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Intramedullary nailing in open tibia fractures: a comparison of two techniques

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Abstract We analyzed 51 patients with open tibial fractures treated with intramedullary nailing. In 29 patients the nailing was performed without reaming and in 22 after the "reamed-to-fit" technique. There was no statistically significant difference in the rate of union. The nonreamed group required a greater number of secondary procedures to achieve union and had a higher but not statistically significant incidence of infection. Analysis of the operative and anesthesia cost associated with the additional procedures revealed that on average, patients receiving nonreamed nailing incurred a cost of $4,900 more per fracture than patients of the reamed-to-fit technique. The healing rates of open tibia fractures using either minimally reamed or nonreamed techniques of intramedullary nailing are comparable. No increase in the rate of infection with the reamed-to-fit technique was found. A significant increase in the number of secondary procedures required to achieve union was found with the nonreamed nailing technique.

Résumé Nous avons analysé 51 malades avec une fracture tibiale ouverte traitée par enclouage centromédullaire. Pour 29 malades l'enclouage a été exécuté sans alésage et pour 22 avec la technique d'alésage adapté. Il n'y avait aucune différence statistique dans le taux de consolidation. Le groupe sans alésage a exigé un plus grand nombre de gestes secondaires pour obtenir la consolidation et avait un plus grande fréquence d'infection sans que cela soit statistiquement significatif. L'analyse du coût opératoire et de l'anesthésie, associée aux procédures supplémentaires montre qu'en moyenne un malade traité sans alésage a un coût de €4,100 de plus par fracture que le malade avec la technique d'alésage adapté. es taux de consolidation des fractures tibiales ouvertes en utilisant l'enclouage avec alésage adapté ou les techniques sans alésage sont comparables. Aucune augmentation dans le taux d'infection avec la technique d'alésage adapté n'a été trouvée. Une augmentation notable du nombre de procédures secondaires nécessaires pour obtenir la consolidation a été notée avec la technique de l'enclouage sans alésage.

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Introduction

Significant rates of infection, nonunion, and delayed union are reported complications related to the treatment of open tibia fractures [10, 24]. Some continue to advocate some type of external fixation as the treatment of choice for an open tibia fracture. Pin tract infections, bulky frames, and problems with union, however, have limited the widespread use of external fixation for such fractures [2].

Early reports of nailing of open tibia fractures showed aggressive reaming and very large diameter nails (13–16 mm). This degree of reaming caused thermal damage to the bone, increased rates of infection, and subsequently decreased union rates [3, 5, 12, 18, 24]. As a result, small-caliber nails (8–9 mm) were inserted without reaming in order to avoid thermal injury and to minimize disruption to the remaining tibial blood supply [5, 23]. Nonreamed tibial nails subsequently demonstrated a residual incidence of hardware problems and nonunion. These problems seemed to be related to the small caliber of the nail and locking bolts and were especially apparent in axially unstable fractures [5, 24]. As the thermal and biologic impact of various degrees of reaming was elucidated, more recent techniques of tibial nailing have suggested that "minimal reaming" may offer advantages over both aggressively reamed and nonreamed techniques [15, 24, 26]. With this technique, reaming is done only to widen the diaphyseal region by eliminating easily removable bone. This technique allows the insertion of larger diameter nails with larger cross-locking screws while avoiding the problems associated with more aggressive reaming.

The purpose of the present study is to report our experience, comparing nonreamed versus "reamed-to-fit" nailing of all open tibia fractures presenting to the author's institution.

Methods

All open tibia fractures over a 4-year period treated with one of two treatment protocols were evaluated. Based on which senior surgeon was staffing the case, either a nonreamed or reamed-to-fit intramedullary nail was placed. Fifty-one adult patients with open fractures were included. Fractures were assigned a Gustilo grade after debridement [10]. Fractures within the distal one-fifth of the bone and within the proximal one-fourth were excluded, since these were not amenable to treatment with intramedullary nailing.

Every open fracture received early antibiotic treatment. Gustilo I and II fractures were treated with cefazolin. In patients with a true penicillin allergy, clindamycin was substituted for the cefazolin. Gustilo grade IIIa fractures received both cefazolin and gentamicin. Gustilo grade IIIb and IIIc fractures received a dose of 2 mU of IV penicillin in addition to cefazolin and gentamicin due to the high amount of contamination in these wounds.

Each protocol employed modern aggressive debridement techniques. All necrotic and devascularized tissues including bone were removed. Multiple irrigation and debridement procedures were performed until the wound was clean and all tissues viable. Microvascular coverage, when indicated, was obtained within 3–14 days. The main protocol differences were that one group of surgeons always placed nonreamed tibial nails, while the other group used a minimally reamed technique using the reamer as a canal sound. The only other difference between the two protocols was that the minimally reamed technique also used antibiotic-impregnated polymethylmethacrylate beads for grade IIIb open fractures as a temporary adjunct treatment before definitive tissue coverage was obtained.

In both groups, patients had restricted weight bearing until healed and were evaluated at routine intervals. Healing was achieved when three-cortex callus bridging was demonstrated and weight bearing was not painful. The need for bone graft or other secondary intervention was determined based on established guidelines in the literature and the judgment of the surgeon. Secondary procedures were deemed necessary when hardware complication was impending or when lack of radiographic progression was seen on two serial X-rays 6 - 8 weeks apart. In addition to evaluating demographic and perioperative data, clinical and radiographic healing, complications, the occurrence of infection, hardware problems, and the need for secondary surgery related to the indexed fracture were examined. Global cost differences between the two protocols were determined using the hospital's cost basis as an academic institution. To eliminate disposition and logistic bias, only operating room and anesthesia costs were included in the analysis. Statistical analysis was done using a Fishers exact test with a $p<0.05$ considered as significant.

Results

Fifty-one patients were identified for the study; 22 comprised the reamed group with 15 men and seven women with a mean age of 38 (17–69) years. The nonreamed group contained 29 patients comprised of 24 men and five women with a mean age of 40 (15–76) years. No significant differences in demographics, mechanism of injury, type of fracture, location of fracture, or other peroperative data were present. Fracture grades are presented in Table 1.

In the reamed (R) group, 21/22 fractures, and in the nonreamed (NR), group 28/29 fractures, ultimately went on to union. The healing rate was reported as percent healed at each follow up interval: 12 months (R=73%, NR=85%), 18 months (R=82%, NR=92%), and 24 months (R=95%, NR=96%). It appeared that the reamed group healed slightly slower than the nonreamed group, but the difference was not statistically significant. There was one amputation in each group.

The nonreamed group required significantly more supplemental procedures than the reamed group (R=11, NR=28). In the reamed group there were five dynamizations, four bone grafting, and two supplemental fixations (screws/plates). In the nonreamed group, there were 12 dynamizations, 11 bone grafting, and five exchange nailing. Additionally, six patients in the nonreamed group had the use of an electrical bone stimulator during the course of treatment. These were used in cases where several other procedures had not resulted in union as an effort to avoid even further surgery.

Nonreamed nailing group required a statistically significant greater number of procedures to attain healing ($p<0.05$). A second intervention was required for 9/22 patients of the reamed group and 20/29 of the nonreamed group. A third procedure was required for 8/29 of the nonreamed group and only 2/22 of the reamed group. A fourth, fifth, and sixth procedure was required for two fractures of the nonreamed group but none of the reamed group (Table 2).

Infections developed in two patients in the reamed group (both grade IIIb) and seven (one grade II, one grade IIIa, and five grade IIIb) of the nonreamed group (p=NS). In the reamed group, it was noted that the infections occurred in two patients with delayed flap coverage. These patients were grafted at 8 and 14 days. The average number of days to coverage for all noninfected reamed tibias was 3.6. There were three screw failures in the

Table 1 Fracture grades

Gustilo open grade	Reamed	Nonreamed
I	2	3
II	4	7
IIIA	4	2
IIIB	12	16
IIIC	0	1
Total (n=51)	22	29

Table 2 Secondary procedures

Time	Reamed	Nonreamed
Second intervention	9/22	20/29
Third intervention	2/22	8/29
Fourth intervention		2/29
Fifth intervention		1/29
Sixth intervention		1/29

nonreamed group and one in the reamed group. No nails broke or needed to be replaced due to impending failure.

Cumulative surgical, anesthesia, and operating room costs for each method of nailing beyond the initial nailing procedure was evaluated. When all secondary procedures were averaged for each method of nailing (cumulative procedural costs/number of fractures), the average cost of using the reamed-to-fit technique was approximately US $4,900/fracture less than with the nonreamed technique ($8,500 versus $3,600).

Discussion

Clinical and basic scientific studies have enabled surgeons to reduce rates of infection, improve rates of healing, and improve clinical outcomes for all open fractures [10]. Advances in wound debridement, antibiotic therapy, and tissue coverage have occurred concurrently [6, 7, 9, 21]. Supporters of the nonreamed technique hold to the concern that reaming increases the rate of infection due to bone devascularization. Klein demonstrated in a canine model that, on average, 31% of cortical blood supply was disrupted during nonreamed tibial nailing versus an average of 70% for reamed nailing. His study compared nonreamed nailing and the insertion of nails after reaming one-third of the inner cortex at the isthmus [17]. Conflicting data in sheep tibiae demonstrated decreased endosteal perfusion with reaming, but equal blood flow to the fracture callus and callus strength [25].

No model has yet reproduced the environment of the high-energy tibia fracture. There are many studies that document the severe disruption of endosteal circulation with reaming and subsequent bone necrosis [4, 16, 19, 25]. Klein et al. demonstrated a severe vascular insult with aggressive reaming in dog tibiae [17]; Melcher showed an increased rate of infection with reaming in rabbit tibia fractures[20, 21]. Further studies in closed sheep fractures demonstrated equal blood flow in fracture callous and equivalent callus strength and stiffness for reamed and nonreamed nailing [25]. In a model that simulated the periosteal stripping of an open fracture, others have shown an increase in perfusion when reaming is used [14]. Previous literature discouraged the use of large-caliber nails with reaming and encouraged the use of smaller caliber nails inserted without reaming due to a decreased risk of infection [11, 22]. In 1986, Chapman stated that reamed nailing of open tibia fractures was contraindicated because of the high incidence of sepsis [5].

The concept of minimal reaming is actually a reamed-to-fit method, wherein the reamer is used only to “sound” the medullary diameter of the tibia and to facilitate the path for nail insertion. By reaming only until true endosteal “chatter” is encountered, we minimize the possibility of thermal damage. A previous study found that it is the first pass of any reaming that is primarily responsible for the disruption of medullary blood supply [16]. We feel that in the absence of thermal injury (from aggressive reaming), there should be little difference between the passage of an 8 mm reamer versus an 8 mm nail. As such, the vascular effects of nonreamed nails and reamed-to-fit nails may be similar, and in the absence of aggressive reaming that may cause thermal damage, the mechanical advantages of a larger nail that fills the canal outweigh the theoretical disadvantages of endosteal reaming.

Recent studies demonstrate that minimally reamed nail insertion is comparable to nonreamed nail insertion, and it may in some ways be better [1, 15]. Keating demonstrated that for open fractures treated with minimally reamed intramedullary nailing, there was no difference in the incidence of infection, union occurred at the same rate, and the rate of nonunion was not significantly different [15]. Others have corroborated these findings, and some have found increased hardware complications and increased numbers of secondary procedures required with nonreamed nailing [1, 8]. To date, most surgeons have come to accept one-pass reaming as acceptable. The present study further elucidates some practical advantages to the method.

Open tibial fractures are historically notorious for their prolonged healing time and extensive fracture care required to achieve union. For this reason, we elected to discuss our healing rates in terms of months rather than weeks. The fact that several of our patients required 24–48 months to achieve union is a testament of the severity and difficulty in treating these complex fractures. This study has several weaknesses regarding methodology. First, it was not truly randomized. If surgeon-controlled grouping results in relatively similar groups as was present in this study, the weakness of nonrandomization is decreased. Another issue is that of antibiotic bead usage. Although there was no increase in the rate of infection with the ream-to-fit technique, we acknowledge that the use of beads may have biased the reamed group with regard to infection and if not used may have resulted in an increased rate of infection [13]. However, to equal that of nonreamed nails, the rate would have had to increase by 150%; we feel that this amount of impact would be unlikely. Also, the sample size was far too small to elucidate statistically significant differences in rates of infection. Because of our findings, the authors do not feel that the use of beads in the reamed group would invalidate the conclusions of the study. Additionally, recent studies using the ream-to-fit technique found no difference between reamed and nonreamed nailing with regard to healing and infection [8, 15].

This study identified that unreamed nailing results in the need for a significantly greater number of procedures to achieve healing. This finding also has implied social and economic effects. Considering that the incidence of tibia fractures is approximately 2/10,000 people, of which approximately 25% are open, the economic impact of such additional procedures in a large population can be substantial. The duration of time off work, psychological stresses, and personal financial burdens are implied although not reported in this study. The reason that only the surgical costs were reported was due to the overwhelming number of confounding parameters that influence other variables such as length of stay, total cost of treatment, and the above-noted social-economic variables. Nonetheless, the impact, however imprecise, cannot be ignored.

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