Influence of Nail Prominence and Insertion Point on Anterior Knee Pain After Tibial Intramedullary Nailing

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**abstract**

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Chronic anterior knee pain is the most common complication after tibial nail insertion. Its etiology remains unknown, and multifactorial sources have been suggested. The authors believe that nail prominence and the insertion point of the nail are important in the development of anterior knee pain. The purpose of this retrospective study was to evaluate the roles of the insertion point and nail prominence in anterior knee pain after tibial intramedullary nailing using a transtendinous approach and a common nail type. A total of 108 patients with tibial shaft fractures underwent reamed intramedullary nailing using a transtendinous approach between 2006 and 2009. Mean follow-up was 26.8±5.0 months. A visual analog scale (0-100) was used to estimate anterior knee pain severity while patients performed 7 activities retrospectively. Radiographic assessments, including nail prominence and insertion point, were performed. Sixty (55.6%) patients experienced knee pain (group P) and 48 (44.4%) did not (group N). Significant differences were not found between the groups with respect to demographics, nail diameters, or fracture classifications. Less superior and more anterior nail prominences in radiographic assessments were significantly associated with anterior knee pain. When the insertion point was over the bottom half of the anterior cortex, the influence of anterior nail prominence was more obvious. Nail removal resulted in diminished pain during the 7 assessed activities. Nail insertion should be over the bottom half of the anterior cortex, with minimal anterior nail prominence. If anterior knee pain occurs, removal of the nail should be considered.

**Figure:** Lateral radiograph illustrating superior nail prominence (the distance from the proximal tip of the nail to the tibial plateau) (A) and anterior nail prominence (the distance from the anterior tip of the nail to the anterior tibial cortex) (B).
Over the past few decades, intramedullary (IM) nailing for tibial shaft fractures has been demonstrated to produce excellent results.\(^1\) Chronic anterior knee pain following nail insertion is the most frequently noted complication,\(^4\) and its incidence has been reported to be up to 86%,\(^5,6\) This complication has been particularly influential in contributing to the functional outcome of this type of surgery.\(^7\)

In recent years, a growing number of studies have investigated the cause of anterior knee pain after tibial IM nailing. However, its etiology remains unknown, and multifactorial sources have been suggested, including surgical approach,\(^7,13\) nail prominence,\(^4,14,15\) thigh muscle strength,\(^16\) insertion point with any accompanying iatrogenic intra-articular injury,\(^17,18\) injury to the patellar tendon or Hoffa fat pad,\(^19,20\) injury to the proximal tibiofibular joint,\(^21,22\) and injury to the infrapatellar branch of the saphenous nerve.\(^23\) However, limited studies have addressed the potential causal relationship of nail prominence and have usually included different approaches and/or nails in a single study.\(^7,8,14,15\) Some authors failed to demonstrate an association between nail protrusion and anterior knee pain.\(^7,8\) However, other authors reported that nail prominence was associated with knee pain.\(^14,15\) These results show that the relationship between nail prominence and anterior knee pain is still inconclusive. Based on the current authors’ clinical observations and experience, they believe that nail prominence and the insertion point of the nail are important in the development of anterior knee pain. Therefore, the purpose of this retrospective study was to evaluate the incidence of anterior knee pain following IM nailing using a transtendinous approach and a common type of nail, as well as the roles of nail prominence and insertion point. In addition, the authors aimed to determine whether anterior knee pain would diminish after nail removal. The study design was approved by the appropriate ethics review boards.

**MATERIALS AND METHODS**

Between January 1, 2006, and December 31, 2009, a total of 158 consecutive adult patients sustaining tibial shaft fractures underwent reamed IM nailing at the authors’ institution. Patients who had knee pain that could be documented to have existed prior to the injury (n=3) and patients who were lost to follow-up (n=47) were excluded from the study. The final study group comprised 58 men and 50 women with a mean age of 35.0±16.4 years and a mean follow-up of 26.8±5.0 months.

The 108 patients underwent reamed IM nailing (M/DN tibial nail; Zimmer, Warsaw, Indiana) using a patellar tendon-splitting (transtendinous) approach. Each patient was placed supine on the operating table with the injured limb hanging down. A longitudinal incision was made along the midline of the patellar tendon extending from the inferior pole of the patella to the tuberosity. The patellar tendon was carefully bisected and retracted bilaterally. The stationary insertion point of the T-handled awl was defined according to the surgeon’s discretion. A bulb-tipped guidewire was inserted through the insertion hole and passed into the distal fragment under reduction. The tibial canal was reamed to be 1 mm larger than the nail’s diameter, and the nail was inserted with 2 proximal locking screws and 2 distal locking screws.

All medical records were reviewed to extract demographic data and surgical information, including sex, age, fracture classification, nail diameter, follow-up period, time to nail removal, and complications. A visual analog scale (VAS) was used to estimate the severity of the anterior knee pain experienced by the patients during 7 activities, including rest, walking, running, squatting, kneeling, and ascending and descending stairs. This scale, with a range of 0 to 100, was embedded in a questionnaire and used at the last outpatient clinic follow-up visit before nail removal and 1 year after nail removal. Patients were classified into group N (those not experiencing pain) or group P (those experiencing pain) based on whether they experienced pain during 1 or more of these activities.

Radiographic evaluations, including standard anteroposterior and lateral views, were performed at each follow-up. Union was defined as the development of a complete bridging bone and obliteration of the fracture gap. Superior and anterior nail prominence was measured in the lateral view using the methods reported by Keating et al\(^7\) and Song et al\(^14\) (Figure 1). In addition, the insertion point of the awl was theoretically defined as the intersection between the anterior tibial cortex and the bisection of the proximal nail. The distance between the upper ends of the anterior cortex to this insertion point was measured as the awl-plateau (AP) distance, and the distance between the lower ends to this insertion point was measured as the awl-tuberosity (AT) distance (Figure 2).

To avoid measuring variation caused by knee rotation during the lateral view, the lateral view was standardized so that the...
posterior femoral condyles were seen superimposed.

A chi-square test was used to compare the differences for each discrete variable, and Student’s t test was used for each continuous variable. SPSS version 17.0 statistical software (SPSS Inc, Chicago, Illinois) was used to conduct all statistical analyses. A P value less than .05 was considered significant.

RESULTS

Group N comprised 48 patients (26 men and 22 women; mean age, 33.1 years) who received nails with a mean diameter of 10.3 mm. The Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association (AO/OTA) fracture classification was 42A in 36 patients, 42B in 8, and 42C in 4. All 48 patients had eventual union. Mean follow-up was 26.5 months, and no complications developed in any patient.

Group P comprised 60 patients (32 men and 28 women; mean age, 36.5 years) who received nails with a mean diameter of 10.3 mm. The AO/OTA fracture classification was 42A in 36 patients, 42B in 18, and 42C in 6. These 60 patients also had eventual union. Mean follow-up was 27.0 months, and anterior knee pain was the only complication to develop in any patient. Significant differences were not observed in the demographics between the 2 groups (Table 1).

Radiographic assessments indicated that there was significantly less superior nail prominence and significantly more anterior nail prominence in the patients in group P (Table 2). However, a significant correlation was not found related to the AP or AT distances. Taking into account the relationship between the height of the insertion and the anterior nail prominence, the results showed that anterior nail prominence was significantly correlated to anterior knee pain if the insertion occurred over the bottom half of the anterior cortex. However, the top half did not demonstrate this relationship.

Kneeling resulted in the highest incidence (90%) and the most severe knee pain (60.7±22.4) among the 7 activities. A total of 50 patients with anterior knee pain underwent nail removal at a mean of 14.7 months. The severity of the anterior knee pain during the performance of these 7 activities improved significantly after nail removal.

DISCUSSION

Intramedullary nailing for tibial shaft fractures has yielded excellent results with respect to union rates and functional recovery.1-3 However, anterior knee pain is a common complication after IM nailing,4-11 reported occurring in up to 86% of patients, independent of the approach used.9 In the current retrospective study, 56% of patients reported anterior knee pain. Although the knee pain was mild to moderate, it can significantly affect quality of life8,14 and is negatively correlated with fracture union.24 Although the etiology of anterior knee pain remains unknown, it seems to be multifactorial.9,13-22 Keating et al7 and Court-Brown et al8 reported that younger patients tend to be more symptomatic than older patients,
likely as a result of being more active. A few studies reported that women also tend to be affected more often than men.\textsuperscript{13,15} Furthermore, unreamed procedures involving smaller-diameter nails are associated with a lower incidence of anterior knee pain, possibly because of less bone and soft tissue injury.\textsuperscript{22} However, the current study failed to demonstrate a relationship between the incidence of anterior knee pain and sex, age, nail diameter, or fracture classification.

The surgical approach used during IM nailing also contributes to anterior knee pain. The paratendinous approach does not divide the patellar tendon, avoids reamer-induced soft tissue injury, and should theoretically be associated with less incidence of anterior knee pain. Two studies reported that the transtendinous approach had higher rates of chronic anterior knee pain than the paratendinous approach\textsuperscript{6,7}; the authors recommended the routine use of a medial paratendinous approach. This approach has resulted in 50%,\textsuperscript{7} 51%,\textsuperscript{6} and 64%\textsuperscript{14} of patients experiencing knee pain. However, several authors have failed to find an association between the type of surgical approach and the presence of anterior knee pain.\textsuperscript{8,9,13} They commented that the use of the paratendinous approach should retract the patellar tendon during reaming and may cause trauma to the patellar tendon and anterior knee pain.\textsuperscript{8} In the current study, 56% of patients reported anterior knee pain with the transtendinous approach, an incidence similar to that reported with the medial paratendinous approach.

Nail prominence and improper insertion points have also been reported to be causative factors of anterior knee pain. Some authors considered that improper insertion points may induce iatrogenic intra-articular injury to the anterior horn of each meniscus, the lateral tibial plateau, and the transverse ligament.\textsuperscript{17} Use of the ideal insertion point may cause less iatrogenic damage to structures around the insertion site. However, nail prominence over the anterior cortex appears to irritate the overlying patellar tendon, resulting in anterior knee pain. Keating et al\textsuperscript{7} and Court-Brown et al\textsuperscript{8} failed to demonstrate an association between nail protrusion and anterior knee pain. However, Bhattacharyya et al,\textsuperscript{15} who used the same methods described by Keating et al,\textsuperscript{7} demonstrated such a relationship between nail protrusion and various postoperative activities. They reported that the nail-apex distance (defined as the sum of the superior prominence and anterior nail prominence) was associated with overall knee pain. Moreover, they demonstrated that a nail-apex distance of less than 2.5 cm reduced overall knee pain.\textsuperscript{15} Another study found that moderate to severe knee pain had a significant correlation with both superior nail prominence and nail-apex distance\textsuperscript{14}; however, no correlation was observed between knee pain and anterior nail prominence. The authors reported that only 2 patients had nails protruding beyond the anterior cortex, and this protrusion was less than 2 mm.\textsuperscript{14}

In the current study, group P had significantly lower superior and higher anterior nail prominences than group N. However, the distances from the insertion point over the anterior cortex to the plateau (AP distance) or to the tuberosity (AT distance) were not significantly related to knee pain. No significant difference in AP or AT distance may be because of their respective effects if too short. The lower superior prominence and the AP distance implied that the insertion point was near the anterior joint line, resulting in a high risk of iatrogenic damage to the meniscus, cartilage, fat pad, and transverse ligament. Although the AP distance was not significantly different between the groups, a trend toward a shorter distance was observed in group P. Anterior nail prominence was also significantly higher in group P, possibly irritating the overlying patellar tendon; however, some authors reported no such association.\textsuperscript{7,8} The difference may be that the nail’s position altered the influence of the anterior nail prominence. When the insertion point was over the bottom half of the anterior cortex (AP/AT>1), the difference was significant. In contrast, when the insertion point was over the top half (AP/AT<1), no significant difference was observed. The authors believe that, in addition to the anterior prominence, the site of prominence over the anterior cortex is a contributing factor for knee pain. If the nail is closer to

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**Table 2**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean±SD</th>
<th>Group N\textsuperscript{a}</th>
<th>Group P\textsuperscript{b}</th>
<th>P*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nail prominence, mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Superior</td>
<td>13.1±6.5</td>
<td>9.3±6.1</td>
<td>.032</td>
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<tr>
<td>Anterior</td>
<td>3.7±3.9</td>
<td>6.1±3.2</td>
<td>.015</td>
<td></td>
</tr>
<tr>
<td>Awl-plateau distance, mm</td>
<td>15.6±6.1</td>
<td>13.4±4.5</td>
<td>.143</td>
<td></td>
</tr>
<tr>
<td>Awl-tuberosity distance, mm</td>
<td>13.8±4.9</td>
<td>13.5±5.1</td>
<td>.858</td>
<td></td>
</tr>
<tr>
<td>Anterior nail prominence, mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AP/AT&lt;1</td>
<td>4.9±3.3 (n=28)</td>
<td>6.4±2.8 (n=32)</td>
<td>.195</td>
<td></td>
</tr>
<tr>
<td>AP/AT&gt;1</td>
<td>2.0±1.6 (n=20)</td>
<td>5.8±3.7 (n=28)</td>
<td>.005</td>
<td></td>
</tr>
</tbody>
</table>

*Abbreviations: AP, awl-plateau distance; AT, awl-tuberosity distance.

\textsuperscript{a}No anterior knee pain.

\textsuperscript{b}Anterior knee pain.

\textsuperscript{c}Independent-samples t test.
the junction of the patellar tendon and the tibial tuberosity, a smaller free space may easily induce patellar tendon irritation.

Keating et al. noted that 49 (80%) of 61 patients with knee pain required nail removal. At a mean of 16 months following nail removal, pain was completely relieved in 22 patients and partially relieved in 17. In the remaining 10 patients, no improvement was observed. Another study reported that 62 patients with knee pain had their nails removed; 17 (27.4%) experienced complete symptom resolution, 43 (69.3%) showed marked improvement, and only 2 (3.2%) reported worsening symptoms. They concluded that nail removal partially lessens anterior knee pain. In the current study, the severity of anterior knee pain was also significantly diminished after nail removal in 50 patients.

This study has several limitations. First, it was a retrospective study. Second, several surgeons performed the procedures, and each surgeon’s experience level may have influenced outcomes. Third, 50 patients were excluded because of previous knee pain and loss to follow-up, and this may have resulted in a slight bias. Additional randomized studies involving a larger number of patients may be required to confirm these results.

**Conclusion**

Anterior knee pain after tibial IM nailing using a transtendinous approach is not associated with sex, age, nail diameter, or fracture classification. This study concluded that improper positioning of nail insertion and nail prominence are important factors associated with anterior knee pain. Less superior and more anterior nail prominences are significantly associated with anterior knee pain, especially when the insertion point occurs over the bottom half of the anterior cortex; the influence of anterior nail prominence is more obvious. Nail insertion should occur over the bottom half of the anterior cortex to avoid less superior nail prominence and iatrogenic intra-articular damage, with the anterior nail prominence being reduced as much as possible. However, if anterior knee pain occurs, nail removal may diminish the pain.

**References**