and anticlockwise so it entered the pedicle at the region of least resistance which is the centre of the pedicle. The depth of the pedicle was confirmed with probe by the markings on it and confirming its position by passing it to 80% of its depth. Now the pedicles were tapped with 5.5mm or 6.25mm taps depending on appropriate size. The pedicle was probed in all four quadrants with a pedicle sound to make sure that solid tube of bone exists and violation of pedicular cortex has not occurred and the screws of appropriate lengths were selected and inserted into the pedicles with help of monoaxial or polyaxial inserter depending on the implant used. During insertion the positions of the screws were checked with image intensifier in both anteroposterior and lateral views. A rod contouring template is placed into the slots of the implants. The template is shaped to reflect the natural curve of spine. A under contoured rod was used to create distraction-extension assembly. The appropriate sized rods (10mm) were selected and contoured using cam action bending instrument to match the template. The rods were held with self-locking, long rod holder and aligned and placed over the slots on the implant placed. A rod pusher straight or curved can be used to push the rod into implant slots. The rod is fixed by inserting the inner screw and outer nut with help of combined insertion device for inner screw and outer nut by gently aligning the inner screw with inner threads of the screw. Use 1-2 counter clockwise turns to engage inner threads. A slight click will confirm proper alignment of screws. The inner screw is rotated clockwise to engage 2-3 threads and is not tightened at this stage. Holding the inserter for inner screw in position the inserter for the outer nut is disengaged from the ball catch holding it and outer nut is lowered and aligned and inserted by rotating clockwise to engage 2-3 threads only and is not tightened, the combi inserter is disengaged by lifting it clean and the assembly is inspected to ensure the threads are properly engaged. All outer and inner screws are similarly inserted over the implant and the assembly is constructed. Using angled spreader, distraction is applied by placing the prongs of spreader straddling the rod and in contact with the head of the implant. Adequate distraction is applied for correction of deformity and the inner screw is tightened with long hex screw driver. A thorough homeostasis was achieved and the wound was closed in layers over drain. Clean dressing was applied.

f) Post- operative treatment

All the patients were given post- operative intravenous antibiotics for 5 days. They were switched over to oral antibiotics till suture removal. Physiotherapy was started from first day post operatively. Sutures were removed on fourteenth day. On the second day patients were allowed to roll from side to side. They were allowed to sit up and were mobilized on a wheel chair after application of KT brace on fifth post-operative day. A close watch was kept for any improvement or deterioration in the neurological status.

g) Follow up

All the patients were followed up at interval of 6th week, 12th week and at 6months on each follow up clinical, radiological & neurological examination was done to assess spinal stability.

IV. Results

- Age and Sex Distribution

AGE	MALES	FEMALES
<20	3	0
21-30	3	0
31-40	5	1
41-50	5	1
51-60	2	0

In this series 18 (90%) patients were male and 2 (10%) were female patients. 3 (15%) patients were below 20 years, 3 (15%) were in the 21-30 age group and 6(30%) were in the 31-40 age group, 6(30%) were in 41-50 age group and 2(10%) were in 51-60 age group.

- Type of Fracture

CLASSIFICATION	NO. OF CASES	PERCENTAGE
A	16	80
B	3	15
C	1	5

In this series there were 16 (80%) of type A fractures, 3 (15%) of type B and 1(5%) with type C fractures.

- Level of Injury

LEVEL	NO. OF PATIENTS	PERCENTAGE
T11	0	0
T12	7	35
L1	8	40
L2	5	25

In this series we had 7(35%) patients with fracture at T12 level, 8(40%) patients with fracture at L1 level, and 5(25%) patients with fracture at L2 level.

- Mean Kyphotic Angle

PRE-OPERATIVE	20.8 DEGREES
3 MONTHS	4.6 DEGREES
6 MONTHS	6.1 DEGREES

In our series the mean kyphotic angle was 20.8° at admission, 4.6° at 3 months follow up and 6.1° at 6 MONTHS follow up. A significant correction in kyphotic deformity after posterior spinal stabilization with pedicle screws and rod system was observed.

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- Anterior Vertebral Body Height

In our study, average anterior vertebral body height was 52%, post op was 85% and at 6 months follow up was 80%.

- Complications

In our series 3 (15%) patients had pressure sores and were treated accordingly. No patient had superficial wound infection. 1(5%) patient had mal-positioning of the screw but developed no neurological complications due to it.

V. Discussion

- Age and Sex Distribution

In our study we had 90% males and 10% female patients. The average age was 36.6 years and more common in the third and fourth decade. Gregory F. Alvine et al in their study found that average age was 31 years, with a male predominance [16]. Nasser M.G et al in their study found that average age was 28.8 years with a male predominance [17]. Rick C. Sasso et al, in their study had 77% males and 23% females with a mean age of 34 years [18]. Razak M et al in their study found that average was 30 years with a male predominance [19].

- Mode of Injury

In our study we noted fall from a height in 80% patients as the most common mode of injury and was mainly the result of work injury. Road traffic accident was the second commonest cause 15% of patients and fall of heavy object in 5%. Nasser M.G et al in his study noted that the main cause of injury was fall from a height and road traffic accident was the second commonest [17]. Gregory F. Alvine et al noted that in 52% of patients injuries resulted from fall from a height, in 39% patients due to road traffic accidents and 9% due to fall of heavy objective [16]. Razak M, et al in his study noted that 69% of injuries were caused from fall from height, 31% due to road traffic accident [19].

- Classification Type

In our series we found 80% of patients with AO Type-A fractures, 15% with AO Type-B fractures and 5% with AO Type-C fractures. Nasser M.G et al in their study noted 76% of patients with Type-A, 8% with Type-B and 16% with Type-C [17]. Rick C.Sasso et al noted that 62.5% had AO Type-B and 37.5% had AO Type-A fractures [19]. Gregory F.Alvine et al noted that Type-B fractures were seen in 57.5% of patients Type-A in 22.5% and 20% Type-C [16].

- Neurological Status

In this study 4(20%)patients were of grade A, 4 (20%) were grade C,and12(60%) were grade D at admission and at latest follow up 15 cases showed at least 1 ASIA Grade improvement.

Nasser M.G et al. noted that patients who had neurological deficits showed atleast 1 grade improvement at latest follow up [17]. Gregory F Alvine et al noted that neurological improvement was seen in 50% of cases with 40% improving with 1 grade and 20% with 2 grades and none had decrease in neurological level [16]. Rick C.Sasso et al., in their study noted that all patients with incomplete neurological deterioration improved at least by 1 grade [19]. Razak M et al noted that 64.4% of those with incomplete lesions showed an improvement of at least 1 grade [18].

- Radiological Parameters

In our series the mean kyphotic angle by Cobb's method was 20.8° on admission, 4.6° post operatively and 6.1° at latest follow-up. Nasser M.G et al noted the kyphotic angle was 23.6° on admission, 7° post –operatively and 11.5° at latest follow-up [17]. Gregory F. Alvine et al noted that sagittal plane angulation was 12° pre operatively, 1° post operatively and 6° at follow-up [16]. Rick C.Sasso et al noted that the kyphotic angle was 17.6° pre operatively, 3.5° post operatively and 11.6° at latest follow up [19]. Razak M. et al. noted that the average kyphotic angle was 20° pre operatively, 7° post operatively and 9° at latest follow up [18].

- Time Duration

In our series the duration from injury to admission was a mean of 1.90 days, from injury to surgery was 3.85 days and average hospital stay was 17.2 days. Rick C.Sasso et al noted in their study that average time interval between time of injury to time of surgery was 4 days and mean hospital stay was 16 days [19]. Razak M et al noted that average time duration to surgery was 5.6 days and average hospital stay was 24 days [18].

- Complications

In our study we had 3 patients with pressure sores and no patient with superficial wound infection. 1 case of misplacement of pedicle screws was noted. No neurologic complications were noted in the patient with misplacement of screws. As the literature suggests only 0-1%complication rate in patients with misplacement of screws, no revision surgery was undertaken.

Khan. I et al in their study noted that there was 1 patient with superficial wound infection, and 1 patient with deep vein thrombosis [20]. Razak M et al noted 2 instances of hardware loosening and 3 misplaced pedicle screws [19].

VI. Conclusion

This study was conducted to assess the Radiological, Neurological and Clinical outcome of surgical management of thoracolumbar fracture spine with pedicle screws and rod system.

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We conclude:

1. Thoracolumbar spine fractures are more common in the 3rd and 4th decade of life with male predominance due to outdoor activities.
2. The commonest mode of injury was fall from a height.
3. Management of thoracolumbar spine fractures requires careful pre-operative planning, patient selection, neurological evaluation and meticulous intra-operative care and post-operative rehabilitation including detailed counselling for good functional outcome.
4. The posterior midline approach provides adequate exposure and direct visualization.
5. Pedicle screw fixation should be done as early as possible in order to facilitate neurological recovery, help in good nursing care and early mobilization of the patient and to prevent deterioration of the neurological status.
6. Pedicle screw instrumentation provides less surgical exposure, correction of deformity and better stabilization, of one motion segment above and below the fracture. It provides fixation and stabilization of all the three columns. So stabilization, reduction and decompression using pedicle screws and rods helps in stabilization of unstable fractures and helps in further neurologic recovery of the patient.
7. Early surgical intervention helped in good neurological recovery.

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Acknowledgments

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Manuscript Style Instruction (Optional)

- Microsoft Word Document Setting Instructions.
- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11'", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

Structure and Format of Manuscript

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

a) A title which should be relevant to the theme of the paper.
b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
d) An introduction, giving fundamental background objectives.
e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
f) Results which should be presented concisely by well-designed tables and figures.
g) Suitable statistical data should also be given.
h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

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The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

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A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, “What words would a source have to include to be truly valuable in a research paper?” Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

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Numerical methods used should be transparent and, where appropriate, supported by references.

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Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

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Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

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Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

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Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

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2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

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7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

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11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

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18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

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22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

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- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

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Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

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The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

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Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

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When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

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Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

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- Leave out information that is immaterial to a third party.



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Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
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References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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