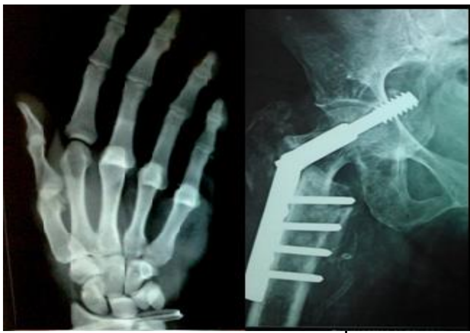
International Journal of Orthopaedics Sciences 2021; 7(1): 162-169



International Journal of Orthopaedics Sciences

E-ISSN: 2395-1958
P-ISSN: 2706-6630
IJOS 2021; 7(1): 162-169

www.orthopaper.com
Received: 11-11-2020
Accepted: 20-12-2020

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Prospective study on functional outcome of fracture shaft of femur (Winquest Hansen type 1, 2 and 3) treated with intramedullary interlocking nail

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DOI: https://doi.org/10.22271/ortho.2021.v7.i1c.2476

Abstract
The management of femoral shaft fractures using intramedullary nailing is a popular method. The purpose of this study was to evaluate the functional outcome after antegrade intramedullary nailing of traumatic femoral shaft fractures. In a prospective study, patients with a femoral shaft fracture but no other injuries to the lower limbs or pelvis were included. A total of 40 patients met the inclusion criteria. All were operated by the standard procedure of antegrade intramedullary interlocking nailing. Patients were reviewed at 1, 3, 6, 12 months and we used KLAUSS & KLEMN CRITERIA and McNAIRS LOWER LIMB QUESTIONNARE for quantification of functional outcome. The mean age of such fractures was 24 years (+/- 5 years), majority being a male and the main mechanism of injury being RTA. There were 2 cases of fat embolism and 2 cases of superficial infection which were healed by the conservation method. The average time of radiological union was 12-24 weeks. There was no case of non-union but 1 case of delayed union for which dynamization was done. Final functional outcome came out to be good to excellent in all the patients.

Keywords: Shaft of femur fracture, intramedullary nailing, Winquest Hansen, kaluss and klemn criteria, mcnair lower limb questionnaire

Introduction
In the field of traumatology, the fracture shaft of the femur is one of the most common fractures encountered by orthopaedic surgeons. The femur is one of the principal weight-bearing bones of the body, so diaphyseal fractures are associated with significant morbidity and mortality. Technical advancement has led to advanced mechanization and is accompanied by an increased acceleration of traffic, leading to such fractures. Femoral shaft fractures comprise 5 -6% of all long bone fractures in adults [1]. As the fracture shaft of the femur is a high-velocity injury, it is often associated with other systemic injuries or multiple fractures. The incidence of fracture shaft of femur ranges from 9.9 to 12 per 1,00,000 per year [2, 3] most of which occurs in males. A bimodal age of presentation is seen in cases of fracture shaft of the femur. It is more commonly seen in 15 to 24 years [2] of individuals associated mostly with road traffic accidents and also in around 75 years of elderly populations associated with trivial injuries like falls from standing height. Even though the femoral shaft fracture management gained importance way back in 18th century due to its disastrous complications like fat embolism, acute respiratory distress syndrome, and prolonged morbidity and mortality, there wasn't much improvement till the turn of the 20th century due to a lack of proper instrumentations, adequate knowledge of fracture anatomy, and the biomechanical principles of fracture healing. Morbidity in the form of limb shortening, malalignment, knee contractures, and other complications may arise from fracture shaft of the femur. Mortality is infrequent but still can result from an open wound, fat embolism causing adult respiratory distress syndrome, or multiple organ failure, especially in the polytrauma patients. Both morbidity and mortality can be diminished by prompt reduction and internal fixation of the fracture [4]. Restoration of alignment, rotation, length, preservation of the blood supply to aid union, and rehabilitation of the patient is the goal of treatment. The type and location of the fracture, degree of comminution, the age of the patient, patient's social, economic demands, and other associated fractures may influence the method of treatment.

There is a gradual transformation in the treatment of fracture shaft femur from skin traction, splints, cast application, open reduction and internal fixation with plates and screws, external fixators to intramedullary nails. Previously intramedullary nails, though popular had some drawbacks as they didn't give rotational stability and also were poor in maintaining axial length. Then, eventually came the concept of the interlocking nail with proximal and distal bolts, which ultimately solved these issues. Currently, intramedullary interlocking nailing has been recognized as a reliable method for the treatment of fracture shaft of femur with a high union (95-99%) and low complication rates. Though intramedullary interlocking nailing has somewhat become the treatment of choice in case of fracture shaft of femur still, the ultimate success of such a management protocol depends on the fracture pattern, associated injuries, surgeons' experience with the surgery, and patient compliance. Intramedullary interlocking nailing may be related to several pre-operative, intra-operative, and post-operative complications. Pre-operative complications include a fat embolism, polytrauma, open fracture, etc. Intra-operative complications include iatrogenic neck of femur fracture, anterior cortical breach, neural injury to the hip abductors, distal perforations, etc. Post-operative complications can also occur like weakness of hip abductors, surgical site infection, risk of heterotrophic ossification around the hip and fracture-related pain, joint stiffness, delayed union, and non–union which may compromise the final functional outcome of the surgery.

This study aims to analyze the demographics of the fractured shaft of the femur, the several variables in the intra-operative period as well as observation of the functional outcome in the post-operative period. This study also deals with the incidence of complications in the pre-operative, intra-operative, and post-operative periods and the management of such complications.

Material and Methods

Study Population

All cases with a shaft of femur fracture were admitted in the orthopedics ward of Kalinga Institute of Medical Sciences & Pradyumna BAL Hospital between September 1st, 2018 to August 31st, 2019 were included in the study.

Inclusion Criteria

All fresh fracture of the shaft of femur (Winquest Hansen Type 1, 2 & 3) admitted in the orthopaedics ward between September 1st, 2018 to August 31st, 2019.

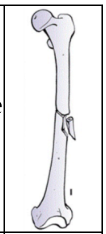
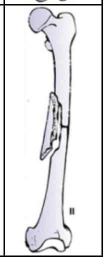
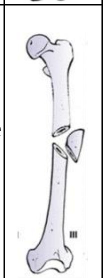
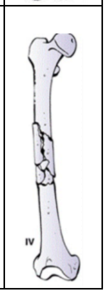
Exclusion Criteria

1. All shaft fractures below 18 years & above 65 years.
2. All shaft of femur fracture are associated with other systemic injuries.
3. Associated ipsilateral hip, knee, or other fractures of the femur.
4. Pathological fractures.
5. Re-fracture of shaft of the femur.
6. Segmental Femur fracture.

Pre-Operative Protocol

All the complex femoral shaft fractures were examined by taking a thorough history, general examination was done to look for associated injuries or any neurovascular deficit. A thorough examination of the ipsilateral hip and knee were performed. All shafts of femur fractures were stabilized initially with a Thomas splint. All patients were stabilized hemodynamically with intravenous fluids, blood transfusion if required. Radiographic evaluation is done by obtaining antero-posterior and lateral views of the femur, hip, knee as well as an antero-posterior view of the pelvis. The radiographs were critically evaluated to determine the associated comminution, presence of any visceral injury, any air in the soft tissue, the amount of fracture shortening, and to classify fracture according to Winquest Hansen classification. Pre-operative blood investigations were sent with the planning of surgical procedures, keeping in mind about patient's comorbidities. All patients planned for surgery were routinely transfused with pre-operative antibiotics, i.e. intravenous 3rd generation cephalosporin+sulbactum, half an hour before the incision along with a proton pump inhibitor and suitable intravenous fluid.

Winquest Hansen Classification

Type 1	Minimal or non-existent comminution at the fracture site	
Type 2	Greater than 50% cortical contact of the wedge fragment	
Type 3	Less than 50% cortical contact of the wedge fragment	
Type 4	Segmental fracture with no contact between proximal and distal fragment.	

Surgical Procedure

All femur fractures were fixed by the standard method of antegrade femoral nailing.

Patient positioning and preparation

The patient was kept supine on a radiolucent fracture table with the affected leg in traction by traction boot. The other leg was supported by a leg rest platform in a hemilithotomy position (fig-1). Traction was applied to the affected leg, and length is achieved as confirmed by the fluoroscopy. The rotational alignment was achieved by either internally or externally rotating the leg in the traction boot, confirmed by fluoroscopy. Antiseptic wash was given, and proper sterile draping was done (fig-2).

Fig 1: Patient position

Fig 2: Dressing and draping

Operative Technique

The greater trochanter is palpated, and a 3 cm incision was given 3 cm proximal to the greater trochanter along the femoral axis. The entry point was made with an awl (fig-3) just medial to the tip of the greater trochanter (fig-4). The entry point was broadened with a solid hand reamer (fig-5, 6). A beaded guidewire was passed up to the distal femur epiphyseal line under C-arm guidance (fig-7, 8). Reaming of the medullary canal was done with a cannulated reamer, and a nail was selected 1.5mm less than the widest used reamer diameter (fig-9). A femoral interlocking nail (stainless steel/titanium) was mounted in the jig and inserted (fig-10). Distal locking was done by freehand technique under c-arm guidance (fig-11, 12, 13, 14). Proximal locking was done through a jig (fig-15, 16, 17). The wound was closed in layers, and a sterile dressing was applied.

Fig 3: Making entry point

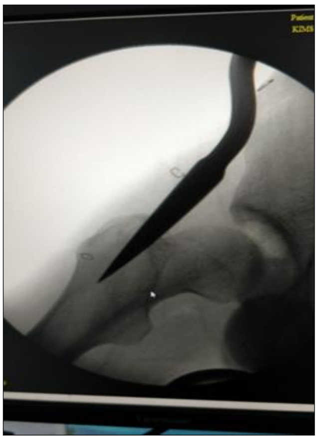


Fig 4: Entry point

Fig 5: Developing entry point entry point

Fig 6: Developing entry point

Fig 7: Distal guide wire placement in lateral view

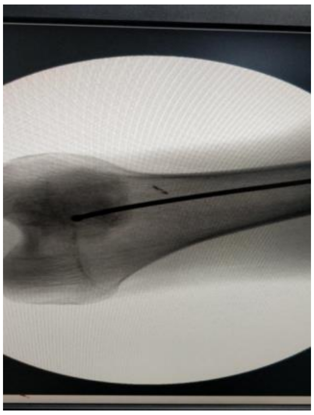


Fig 8: Distal guide wire placement in anteroposterior view

Fig 9: Reaming

Fig 10: Nail insertion

Fig 11: Free hand technique for distal locking

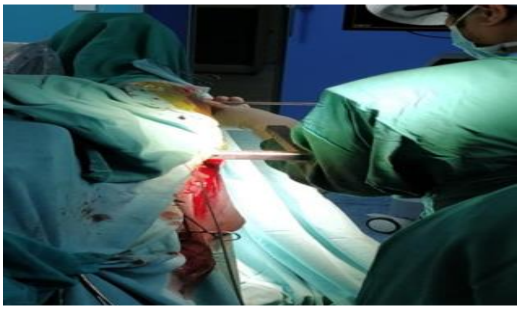


Fig 12: Distal screw application

Fig 13: Distal screws given

Fig 14: Distal drilling by freehand technique

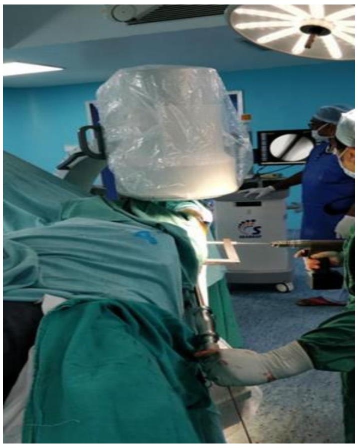


Fig 15: Proximal drilling

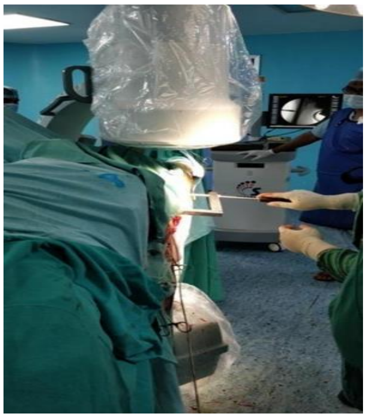


Fig 16: Proximal screw application

Fig 17: Proximal screw given

Postoperative Protocol

One dose of postoperative antibiotics was given, along with adequate pain control medications. Static quadriceps exercise was started after 24 hours. Early knee mobilization was encouraged after 48 hours as far as the patient tolerates pain. Non-weight-bearing walking with a walker was advised as soon as possible. Suture removal was routinely done on the 14th day. Partial weight-bearing was advised after four weeks. Full weight-bearing was advised after 12 weeks. All patients were followed up regularly, upon which clinical, and radiographic evaluation was done to assess the fracture healing at 1, 3, 6 & 12 months. The outcome was analyzed with Klauss & Klemn criteria &Mc Nairs lower limb questionnaire.

Table 1: Klauss & Klemm Criteria (Deepak MK, *et al.* Ann Afr. 2012 Jan-Mar)

Excellent	Normal radiographic alignment Full hip and knee motion No muscle atrophy
Good	Angular deformity ≤ 5 degrees Muscle atrophy ≤ 2 cm Slight loss of hip and knee motion Shortening ≤ 2 cm
Fair	Angular deformity 5 – 10 degrees Moderate (25%) loss of hip and knee motion Muscle atrophy > 2 cm Shortening > 2 cm
Poor	Angular deformity > 10 degrees Marked loss of hip and knee motion Marked muscle atrophy Marked shortening.

Mc NAIRS LOWER LIMB TASK QUESTIONNAIRE

ACTIVITIES OF DAILY LIVING SECTION

INSTRUCTIONS

If you did not have the opportunity to perform an activity in the past 24 hours, please make your best estimate on which response would be the most accurate.

Please also rate how important each task is to you in your daily life according to the following scale:

1. Not important
2. Mildly important
3. Moderately important
4. Very important

DAILY ACTIVITIES SECTION

Please answer all questions.

	NO DIFFICULTY	MILD DIFFICULTY	MODERATE DIFFICULTY	SEVERE DIFFICULTY	UNABLE	IMPORTANCE OF TASK
1. Walk for 10 minutes	4	3	2	1	0	1 2 3 4
2. Walk up or down 10 steps (1 flight)	4	3	2	1	0	1 2 3 4
3. Stand for 10 minutes	4	3	2	1	0	1 2 3 4
4. Stand for a typical work day	4	3	2	1	0	1 2 3 4
5. Get on and off a bus	4	3	2	1	0	1 2 3 4
6. Get up from a lounge chair	4	3	2	1	0	1 2 3 4
7. Push or pull a heavy trolley	4	3	2	1	0	1 2 3 4
8. Get in and out of a car	4	3	2	1	0	1 2 3 4
9. Get out of bed in the morning	4	3	2	1	0	1 2 3 4
10. Walk across a slope	4	3	2	1	0	1 2 3 4

RECREATIONAL ACTIVITIES SECTION

Please answer all questions

	NO DIFFICULTY	MILD DIFFICULTY	MODERATE DIFFICULTY	SEVERE DIFFICULTY	UNABLE	IMPORTANCE OF TASK
1. Jog for 10 minutes	4	3	2	1	0	2 3 4
2. Pivot or twist quickly while walking	4	3	2	1	0	2 3 4
3. Jump for distance	4	3	2	1	0	2 3 4
4. Run fast/sprint	4	3	2	1	0	2 3 4
5. Stop and start moving quickly	4	3	2	1	0	2 3 4
6. Jump upwards and land	4	3	2	1	0	2 3 4
7. Kick a ball hard	4	3	2	1	0	2 3 4
8. Pivot or twist quickly while running	4	3	2	1	0	2 3 4
9. Kneel on both knees for 5 minutes	4	3	2	1	0	2 3 4
10. Squat to the ground/floor	4	3	2	1	0	2 3 4

TOTAL (/40):

Footnote: All the patients were recruited after proper informed consent and after ethical committee approval for the said study.

Results and Discussion

Fractures of the shaft of the femur are usually a result of high-energy trauma and are accompanied by severe injuries to other organ systems. The therapeutic goals in the treatment of this fracture are avoidance of cardiopulmonary problems, prevention of infection, early mobilization, and functional rehabilitation of the limb as made evident by B.O. Thoresen, Alho. A *et al.* in 1985 [19]. Winquist and Hansen *et al.* found out that complex femoral fractures are uncommon and usually caused by high-energy violence[15]. Incidence is 1-5% of femoral shaft fractures as per Church J. C *et al.* [16] and Wu C. C, Shih C.H *et al.* [17].

We considered fracture to be united when there is no tenderness or pain during weight-bearing and when there is radiographically bridging callus with cortical density connecting three segments as per recommendations set by Wu.C.C, Wen. J.C. *et al.* in 1997 [18].

Intramedullary interlocking nailing has proved to be an effective method in the treatment of the complex fracture shaft of the femur in adults. Due to the presence of muscles and excellent soft tissue coverage around the femur, the destruction of endosteal blood supply due to reaming does not impede the fracture healing. According to the study by B.O. Thoresen, A.Alho *et al.*, the intramedullary interlocking nail acts as an internal splint and provides rigidity and rotational stability [9]. The majority of the cases in our study belonged to the age group of 18-29 years. The mean age came out to be 32.35 years. In the study of Wiss *et al.*, the mean age was 29 year[5]. Fracture shaft of the femur is an injury mainly caused by high-energy trauma. As, in a developing country like India, which mainly is formed of a young population, fracture shaft of femur also shows a predominance in the young population. The series of Thoresen *et al.* constituting of 48 cases of femoral shaft fractures stated a mean age of 28 years [9]. White *et al.* observed the mean age of 28 years in their study [11].

In most of the studies and in ours too, the incidence was significantly higher in males (33 males and seven females). A study by Wiss Fleming *et al.* found male predominance (83.7%) in his 111 patients series. Alho *et al.* reported 55% male predominance in 120 patients. In this series, we had 31 cases of road traffic accidents, i.e. around 77.5%. The incidence of road traffic accidents has been on an increasing scale. Winquist *et al.* [9] also had 77% of cases because of motor vehicular accidents. This observation by various authors implies that fracture shaft femur is usually a result of high-energy trauma. So, it is commonly associated with other injuries. As the work pool of India mainly constitutes of the male gender who labor in the open environment and due to the increase in the population of automobiles, these male labourers become victims of road traffic accidents and come up with fractures like that of shaft of the femur.

In the series of Johnson and Greenberg, the right side was predominantly involved[19]. In the series of Wiss *et al.* of comminuted fractures, the right side was predominantly involved [5]. Though this finding is consistent with several studies but still there is no explanation as to why there is a right side predominance of such fracture. In our study, as well, we found that there is a preponderance of fracture of the right side femur shaft (55%).

In our study, there was a predominance of type 3 > type 2 > type 1 of Winquest Hansen classification of fracture shaft of the femur. As fracture shaft of the femur is a result of high-velocity trauma thus, there is a predominance of more comminution as can be conferred from our study itself.

The time gap between injury and surgery ranged from 1 day to 10 days with an average delay of 4.27 days as compared to Blumberg *et al.* [20] (3.5 days) and Hanks *et al.* [10] (7.5 days).

Following surgery, quadriceps strengthening and knee range of motion exercises were started as soon as possible. Patients were primed for walking initially without weight and then weight-bearing was started gradually. This protocol encouraged the patient to constantly function in the affected limb, eventually improving the functional outcome.

The average time of hospital stay in our study was an average of 13.37 days, compared to Wiss *et al.*, which was 12 days. Several other studies like that by Winquist Hansen *et al.* and Gross Kemph *et al.* found hospital stay duration to be 44 days and 21 days, respectively. This proves that with passing years, the fracture shaft of femur has been well deciphered and the surgical expertise of closed intramedullary interlocking nailing has improved considerably decreasing patient morbidity and mortality.

The major advantage in closed intramedullary interlocking nailing is that, in this procedure, the fracture hematoma is not disturbed. This hematoma, being rich in osteoprogenitor cells boosts fracture healing manifold. The average time for the union in our series was ranging from 12 – 24 weeks with a mean time of 18 weeks. A study by Gross Kempf *et al.*, in 1985 reported union at 18 weeks, Thoresen *et al.*, too in 1985 reported union at 16 weeks, Wiss *et al.* obtained union at 26 weeks in 1986.

The incidence of infection following open nailing was reported by Wiss *et al.* as 8.3% and by Jo *et al.* as 13%. The prevalence of infection was drastically low in closed interlocking due to the fact that the incision line is much smaller and soft tissue handling is much less. In our series, 2 cases developed a superficial infection. Both cases were managed with antibiotics and did not need any surgical intervention. The incidence of deep infection in the study of Weiss *et al.* was 8%, whereas, in the study by Klemm *et al.*, it was 2.4%. In our study, there was no deep infection. The reason for such a low rate of infection can be atributed to the less interval between admission and surgery. Moreover, routine higher broad spectrum antibiotic injection in the pre-operative period and maintenance of proper intra-operative sterilization and regular dressing in a sterile environment acted as a catalyst in achieving such a low rate of infection.

In our study, there were 2 cases of Fat Embolism, one pre-operative and another immediate postoperative. Both patients were shifted to the Intensive Care Unit and were treated conservatively by the oxygen therapy, fluid resuscitation, and stimulation. They recovered within 48-72 hours, none required invasive ventilation and returned back to the orthopaedic ward.

There was 1 case of a delayed union as evident by the absence of any visible callus even after six months [12, 13, 14]. There was no evidence of infection as evident from inflammatory markers being in the normal range. A post-operative radiogram showed a fracture fixed in distraction, causing such a complication. It was managed by dynamization i.e removal of the distal static screw, which was done at 6 months. Eventually, at 1 month following dynamization, the attempt of fracture union by callus was observed and at 3 months following dynamization, the fracture was seen to be united. There was no incidence of non-union in our series. The absence of non-union points towards the surgical expertise of the surgeon and favourable patient factors like young age, early intervention and proper rehabilitation.

The functional outcome in our study was 75% good and 25% excellent results. The factors that contributed to such favourable results can be expressed in the following points:

- The young age group of the study population.
- Early presentation and intervention.
- Maintenance of fracture hematoma and preservation of vascularity of fracture site.
- Stable fixation.
- Proper physiotherapy protocol.
- Effective patient and family education.

Table 2: The comparison of the findings of our study with several other studies pertaining to similar pathology is given in the following tables

	No. of cases	Duration of hospital stay	Union (weeks)	Deep Infection (%)
Present study	40	13.37	18.5	0
Thoresen *et al.* [17].	48	-	16	0
Grosse Kemph *et al.* [16].	49	21	18	2.1
Winquist and Hansen [52].	245	26	14	0.4

Table 3: Comparative studies

	Percentage of good/excellent results
Present study	100
Johnson *et al.* [56].	96.1
Grosse Kemph *et al.* [16].	90
Weiss *et al.* [8].	92
Klauss Klemm *et al.* [15].	97

Limitations of the study include

- Small study population.
- No control group.
- Single surgical procedure.
- Short follow-up period.

Conclusion

Closed intramedullary interlocking nailing is a very effective, successful and time-tested method of treatment for diaphyseal fractures of the femoral shaft.

It is advantageous over other methods of treatment because:

- Fracture hematoma not disturbed.
- Fracture site vascularity is not further hampered.
- Stable fixation.
- The faster rate of fracture union.
- Lower rate of complications like infection & nonunion.
- Allows early mobilization & return to normal activities

Acknowledgements

This paper is a milestone and is one of the most significant challenges I have ever faced in my academic career. It is the result of a challenging journey, upon which many people have contributed and given their support. A major research project like this is never the work of anyone alone, and without the support, patience and guidance of the following people, this study would not have been completed. It is to them that I owe my deepest gratitude.

First and foremost, I would like to thank God Almighty, for his blessing that has helped me reach here. Words are not enough to express my gratitude to my loving parents, my father Dr Sunil Kumar Pal, my mother, Mrs Bani Pal whose constant guidance helped me choose the right path always and be the best version of myself. They have been continuous motivational figures.

I would like to express my deep sense of gratitude to Dr Debasish Mishra, Associate Professor, Department of Orthopaedics, K.I.M.S., who undertook to act as my supervisor despite his many other professional commitments. His wisdom, knowledge and commitment to the highest standards inspired and motivated me in the completion of this dissertation.

I would like to express my deep sense of gratitude to Prof. (Dr.) Sundar Narayan Mohanty, H.O.D, Department of Orthopaedics, K.I.M.S., Prof. (Dr.) Santosh Rath, Department of Orthopedics, K.I.M.S., for their support, guidance, and encouragement throughout my educational career.

All my instructors and teachers, especially my co-supervisor Dr. Saurav Narayan Nanda, Assistant Professor, Department of Orthopaedics, K.I.M.S., who throughout my educational career has supported and encouraged me to believe in my abilities, allowing me to reach this accomplishment.

I express my sincere regards to my other faculties, Dr. Saswat Samant, Dr K.Srikant, Dr Bibhudutta Sahoo and Dr Aditya Prasad Panda, Department of Orthopaedics, K.I.M.S. for their timely suggestions and knowledgeable advice, constant encouragement and co-operation at every stage without which completion of this paper would have been impossible. I am deeply indebted to all other faculty members of the Department of Orthopaedics at K.I.M.S. to whom I owe all my knowledge.

Finally, I would like to pay my special thanks to the Faculty members of the Department of Anaesthesiology and Radiology for their support when I needed it.

I wholeheartedly thank all my colleagues, seniors, and juniors, without whose direct or indirect help, this work would not have been possible. All my patients who participated in this research project with interest and enthusiasm and without whose participation, this project would not have been possible. I am also thankful to the Scientific and Ethical Committee for their approval and guidance.

Special thanks to Pharmacists, O.T. technician, Post-operative recovery unit, O.T. and Ward Nurses along with the Medical Records Department and all the hospital staff for their help and support.

Lastly, I apologize to all those whom I could not enumerate here but have helped me in their capacities for the completion of this research work.

I humbly place my thesis before my readers with the sincere hope, that it will be regarded as an honest effort on my part.

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