Effects of morphological changes in the patellar tendon on the development of anterior knee pain after intramedullary nailing for tibial shaft fractures: A retrospective comparative study

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ABSTRACT

Objective: This study aimed to investigate the effects of morphological changes of the patellar tendon (length, width, and thickness) on the development of anterior knee pain (AKP) after intramedullary nailing (IMN) of tibial shaft fractures.

Methods: A total of 39 patients, treated by IMN using the transpatellar approach for tibial shaft fractures, were retrospectively reviewed and included in the study. The patients were then divided into 2 groups based on the presence of AKP: group A, patients who developed AKP (9 men, 9 women; mean age=35.39±9.32 years), and group B, patients without AKP (13 men, 8 women; mean age=41.38±14.78 years). To assess the morphological changes in the patellar tendon, magnetic resonance imaging was performed on the operated and unoperated, contralateral knees of the patients. The patellar tendon index (PTI) was calculated using the length, width, and thickness of the patellar tendon, and a set of variables was established to be a proportion of the measurements of the operated knees to those of the unoperated ones (operated/healthy PTI ratio). PTI ratios were compared between both the groups. Furthermore, the morphological features of the patellar tendon, including the length, width, and thickness, were examined within the groups as independent variables. To assess pain intensity in group A, a 10-cm visual analogue scale (VAS) was used. To evaluate functional status, the Lysholm knee scoring system was used.

Results: The PTI ratio was significantly higher in group A (1.37±0.12) than in group B (1.03±0.08) (p<0.001). In group A, the mean VAS score was 5.35±1.11, and a moderate linear correlation was found between PTI ratios and VAS scores (r=0.494, p=0.044). In group B, the width and thickness of the patellar tendon were found to be significantly different between the operated and unoperated knees (p=0.024 and p=0.002, respectively). In group B, there was no difference between the operated and unoperated knees in terms of the 3 measurements (length, width, and thickness) (p=0.762, p=0.753, and p=0.118, respectively).

Conclusion: Evidence from this study revealed that morphological changes occurring in the patellar tendon after IMN for tibial shaft fractures using a transpatellar approach may have a significant role in the development of AKP. The increase in the tendon width and thickness may be the cause of pain and insufficient knee function in such patients.

Level of Evidence: Level III, Therapeutic study

Introduction

Tibial shaft fractures are commonly treated surgically with intramedullary nailing (IMN) in adults (1). The mean incidence of anterior knee pain (AKP), which is the most common complication of IMN, has been reported as 47.4%, ranging from 10% to 86% (1-6). In etiology, the transpatellar approach is blamed for pain rather than the parapatellar approach (7, 8). However, the etiology of AKP in tibial IMN is considered to be multifactorial (3).

During tibial IMN, dissection of the patellar tendon causes changes in this area. In a recent study, Erinc et al. compared the patellar tendon thickness and width of the surgical side with those of the healthy side using ultrasonography (9). They found an increase in thickness and width on the surgical side, but no significant difference was found between patients with AKP and those with no pain. Changes in the sagittal plane of the patellar tendon after tibial IMN were evaluated in another study using magnetic resonance imaging (MRI). In that study, the decrease in patellofemoral joint kinematics in the sagittal plane was attributed to volume loss in the quadriceps tendon and atrophy in the gracilis muscle (10).

No study exists in the literature examining the patellar tendon changes using MRI in AKP observed after IMN in tibial shaft fractures, comparing it with the healthy side. This study aimed to demonstrate the changes in the width, depth, and length of the patellar tendon after tibial IMN with the transpatellar approach using MRI and to compare the measurements of these changes between patients with and without knee pain. The hypothesis of the study was that improvements in these variables would be better in patients without knee pain.

Materials and Methods

Patients who were treated with rigid IMN for tibial shaft fractures via the transpatellar approach in our clinic of orthopaedics and traumatology, Silopi State Hospital, Şırnak, Turkey, were retrospectively reviewed and included in the study. The patients were then divided into 2 groups based on the presence of AKP: group A, patients who developed AKP (9 men, 9 women; mean age=35.39±9.32 years), and group B, patients without AKP (13 men, 8 women; mean age=41.38±14.78 years). To assess the morphological changes in the patellar tendon, magnetic resonance imaging (MRI) was performed on the operated and unoperated, contralateral knees of the patients. The patellar tendon index (PTI) was calculated using the length, width, and thickness of the patellar tendon, and a set of variables was established to be a proportion of the measurements of the operated knees to those of the unoperated ones (operated/healthy PTI ratio). PTI ratios were compared between both the groups. Furthermore, the morphological features of the patellar tendon, including the length, width, and thickness, were examined within the groups as independent variables. To assess pain intensity in group A, a 10-cm visual analogue scale (VAS) was used. To evaluate functional status, the Lysholm knee scoring system was used.
Examples of the patellar tendon length, width, and thickness were measured by the senior author and a surgical resident. The Lysholm knee scoring system was used for functional evaluation of the knees. Pain assessment in group A was performed using a 10-cm visual analogue scale (VAS). They were asked to evaluate the pain that they felt on a range of 0 (no pain) to 10 (maximum) (11). The Lysholm score was planned, scoring assessments were performed in the presence of a specialist orthopedist. The subsequent treatment process for AKP complaints of the patients in group A was conducted by the algology department.

MRI was performed using a GE Sigma 1.5 T MRI Scanner (GE Healthcare, Milwaukee, WI, USA) with the patient in the supine position, with both legs in the same position, using a body coil but no contrast agent. The sagittal and axial sections were taken for both sides. A parameter developed by the study team, named the patellar tendon index (PTI), was obtained from these sections. To calculate this index, the length, width, and thickness measurements of the patellar tendon were taken from the relevant sections of the MRI images. The length of the patellar tendon was taken from the mid-sagittal section on the T1 sequence, and the width and thickness were obtained from the same level, also on the T1 sequence, from the axial section (Figure 1). As a result of multiplying the measured values with each other, the PTI used in the study was obtained as a relative patellar tendon volume parameter. These values, which were calculated separately for the operated and healthy sides of each patient, were compared as the operated/healthy PTI ratio. In addition, the length, width, and thickness parameters that made up the PTI were examined within the groups as independent variables. Measurements were performed by 2 specialist orthopedists and 1 radiologist, who were blinded to the study. The values obtained by taking the average of 3 measurements made by the authors individually were used in the study.

Statistical analysis
IBM Statistical Package for the Social Sciences Statistics for Windows 21.0 (IBM SPSS Corp., Armonk, NY, USA) was used for data analysis. Data were summarized with mean, standard deviation, median, and minimum-maximum values. To check whether the data were normally distributed, the Kolmogorov-Smirnov test was used.

All surgical procedures were performed by a team including the senior author, who was certified by the AO Foundation (Arbeitsgemeinschaft für Osteosynthesefrage), and 2 surgical residents. No tourniquet was applied to any of the patients. A 3- to 5-cm incision was made in the middle of the patellar tendon using the transpatellar approach because of isolated tibial shaft fractures, 39 patients (22 men, 17 women; mean age: 36.6±12.7 years) who met the inclusion criteria with completed fracture healing and who were followed up for at least 1 year were included in this cross-sectional study.

MRI was performed bilaterally in patients who were invited for outpatient clinic control after a follow-up period of over 1 year. Those who were experiencing pain on or around the patellofemoral joint without macroscopic (keloids or hypertrophic scars, cysts, or cyst-like lesions, skin lesions like a plaque psoriasis, and so on) changes for at least 3 months were assigned to group A (those with pain). Those without these complaints were assigned to group B (no pain). Pain assessment in group A was performed using a 10-cm visual analogue scale (VAS). They were asked to evaluate the pain that they felt on a range of 0 (no pain) to 10 (maximum) (11). The Lysholm knee scoring system was used for functional evaluation of the knees. During the outpatient clinic follow-up in which MRI examination was planned, scoring assessments were performed in the presence of the senior author and a surgical resident. The Lysholm knee scoring system includes 8 separate sections and evaluates the presence and severity of pain as well as the functional status of the knee during daily activities. It does not cover sports and recreational activities. The maximum score of the scale is 100 (12). In group B, VAS score was assumed to be 0 because patients in this group had no pain complaints. In-group assessment was performed only in group A in terms of pain score. The statistical analysis was performed using the Kolmogorov-Smirnov test.

HIGHLIGHTS
- In patients treated with intramedullary nailing (IMN), anterior knee pain (AKP) is an important problem affecting the quality of life.
- The cause of the AKP is controversial.
- This study demonstrated that there was a direct association between the changes occurring in the patellar tendon and AKP when the transpatellar approach was used in IMN.

Figure 1. a-d. Examples of the patellar tendon length, width, and thickness measurements obtained from the mid-sagittal and axial sections on the T1 sequences of the magnetic resonance imaging scans
When the parametric assumptions were not met, the Mann-Whitney U test was used for comparing the 2 independent groups in terms of a numerical variable. The normality of the PTI and VAS scores was tested with the Shapiro-Wilk test. As the VAS scores did not show normal distribution, the relationship between the 2 variables was evaluated using the Spearman correlation analysis. p<0.05 was considered statistically significant.

Results

A total of 39 patients (22 men, 17 women), treated with rigid IMN after tibial shaft fractures, were followed up for an average of 31.95±2.6 (14-48) months in our clinic. In all patients, the fracture was healed in 17.2±2.6 (14-26) weeks without additional treatment. After surgical treatment, no restriction/joint stiffness requiring rehabilitation occurred in any of the patients. The incidence of AKP was 46.15%.

Group A included 18 patients (9 men, 9 women) with AKP, and group B included 21 patients (13 men, 8 women) with no AKP. There was no statistically significant difference between the 2 groups in terms of age, sex, time to union, or follow-up duration (Table 1).

The mean VAS score was 5.35±1.11 (4-7) in group A. It was observed that with an increasing operated/healthy PTI ratio, the VAS score increased. A moderate linear correlation was found between the operated/healthy PTI ratio (r=0.494, p=0.044) (Figure 2). There was also a significant difference between the groups in terms of the Lysholm score (p<0.001). The average Lysholm score of group A was found to be 80.17±3.05, which was lower than that of group B (89.76±3.05).

Discussion

This was the first study in the current literature evaluating AKP developed after rigid IMN treatment via a transpatellar approach for tibial shaft fractures in which pain was evaluated along with MRI scans of both operated and healthy knees. The parameter that was developed and named PTI enabled intergroup and intragroup comparisons to be performed objectively. There were no differences between the 2 groups in terms of age, sex, or follow-up duration. The most striking result was that changes in the tendon in the transpatel-
lar approach significantly affected the pain and functional scores. In the transpatellar IMN applications, avoiding interventions that damage the tendon and encouraging soft-tissue-preserving approaches can prevent AKP.

Tibial IMN is the most commonly used method for tibial shaft fractures; however, it is also the treatment modality in which AKP is the most common complication (7, 13). The differences in the reported incidences of AKP after tibial IMN arise from the differences in the definition of pain. Obremsky et al. reported that 11% of patients had severe pain in the 1-year follow-up period after IMN treatment for tibial shaft fractures, and 48% patients reported pain at least once (14). A group using the tibial IMN application with the suprapatellar approach published their early results. In their study, it has been reported that no AKP was found in 97.2% of the patients in the 1-year follow-up in a total of 37 patients (15). In studies comparing the transpatellar and parapatellar approaches in knee flexion and suprapatellar and lateral parapatellar approaches in semi-extension, no difference was found in terms of patient feedback scores or AKP (16, 17).

The incidence of knee pain found in this study was 46.15%, which was consistent with that in the literature (9). Prospective studies that can evaluate knee pain more reliably and objectively and compare surgical techniques are warranted.

Changes in the patellar tendon size are one of the issues on which researchers have focused. In a study in which patellar tendon size was evaluated with ultrasound after IMN, the transpatellar and parapatellar approaches were compared in 36 patients. In the transpatellar group, it was reported that tendon thickness was high, which was not associated with AKP (18). Türkmen et al. have examined the Insall-Salvati and Caton-Deschamps indices and showed that there was shortening in the patellar tendon when compared with the healthy side in patients with tibial shaft fractures treated with IMN (19). However, contrary to expectations, its relationship with AKP was not established. Kızilkaya et al. have found that patellar tendon thickness was higher in patients with patellofemoral pain syndrome than in the healthy group (20). Our study found that the width and thickness of the patellar tendon in group A were significantly different on the operated side than those of the healthy side. However, there was no significant difference in the patellar tendon length between the operated and healthy knees of either patient group (Table 2).

In this study, the Lysholm score was used to evaluate knee functions and VAS was used to evaluate AKP. A moderate linear correlation was found between the PTI and VAS (r=0.494, p=0.044). As the operated/healthy PTI ratio increased, the VAS score increased and the Lysholm score decreased. The average VAS score for AKP was found to be moderate (5.35±1.11). These findings supported the hypothesis that patellar tendon changes may be associated with AKP. However, as Jankovic et al. stated, there exists no method in the literature that has been successful in describing AKP and functional changes and understanding them with objective data (21). In this study, significant differences in the Lysholm score were observed between the groups with and without AKP.

In tibial IMN applications, the entry site has been one of the most discussed issues in the etiology of AKP. In 2 retrospective studies, a direct relationship between the transpatellar approach and AKP was suggested (7, 8). Väisälä et al. have compared the transpatellar and parapatellar approaches and opined that there was no difference in terms of AKP, and most patients recovered after a while (18). However, another study stated that the correlation between fracture healing and the time elapsed after surgery was not applicable for the pain score (22). In our study, we attributed the etiology of the pain to the structural changes that occurred in the more affected patellar tendon in the transpatellar approach.

The main limitation of this study was the relatively small number of retrospective patients. Another limitation could be evaluating only the patellar tendon changes in AKP, for which more than 1 etiology is blamed, among patients operated using the transpatellar approach. However, in both the groups, healthy knees constituted an important control parameter. Evaluating pain scores cross-sectionally only during MRI evaluation and using a single functional score may be considered as other limiting parameters. The lack of measurable parameters in the literature to assess the damage caused by reaming on the patellar tendon is an important limitation of such studies.

In conclusion, although IMN is the gold standard for treating tibial shaft fractures, AKP is one of its complications that can be difficult to manage. In this study, we demonstrated that the changes occurring in the patellar tendons of the patients who underwent IMN via a transpatellar approach after tibial shaft fractures were significantly associated with AKP. Increases in the width and thickness, although not detected in the length, of the patellar tendon could be the cause of pain and insufficient knee function in such patients.

Ethics Committee Approval: Ethics committee approval was received for this study from the Ethics Committee of Ankara Bilkent City Hospital (SE1-20-245).

Informed Consent: Written informed consent was obtained from all patients included in the study.

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