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Intramedullary nailing of open tibia and femur fractures through the supra & infrapatellar approach. Is septic arthritis a real concern?

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Introduction

Intramedullary nailing (IMN) can trace its origins back to ancient Egypt, marking a long history of development that has evolved significantly over the decades [1]. Through numerous trials, incorporating various designs and methods with time, modern intramedullary nails have developed to be prominent fixtures within the orthopedic repertoire [2]. The present nails are characterised by their anatomical configurations, mirroring the structural alignment of the bones they are to be used for. Their mechanical attributes relate closely with the elastic properties of cortical bone, as defined by Young's modulus of elasticity. Stringent scientific inquiry in the form of research has further proved their resilience and effectiveness[1].

The surgical approach associated with intramedullary nailing is characterised by its minimally invasive nature, featuring modest incisions and specialized tools that guide precise nail insertion and subsequent interlocking screw placement[3]. With the current array of technological resources, comprehensive literature and instructional videos are readily accessible via the world wide web in the form of digital applications and dedicated websites, detailing the absolute and relative indications for nail employment and outlining a meticulous step-by-step surgical method to achieve optimal and satisfactory outcomes.

Over the last 15 to 20 years, intramedullary nailing has solidified its position as the benchmark for stabilizing long bone fractures, particularly those pertaining to the diaphyseal and selected metaphyseal regions of the femur and tibia [2]. Furthermore, this technique has gained acceptance as a viable treatment modality for humerus and forearm fractures[4,5]. In the context of femoral fractures, intramedullary nails are indicated for a wide spectrum of cases spanning from the per-trochanteric to diaphyseal regions, extending even to highly distal metaphyseal fractures, some of which exhibit intra-articular extension[6]. Each distinct region mandates the use of specific nail configurations to optimize outcomes. Similarly, tibial fractures amenable to intramedullary nailing encompass diaphyseal fractures, including those that encroach upon the proximal metaphyseal region and entail intra-articular involvement, as well as very distal fractures. In cases characterized by heightened complexity in either the femur or tibia, supplementary interventions such as plate osteosynthesis and external fixation might be requisite to facilitate fracture reduction and stabilization[7].

Literature review

As the utilisation of intramedullary nailing has gained prominence over time, a corresponding increase in the volume of published studies has been observed. These investigations have primarily concentrated on delineating surgical indications for nailing procedures, expounding on the surgical techniques involved, and appraising the long-term functional outcomes[8].

The surgical approach employed for retrograde femur fixation involves placing the patient in a supine position on a radiolucent table or trauma table (with patient pulled down to foot of table to allow screening of relevant limb segment), with a bolster or triangular pillow positioned beneath the knee to achieve a knee joint flexion angle of approximately 30-60 degrees [9]. The incision is made over the patellar tendon, and the tendon is gently retracted laterally, enabling a medial approach to the knee joint. Under fluoroscopic guidance, the insertion point for the guidewire and subsequent nail into the femur is determined. This point is typically situated at the midpoint of the femur's intercondylar notch, aligning with the femoral shaft on the anteroposterior (AP) view, and corresponds to the extension of Blumensaat's line (i.e. just anterior to Blumensaat's line), maintaining alignment with the femoral shaft on the lateral view.

For the suprapatellar intramedullary nailing, the procedure is carried out with the patient placed in the supine position on a radiolucent table, without a thigh tourniquet application [10]. The knee is flexed to a 20-30 degree angle using a bolster or triangular cushion into a semi-extended knee position. The approximately 5 cm incision is made over the quadriceps tendon not surpassing the proximal edge of the patella. A lateral retraction of the quadriceps tendon is performed, allowing for a sharp medial parapatellar soft tissue dissection or a through the quadriceps tendon approach into the knee joint is utilised as per surgeon's preference. The fluoroscopy-guided identification of the tibial insertion point ensues, localised medially to the tibial crest in line with the tibial medullary canal on the anteroposterior (AP) view, and at the junction between the tibial plateau and anterior tibial metaphysis on the lateral view. Subsequently, the selected nail is inserted according to established standardised techniques for the specific nail type.

Historically a surgical site infection is defined as microbial contamination of the surgical wound within 30 days of an operation or within 1 year after surgery if an implant is placed in a patient [11]. The infections are defined as superficial, deep or organ space.

The term fracture related infection (FRI) which encompasses all infections occurring in the presence of a fracture was adopted by the FRI Consensus Group in 2018[12]. A definition and diagnostic (confirmatory and suggestive) criteria were

established at that meeting and updated in 2020[13]. The updated diagnostic criteria are set out below.

Confirmatory criteria for FRI:

1. Fistula, sinus or wound break down (communicating with bone or implant)
2. Purulent discharge from wound or presence of pus during surgery
3. Identical pathogens on cultures from 2 specimen taken during surgery
4. Presence of micro-organisms in deep tissue taken during surgery
5. Presence of >5 Neutrophils per high power field on histology

Suggestive criteria for FRI:

1. Clinical signs – any one of: pain, local redness, local swelling, erythema, temp ≥38.3˚C
2. Radiological signs - any one of: bone lysis, implant loosening, sequestration, non-union, periosteal bone formation
3. Single positive deep tissue specimen
4. Elevated inflammatory markers (ESR, WBC, CRP)
5. New, increasing or persistent wound drainage
6. New onset joint effusion in fracture patients

In the presence of a skeletal injury stabilised with an implant that penetrates the joint, the development of an effusion is suggestive of an FRI. This suggestion raises concerns for presence of septic arthritis.

Septic arthritis, a pressing orthopaedic emergency, necessitates immediate joint aspiration or lavage, debridement, and biopsy, with the prompt initiation of broad-spectrum antibiotics[14]. This is adapted to a targeted narrow-spectrum regimen as determined upon microbial identification on cultures.

The potential development of knee septic arthritis stands as a recognised concern in procedures implementing intramedullary nailing devices involving the suprapatellar surgical approach for open tibial fractures and the infrapatellar retrograde surgical approach for open femoral fractures[15, 16]. This risk is raised upon the anatomical disruption of the knee capsular component involved in achieving intra-articular access to the designated nail entry points on the tibia or distal femur. The gravity of this risk is compounded by the fact that reaming through the intraarticular entry point establishes a conduit between the joint and the external environment through the open wound, particularly during the interchange of reamer sizes and placement of the nail. This facilitates the potential migration of inadvertent pathogens that might have been captured during this procedural phase into the joint space. Despite pre-insertion wound cleansing, debridement,

and thorough joint irrigation post-procedure, the possibility of residual joint infection potential remains inescapable.

There are research studies that have cited a statistical risk of 1-3% for septic arthritis following intramedullary nailing procedures involving femurs and/or tibias[17, 18]. Halvorson et al. documented no instances of septic arthritis over a decade in patients who received retrograde femur nails, albeit with only 38 cases being open fractures[16]. In a comprehensive review, Hendrickx et al. analysed 8110 patients who underwent intramedullary nailing for traumatic tibia fractures across a 20-year span, noting a 3.2% incidence of deep infection[19]. In their study, 33% of cases were open fractures. However, the specifics of whether the deep infections included septic arthritis were not expounded upon.

Other studies that investigated the risk of septic arthritis after suprapatellar or infrapatellar intramedullary nailing revealed an incidence of 1.4%[20]. In some instances, no occurrences at all[21]. A few isolated case reports underscored instances of septic arthritis[22, 23].

Purpose

This retrospective cohort study aims to investigate the incidence of septic arthritis in individuals who underwent fracture stabilisation for open fractures via a through knee surgical approach for tibia and/or femur intramedullary nailing at a Level 1 trauma center in a span of a two-year period. The study seeks to provide valuable data that can be extrapolated to similar trauma centers grappling with a comparable burden of open lower limb fractures managed via suprapatellar tibia intramedullary nailing and infrapatellar retrograde femur intramedullary nailing. By evaluating both approaches within a single study, this research endeavors to shed light on the risk of knee sepsis, particularly septic arthritis, arising from these techniques. Our null hypothesis posits that the incidence of septic arthritis is negligible to absent among patients who have sustained open fractures and have undergone treatment with intramedullary nailing through the implementation of the knee intra-articular surgical technique.

Methods

Data acquisition involved tapping into the HIV in Orthopaedic Skeletal Trauma (HOST) Study database, which prospectively collected information on both open and closed femur and tibia fractures that were treated with intramedullary nailing[24]. Due to this study, all open fractures that presented during this time were captured within the data compilation, with details of associated infections, follow-up durations, and any localized or systemic complications duly documented.

After receiving ethical clearance from our institution (HREC590/2016), a search was conducted within the database to identify cases of open femur and tibia fractures occurring from January 2017 to December 2018.

Inclusion criteria included all cases with open fractures of the femur or tibia managed by utilisation of intramedullary devices for fracture fixation through suprapatellar approaches for tibia fractures and infrapatellar approaches for femur fractures (i.e. retrograde femur intramedullary nailing). Open fractures primarily stabilised with external fixation and then secondarily definitively managed with intramedullary nailing were included.

Open fractures were graded from 1 to 3(A-C) according to the Gustillo Anderson classification, those arising from gunshot wounds were included in this classification and graded as Gustillo Anderson grade 1 injuries[25].

Excluded where all cases failing to meet the defined inclusion criteria, those with incomplete data and those whose follow-up periods were shorter than 6 weeks post-surgery.

The default approach for intramedullary fixation of tibia fractures at our center is the suprapatellar approach. Thus, there were no cases that utilised the infrapatellar surgical approach in the database nor in this cohort.

Recorded research data fell under the categories: age, gender, retroviral disease status, injury mechanism, primary and secondary surgical management, occurrences of surgical or fracture site wound infections (FRI) and their management, weight-bearing status during follow-up, and instances of non-unions necessitating further surgical intervention[13]. Though the latter was not the focus of this study, it allowed us to investigate the cause of the non-unions and in this manner exclude a possible associated infective cause which is relevant to this study.

Power analysis was not conducted for this study as an ad hoc power analysis has been found to be misleading and not informative for data interpretation in retrospective studies[24,25].

A comprehensive post operative follow-up of all patients was undertaken over a span of 12 months, involving reviews at 2 weeks, 6 weeks, 3 months, 6 months, 9 months, and 12-month intervals respectively. The initial 6-month follow-ups were conducted in person, while the 9- and 12-month assessments occurred either in person or via telephonic communication.

Results and data analysis.

One hundred and twenty-nine (129) cases of open fractures were captured from the database with intervention through the knee in the form of intramedullary nailing for femur or tibia fracture. Thirteen cases did not fulfil the inclusion criteria and were thus excluded. The cohort therefore consisted of a total of one hundred and sixteen subjects (n=116). The results and data analysis of this large group was subdivided into the retrograde femur group and supra patellar tibia group and is represented as depicted below.

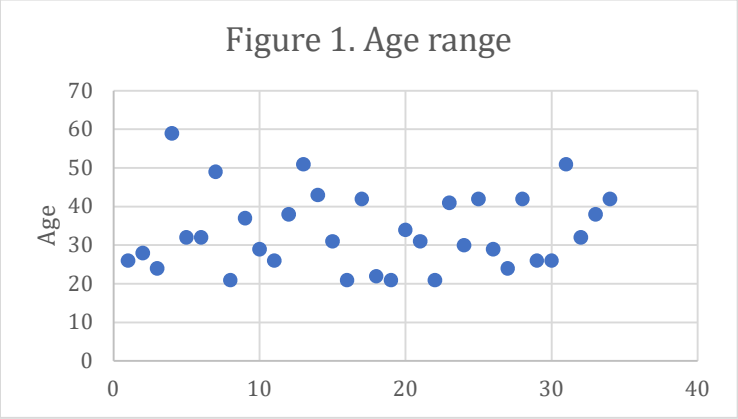
Most of the data collected was categorical in nature. Descriptive methods in the order of ranges, percentages, tables and bar graphs were utilized to explain and display the captured data.

The age category falls under nominal data, therefore, scatter plots were used to represent the distribution.

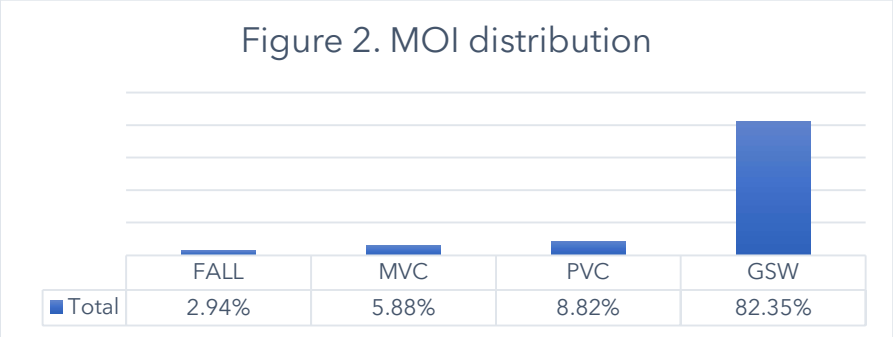
Retrograde Femur group

Among the cases of open femur fractures treated with retrograde femur intramedullary nailing, a total of 41 cases were identified. Six cases were excluded due to a lack of follow-up at the 6-week post-surgery mark, and an additional case was excluded due to incomplete data. The femur group was left with 34 cases that met the research inclusion criteria. There was no femur cases managed with external fixation. All cases were primarily managed with an intramedullary device and wound management as required.

The age range within this group spanned from 21 to 59 years, with a mean age of 33.56 years (refer to Figure 1). The gender distribution was predominantly male, accounting for 97% (33/34) of the cases.

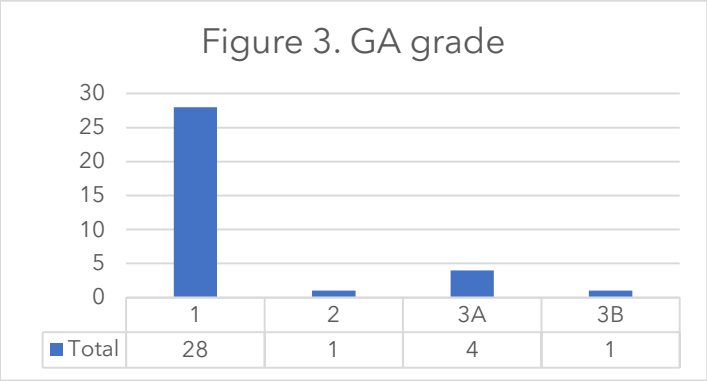


The mechanisms of injury encompassed a range from gunshot injuries (GSW, n=28) to motor vehicle collisions (MVC n=2) and pedestrian vehicle collisions (PVC, n=3) and fall from unspecified height (n=1). The distribution of the injury modes is depicted in Figure 2.



Open fractures were categorized according to the Gustillo Anderson (GA) Classification, from grades 1 to 3C. All gunshot wounds were classified as GA 1.

A notable proportion, 82.35% (28/34) of cases, fell within the GA 1 category, all of which were attributed to gunshot injuries. In the GA 3 category, 14.7 % (5/34) were recorded, with only 2.9% (1/34) falling within the GA 2 category (refer to Figure 3). There were no GA 3C femur injuries.



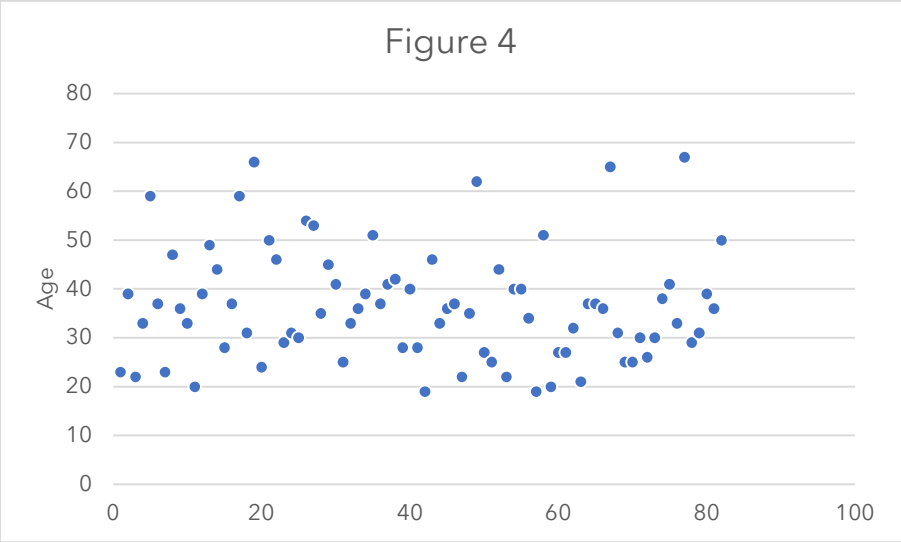
In cases of gunshot wounds, wound washout and dressing were conducted intraoperatively, with wound closure being avoided. Wounds healed by secondary intention. Wounds categorized under higher Gustillo Anderson grades 2-3B underwent debridement and closure as indicated by wound integrity with intramedullary fixation at the same surgical episode.

In this retrograde femur fixation group, 94% of cases exhibited fracture union by the 9-month follow-up point. All cases achieved union by the 12-month mark.

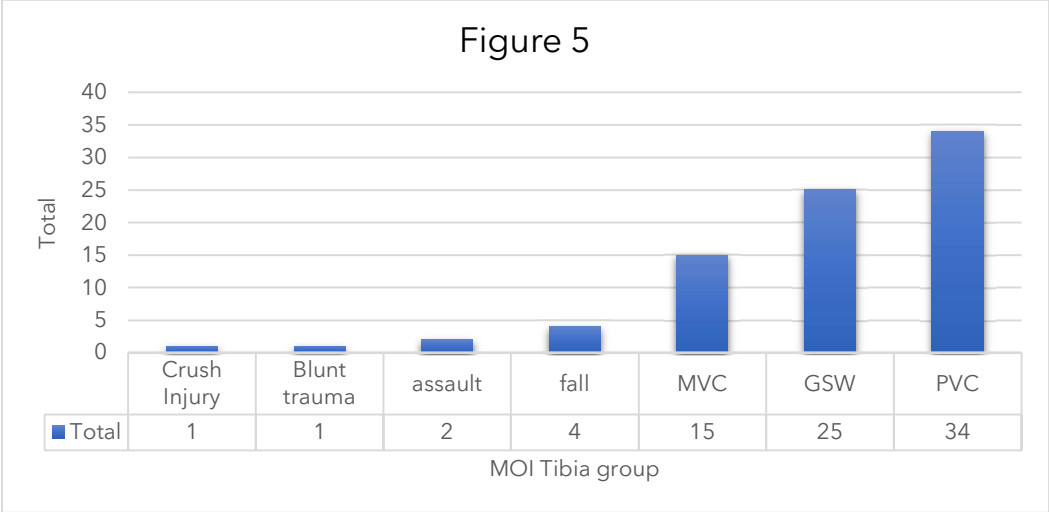
Suprapatellar Tibia group

The total open fracture cases in the suprapatellar tibia fixation group amounted to 88. Five cases were excluded due to incomplete data, study withdrawal, and loss to follow-up. One case experienced fatality due to injuries sustained after the tibia injury in the follow up period before the 6 week follow up instance. The final count of cases included in the suprapatellar group equaled 82.

The group demonstrated a mean age of 36.29 years (range19 to 67). The gender distribution within this group was heavily skewed towards males 81.7% (67/82), with a 18% (15/82) female representation.

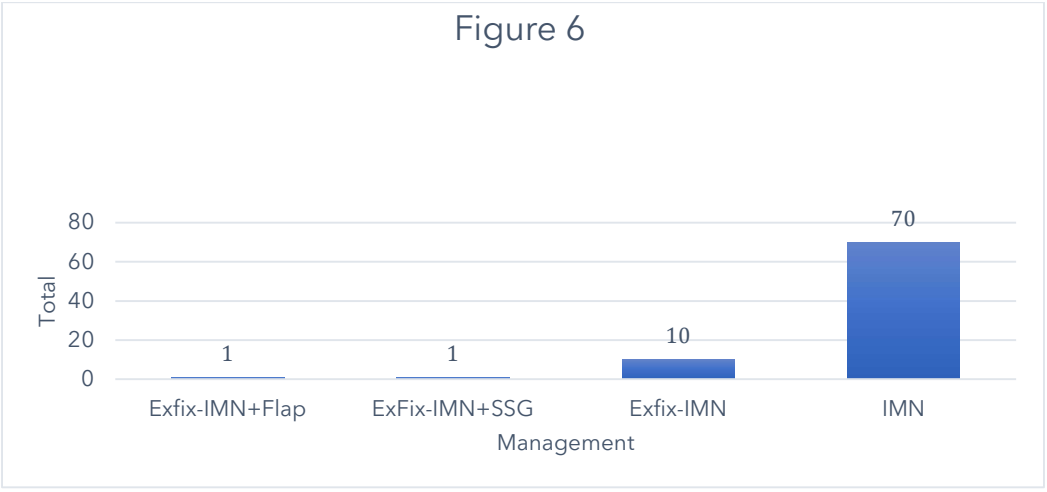


Various mechanisms of injuries are graphically represented in Figure 5. Notably, pedestrian-vehicle collisions (PVC) emerged as the predominant injury mechanism, accounting for 41% of cases. Following this, gunshot wounds (GSW) constituted 25% of cases, succeeded by motor vehicle collisions contributing to 18% of cases.



Consistent with institutional protocol for intramedullary nail fixation of tibia fractures, all cases within the study were managed via the suprapatellar surgical approach[3].

Of the total cases, 85% (70/82) were primarily managed through wound debridement and subsequent intramedullary nailing. Twelve cases (15%) necessitated initial stabilisation via external fixation followed then by definitive intramedullary nailing and wound closure at the second theatre episode. A subset of wounds required additional soft tissue coverage, accomplished through methods such as split skin grafting or local musculocutaneous flap procedures (refer to Figure 6).



A total of 14 out of 82 (17%) fracture related infection (FRI) cases were recorded (Table 1). Nine cases from the subgroup of patients who had primary IMN fixation (n=70) and 5 cases from the subgroup who had secondary IMN fixation (n=12).

There were no instances of knee sepsis uncovered within this study's cohort in the suprapatellar tibia group.

The 9 FRI cases in the primary IMN fixation group were recorded as 8 superficial and 1 deep wound infection at the site of the fracture. The 8 superficial wound infection cases were noted in subjects with GA classification gradings as follows: 1 case in a GA 3b subject, 5 cases in subjects with GA 3A injury, and 2 cases in GA 1 subjects. These cases were managed through wound dressings and a period on antibiotics. The deep wound infection case was in a GA 3B graded subject which was managed surgically by virtue of wound debridement, soft tissue closure in the form of a local musculocutaneous flap, and a 6-week course of antibiotic treatment. All cases achieved fracture union by the 12-month mark.

Table 1 -Fracture related infection per GA grade

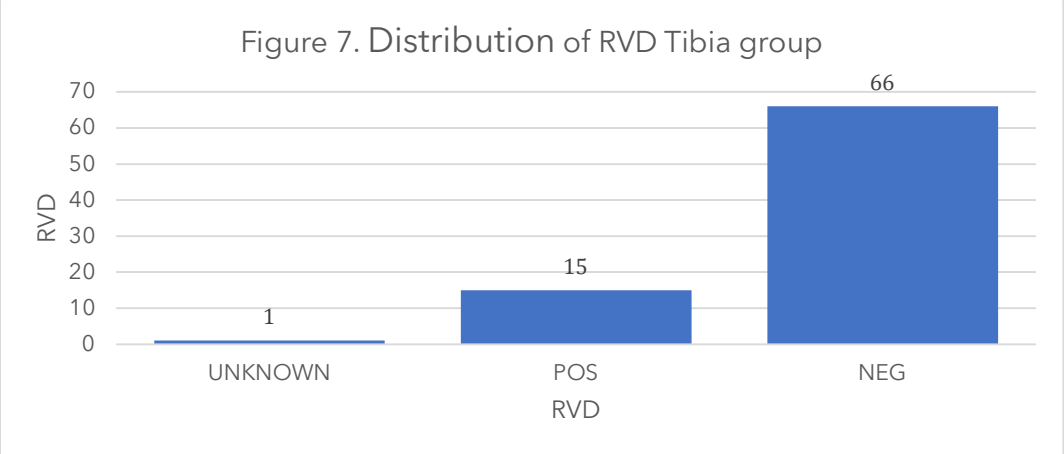
GA class	Total infections
1	4
2	0
3A	7
3B	3
Grand total	14

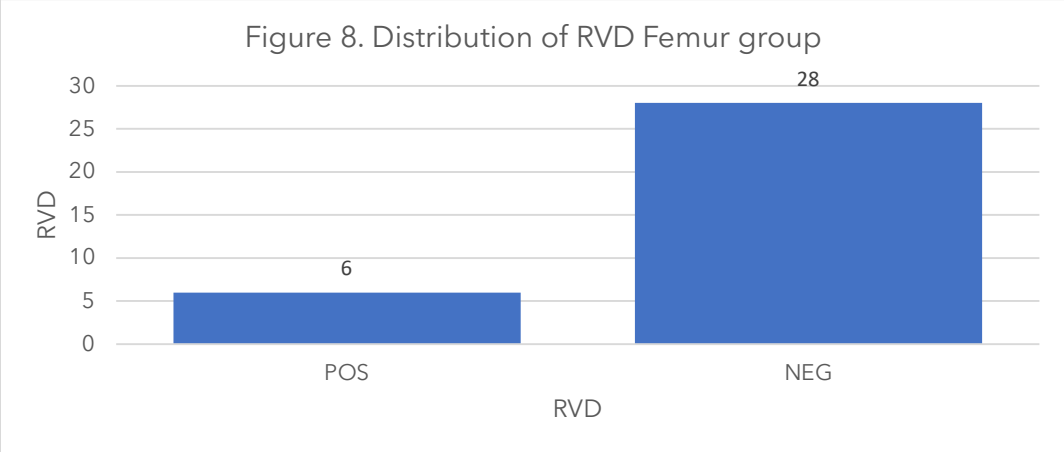
In the subgroup of 12 cases were management entailed the conversion from external fixator to intramedullary nailing, 5 cases exhibited signs of fracture site infection (FRI). Among these cases, 3 instances of infection manifested at the 2-week follow-up, while 2 cases demonstrated infection at the 6-week follow-up. All 5 infection cases underwent wound debridement and dressings only and received a 6-week course of antibiotics. Notably, 3 cases necessitated further intervention beyond the 6-month interval, involving conversion to an antibiotic-coated cement intramedullary nail through an exchange nailing procedure. Following this additional management, all cases progressed to successful fracture union.

The infections encountered were all related to wound sites at the fracture location and fall within the definition of a fracture related infection[11].Appropriate interventions, encompassing surgical measures such as wound debridement and soft tissue coverage, in conjunction with antibiotics and exchange nailing, were undertaken as warranted.

Retroviral disease and infection

In the tibia group,18% (15/82) of the individuals had HIV positive status, with one patient declining to be tested. Within the femur group 17.6% (6/34) of the cases had HIV positive status. (Figures 7 and 8).





The femur group displayed no instances of wound infection. Among the tibia group, 14 cases exhibited infections. Of these infection cases within the tibia group, 4 (29%) were associated with individuals who had HIV positive status.

There were 4 cases that required exchange nailing, specifically transitioning to antibiotic-coated cement nails. This exchange nailing intervention was executed due to infection-related complications, leading to 4 instances of septic non-union.

One of these septic non-union cases was identified within a subject who had an HIV positive status.

Discussion

This study encompassed a total of 116 open fracture cases over a 2-year duration (2017-2018). The overall distribution revealed a pronounced male predominance, constituting 84% of the total cohort. The average age across both the femur and tibia groups fell within the 34-37 age range.

The mechanisms of injury, primarily associated with motor vehicles as passengers, drivers, or pedestrians, along with injuries stemming from gun violence, collectively accounted for 93% of the open fracture cases. Civilian gunshot injuries contributed to 46% of this category, a statistic possibly linked to the prevalent gang-related violence within the geographical region of the trauma center [26].

Regarding high-grade injuries (GA grades 3 A-B), these were chiefly attributed to motor vehicle collisions, both in the femur and tibia groups.

Neither the femur nor the tibia group exhibited cases of knee septic arthritis. These findings are similar to those found by Bailey et al., who assessed the risk of septic arthritis after retrograde femur nailing in open fractures and traumatic wounds over a 13-year span involving 294 cases, including 77 open fractures [16].

Notably, the femur intramedullary nailing group exhibited a lack of soft tissue or fracture wound infections, a phenomenon that might be attributed to the substantial soft tissue coverage present in the thigh region. This ample coverage likely facilitates relatively straightforward soft tissue closure during the surgical procedure. This might also be attributed to the fact that over 80% of the cases in the femur group belonged to GA 1 category.

Within the tibia group, the infections identified were exclusively confined to the fracture site. This outcome can potentially be linked to the tibia's superficial nature, which poses challenges in achieving sound soft tissue closure and subsequently elevates the risk of wound breakdown. The consideration of implementing early soft tissue coverage, such as split skin grafts or flaps, either as a primary or secondary measure, could mitigate this risk[27].

At the 9-month follow-up, over 80% of subjects within both the tibia and femur groups were reported to be fully weight bearing, aligning well with international literature[28].

No noteworthy correlation was observed between an HIV-positive status and development of fracture related infection, as merely 3.4% (4/116) of the overall cohort belonged to this category.

Limitations

A small cohort size represented a limitation to our study. However, within this cohort, there are 53 cases of fractures due to gunshot injury. This represents the largest cohort to our knowledge within an open femur and tibia study researching the incidence of septic arthritis.

A low follow-up rate also ensured exclusion of further cases. It has been found that trauma patients are notorious for poor compliance when it comes to follow up[29].

Conclusion

While septic arthritis remains a concern in surgical cases necessitating knee entry, particularly when coupled with an open fracture, this study did not encounter instances of septic arthritis in open fractures managed through intramedullary nailing via the knee. This underscores the safety of this approach and raises the question: Is septic arthritis a real concern?

Recommendation

There is limited research looking at the risk of septic arthritis after intramedullary nailing through the knee joint. Thus, further research studies with larger cohort, over a longer period and potentially with a multi-center approach may be of great value in formulating a robust answer to the question raised in this research.

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