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Ultrasonographic comparison of bilateral patellar tendon dimensions in patients treated via intramedullary tibial nailing using a transpatellar approach

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ABSTRACT

Objective: One of the most common complications following intramedullary nailing of a tibial shaft fracture is anterior knee pain. The etiology of pain remains unclear. Patellar tendon entry point is the most suspected reason for anterior knee pain. This study, sonographically examined the patellar tendons of patients treated via intramedullary nailing.

Methods: Thirty-two patients with a tibial shaft fracture requiring intramedullary nailing via a transpatellar approach were included in the study. After all patients were grouped by reference to the presence of anterior knee pain, bilateral patellar tendon ultrasonography was performed.

Results: Thirty-two patients were included in the study. Patients were measured postop average in 38.3 months (10th months - 84th months). It was determined that 10 patients of total 32 (31.3%) had anterior knee pain. There were no statistically differences between study groups in the length of patellar tendon. In the painless group; patellar tendon was wider and thicker in the operated side than the non operated side. The mean differences in the thickness between operated side versus non − operated side of the painless group were 5.3 ± 1.8 in the operated side and 3.9 ± 1.4 in the non − operated side ($p = 0.007 < 0.05$). The corresponding values for width of the patellar tendon was 29.6 ± 3.3 in the operated side and 27.6 ± 3.8 in the non − operated side ($p = 0.007 \text{ ‹ } 0.05$). As a result, there were no statistically significant differences between width and thickness of the patellar tendons in the painful group, on the contrary, in the painless group; patellar tendons were wider and thicker in the operated side than those in the non - operated side. Mean values for thickness of the operated and non-operated side were 5.9 ± 2.3 and 4.2 ± 2.0, respectively ($p = 0.059 > 0.05$). Mean values for width of the operated and non-operated side were 30.2 ± 4.5 and 28.5 ± 4.0, respectively ($p = 0.103 > 0,05$).

Conclusion: Based on the ultrasonographic investigation of their patellar tendons after intramedullary nailing of a tibial shaft fracture, in the painless patients group; the patellar tendon was wider and thicker in the operated side than the non − operated side, however, in the painful patients there were no statistically significant differences between this parameters. Although the number of patients was not sufficient to conclude precise relation between patellar tendon entry point and anterior knee pain, we determined that thicker and wider tendon might be less related to anterior knee pain.

Level of evidence: Level IV, therapeutic study.

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Introduction

Currently, reamed or unreamed intramedullary nailing is commonly used to manage tibial diaphyseal fractures.[1–3] The most frequent complication after tibia nailing is anterior knee pain, which is exacerbated by kneeling, squating and climbing. Anterior knee pain may be attributable to the patellar tendon entry point chosen, necrosis of the retropatellar fat pad, destruction of joint cartilage, patellar tendinitis, and/or damage to the meniscus.[4–7] However, no clear cause of this common complication is yet evident.

The most frequently suspected cause of anterior knee pain is the location of patellar tendon entry point. Both transpatellar and parapatellar approaches were investigated to find cause of anterior knee pain. But association between the patellar tendon entry point and anterior knee pain is still unclear. While some authors supposed that splitting the pataller tendon might be cause of anterior knee pain, others assumed that no relationship was found between the pain score and use of the transtendinous or parapatellar approach.[4,8]

Ultrasound have been used to figure out healing and structural changes of patellar tendon after intramedullary nailing in small number of studies. The authors reported even if some changes occurred on tendon dimensions, such as thickening of tendon, the changes were not attributable to chronic anterior knee pain following tibia nailing.[7,9]

The purpose of this study was to determine if there are any sonographic changes in the patellar tendon dimensions following intramedullary nailing of tibia, and if so, to find out whether this change would be responsible for chronic anterior knee pain.

Materials and methods

All patients who underwent intramedullary nailing to treat tibial diaphyseal fractures in our clinic between 2009 and 2015 were invited to visit our polyclinic for baseline examinations. Of the 40 patients who volunteered to participate in the study, one was excluded because of undergoing bilateral operations to treat tibial diaphyseal fractures; two were excluded because they had undergone operations to treat same-side tibial plateau fracture; one was excluded because of undergoing an operation to treat a tibial plateau fracture on the other side; one was excluded because retrograde nailing had been employed to treat a femoral distal diaphyseal fracture on the other side; and three were excluded because of histories of operations to treat prior meniscopathy. The remaining 32 patients, whose fractures had healed uneventfully, who had returned to daily activities, and who did not have any intra-articular disease on the same or the other side, were selected to participate in our study. All volunteers gave written informed consent after the study had been approved by the ethics board of our hospital.

All patients were grouped by reference to the presence of anterior knee pain. Bilateral patellar tendon ultrasonography was performed by a radiologist working in our radiology clinic. Each patient was placed in the supine position with the both hip and knee joints at 45° of flexion. Patellar tendon length was measured from the lower pole to the tibial tuberosity (Figs. 1,2). In addition, tendon thickness and width were recorded (Fig. 3), as was the extent of the hypoechoic area at the tendon entry point (Fig. 4).

Prior to ultrasonography, the anterior knee pain level scores (derived using a visual analog scale [VAS]) during resting, walking, running, crouching, kneeling, going up and down stairs, and sitting for a long period were recorded in all patients with anterior knee pain.

Operative technique

Various surgeons performed tibial intramedullary nailing using the transtendinous approach. No pneumatic tourniquet was applied. The knee was allowed to hang down from the operation table (and was thus at 90° of flexion). A skin incision ca. 5 cm in length was created on the midline of the patellar tendon, running from the knee joint to the tibial tuberosity, to expose the entire depth of the patellar tendon.

The entry point was the midpoint between the lateral tibial eminence and the intersection of the anterior tibial cortex and the tibial plateau. Patellar tendon protectors were placed during reaming. At the end of surgery, the patella was closed with continuous, #1 polyglycan absorbable sutures. An elastic bandage was applied. On day 1 postoperatively, all patients were asked to engage in isometric exercises strengthening the quadriceps muscle. Exercises improving the ranges of motion of the ankle and knee joints were also introduced. All patients were mobilized on crutches on the same day, with toe-touch weight-bearing, and progressed to full weight-bearing by about week 4.

We present means with standard deviations, medians, minima, maxima, frequencies, and rates. The distributions of all variables were analyzed with the aid of the Kolmogorov–Smirnov test. The Mann–Whitney U-test was used to compare quantitative data and the chi-squared test to compare qualitative data. Wilcoxon's test was employed to analyze repeated measurements. SPSS software version 22.0 was used for all analyses.

Results

Of the 32 patients, 12 were female and 20 male, with mean age of 33 (20–59) years. One patient underwent initial external fixation; the final nailing operation was performed on day 34 of hospitalization. This was because the patient had a Gustillo-Anderson type 3B open tibial diaphyseal fracture. The time elapsed since surgery averaged 38.3 months (10–84 months) (Table 1).

Tendon length did not differ between the operated and non-operated knees ($p = 0.440$). The tendon width of operated knees was significantly greater than that of non-operated knees ($p = 0.028$). The tendon thickness of operated knees was significantly greater than that of non-operated knees ($p = 0.0014$) (Table 2).

Tendon length did not differ significantly between the operated and non-operated knees in patients without pain ($p = 1.0$). Tendon length did not differ significantly between the operated and non-operated knees in patients with pain ($p = 0.380$). Tendon width on the operated side was significantly greater than that on the non-operated side in patients without pain ($p = 0.009$), but did not differ significantly between the operated and non-operated knees in

Table 1
Demographic data and classification of the fractures.

		Min–Max	Median	Mean ± s.d./ n-%
Age		20–59,0	33,0	37,1 ± 10,9
Gender	Female			12 37,50%
	Male			20 62,50%
Postop. Time (Mth)		10–84.0	34,5	38,3 ± 20,8
Pain	No			22 68,70%
	Yes			10 31,30%
AO Classification of Fractures	Type A			20 62,50%
	Type B			7 21,90%
	Type C			5 15,60%
Gustillo - Anderson Classification of Fractures	Type 1			25 78,10%
	Type 2			4 12,50%
	Type 3-A			2 6,25%
	Type 3-B			1 3,10%

Table 2
Mean patellar tendon sizes in all patients.

	Operated Side			Non - Operated Side			
	Mean ± s.d.		Med (Min-Max)	Mean ± s.d.		Med (Min-Max)	P
Length	37,2 ± 6,9	35,0	24,2–55,0	28,9 ± 57,7	34,9	28,9–57,7	0.440
Width	29,8 ± 3,7	29,6	21,7–35,4	27,9 ± 3,8	27,5	21,4–37,2	0.028
Thickness	5,5 ± 2,0	5,3	2,6–10,3	4,0 ± 1,6	3,5	2,6–57,7	0.0014

[m]Mann-whitney u test/[w]Wilcoxon test.

patients with pain (p = 0.103). Tendon thickness on the operated side was significantly greater than that on the non-operated side in patients without pain (p = 0.007), but did not differ significantly between the operated and non-operated sides in patients with pain (p = 0.059). The areas of hypoechoic lesions did not differ significantly between operated and non-operated knees (p > 0.05) (Table 3).

Patients with and without pain were similar in terms of all of age, gender, and affected side (right/left) (all p > 0.05) (Table 4).

Patients with anterior knee pain exhibited the highest pain scores when crouching and climbing stairs, and the lowest scores when at rest and walking (Table 5).

Discussion

The tibia is one of the long bones most often subjected to trauma. Tibial diaphyseal fractures require cautious treatment in patients of all ages. Young, active patients require the time to return to active life to be minimized, and that no permanent disability or an inability to return to work should eventuate. The elderly fear the development of dependence.[10] Several studies have reported union, nonunion, and malunion rates after intramedullary nailing; it is accepted that the technique affords satisfactory results.[8,11–13]

Incidence of anterior knee pain after tibia nailing varies widely in the literature. Court-Brown et al reported anterior knee pain incidences of 40.8% and 56.2% in two separate studies.[1,14] Vaisto et al evaluated patients 3 and 8 years postoperatively. The year-3 pain rate was 75% but that at 8 years was only 29%.[15] Alho et al found that the incidence of anterior knee pain after nailing was 14%.[16]

The entry point of patellar tendon is mostly accused for source of anterior knee pain. Orfaly et al found that the incidence of anterior knee pain was 51% in 107 patients treated via the parapatellar approach, but 78% in those treated via the transtendinous approach. They suggested that an incision splitting the patellar tendon might be associated with the development of anterior knee pain.[8] Keating et al recorded insertion of an intramedullary nail through the parapateallar approach resulted in 50% incidence of anterior knee pain, whereas nailing through the transtendinous approach resulted in 77% incidence, they concluded that the transtendinous approach could not be recommended.[17] Court-Brown et al evaluated the data of 11 retrospective and 9 prospective studies. The incidence of anterior knee pain was 47.4% but no relationship was found between the pain score and use of the transtendinous or parapatellar approach.[4]

Vaisto et al used ultrasonography to compare patellar tendon sizes in 36 patients assigned to transtendinous or parapatellar surgical groups. The frequency of anterior knee pain was 50% in both groups. Tendon thickness was greater on sides treated via the transtendinous approach compared with non-operated sides, but the cited authors concluded that the difference was not associated with the development of anterior knee pain.[7] Sale employed a routine transpatellar approach to treat 33 patients, of whom 19 reported anterior knee pain (57.6%). As in the work of Vaisto et al, patellar tendon thickness increased postoperatively but this was thought not to be associated with the development of anterior knee pain.[9]

Table 3
Comparison of the patients according to presence of anterior knee pain.

	Painful Group			Painless Group			p
	Mean ± s.d.		Med (Min-Max)	Mean ± s.d.		Med (Min-Max)	
Length							
Operated Side	36,1 ± 5,9	34,5	27,2–47,0	39,5 ± 8,7	41,4	24,2–55,0	0,238
Non - op. Side	36,3 ± 5,6	34,4	29,6–46,7	40,4 ± 8,5	39,9	28,9–35,4	0,489
p w		1,000			0,308		
Width							
Operated Side	29,6 ± 3,3	29,4	22,0–34,8	30,2 ± 4,5	31,0	21,7–35,4	0,489
Non - op. Side	27,6 ± 3,8	28,1	21,4–37,2	28,5 ± 4,0	26,5	24,6–34,0	0,699
p w		***0,009***			0,103		
Thickness							
Operated Side	5,3 ± 1,8	5,0	2,6–8,9	5,9 ± 2,3	6,0	3,4–10,3	0,625
Non - op. Side	3,9 ± 1,4	3,5	2,6–9,6	4,2 ± 2,0	3,6	2,6–9,4	0,854
p w		***0,007***			0,059		
Hypoechoic lesion	1,4 ± 0,4	1,4	0,6–2,6	1,7 ± 0,5	1,7	1,0–2,5	0,135

[m]Mann-whitney u test/[w]Wilcoxon test.

Table 5
VAS scores of the patients with anterior knee pain.

	Min-Mak	Medyan	Ort. ± s.s./n-%
VAS	16,0–45,0	31,0	30,4 ± 8,6
Rest	0,0–2,0	1,0	0,8 ± 0,8
Walking	1,0–4,0	2,0	2,2 ± 1,0
Running	2,0–7,0	4,0	4,2 ± 1,4
Squatting	3,0–8,0	5,0	5,4 ± 1,4
Kneeling	2,0–7,0	4,5	4,6 ± 1,5
Stairs Down	3,0–7,0	4,5	4,7 ± 1,2
Stairs up	2,0–7,0	5,0	4,9 ± 1,4
After Long Term Sitting	2,0–5,0	3,0	3,2 ± 1,0

Table 4
The distribution of the patients according to pain.

		Painless group			Painful group			p
		Ort. ± s.s./n-%		Med (Min-Mak)	Ort. ± s.s./n-%		Med (Min-Mak)	
Age		35,2 ± 9,5		32,5 (20,0–53,0)	41,4 ± 13,1		37,5 (5-59,0)	0,207
Gender	Female	6	27,3%		6	60,0%		0,076
	Male	16	72,7%		4	40,0%		
Side	Right	13	59,1%		6	60,0%		0,961
	Left	9	40,9%		4	40,0%		
VAS					30,4 ± 8,6		31,0 (6–45,0)	

Mann-whitney u test / Ki-kare test.

Fig. 1. Measurement of the length on the healthy side.

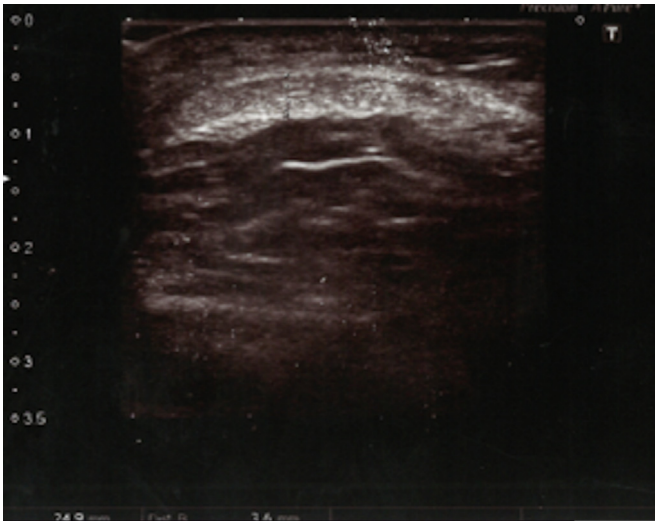

Fig. 3. Measurement of the width and thickness on the operated side.

Adriani et al used ultrasonography to evaluate patellar tendon after its mid - third was removed for anterior cruciate reconstruction in two groups of patients whom tendon donor site was repaired side to side or left open. They found that sutured tendons are wider than non - sutured tendon after 1 year postoperatively, due to hypertrophy of healing tissue. They also observed a low intensity area, which was filled with fibrous tissue, between the two separate cords in the non - sutured group. But, clinically, statistical significance was not observed.[18] Karjalainen et al used ultrasonography to follow up achilles tendon healing. They found negative outcomes in patients whom revealed large, irregular hypoechoic areas within the tendon. They concluded that smaller hypoechoic areas were also evident in patients experiencing favorable outcomes.[19]

In our study, the incidence of anterior knee pain was 31.3% in patients who underwent intramedullary nailing via a transtendinous approach. Anterior knee pain was most severe when kneeling and climbing stair and they experienced least pain when resting or walking. The patellar tendon length was similar between the both painless and painful patient groups. In addition, in the painful patients; the patellar tendon width and thickness were similar between operated and non-operated sides, on the contrary, in the painless patient group; both the width and the thickness were significantly greater in the operated side than the non – operated side. The extent of the hypoechoic area did not differ significantly in patients with and without pain. Although the pain free group had wider and thicker tendon, this change did not explain alone the source of the chronic anterior knee pain. We consider that inadequate healing tissue may conduce to occurrence of chronic anterior knee pain after tibia nailing. Thus, lack of compensatory tendon hypertrophy may lead to anterior knee pain in the patients who treated via intramedullary nailing using a transpatellar approach. Nevertheless, due to insufficient number of patients any certain conclusion was not achieved.

It is evident from the literature that anterior knee pain source is multifactorial. Devitt et al measured the contact forces applied to the patellofemoral joint during two different surgical approaches (transpatellar and parapatellar). They concluded that use of transpatellar entry could trigger widespread chondral damage by increasing stress forces on the articular surface of the patella,

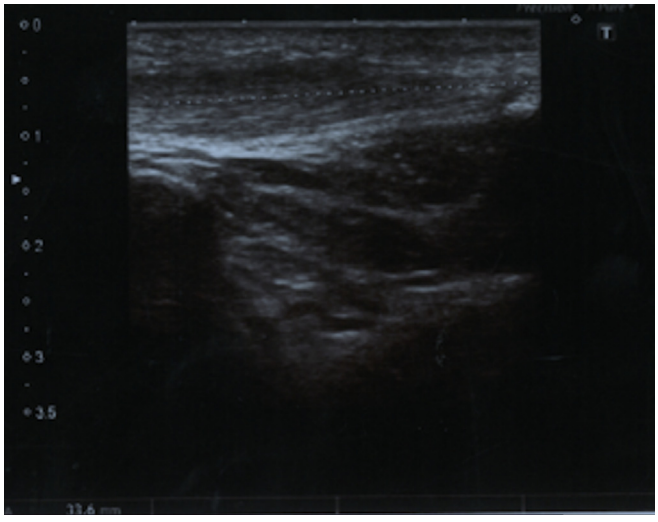

Fig. 2. Measurement of the length on the operated side.

Fig. 4. Measurement of the hypoechoic area on the operated side.

causing later anterior knee pain.[20] Injury to structures surrounding the tibia during preparation of an entry site for intramedullary nailing has also been considered as a possible cause of anterior knee pain. Based on this hypothesis, safe entry point on the bone surface were determined by some authors.[21,22] Bhattacharrya et al reported that the risk of intra-articular damage was higher in patients with narrow tibial plateaus, which are usually females.[5] However, we found no difference between males and females in terms of anterior knee pain.

Conclusion

The source of anterior knee pain after intramedullary nailing of tibia shaft fractures is still controversial. Patellar tendon was thicker and wider in the painless patients than the painful patients. Even though this alterations could not be correlated with anterior knee pain directly, occurring compensatory hypertrophy in the patellar tendon might be less related to anterior knee pain. Accordingly, a future randomized control trial involving a large number of patients could provide more insight into the relationship between chronic anterior knee pain and intramedullary nailing of tibia. Figs. 1–4.

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