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Pain in Anterior Knee after Locked Nailing of Diaphyseal Tibia Fractures

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Abstract

The purpose of the study was to assess the quality of life of the patients with pain in the anterior knee after locked nailing of the diaphyseal tibia fractures, and also to assess the effect of the position of the proximal end of the nail in the tibial metaphysis and the type of tibial fracture on the pain development. ***Material and Methods.*** The study included 70 patients with consolidated diaphyseal tibia fractures undergone closed blocked nailing through the patellofemoral ligament. The results of the surgery were studied in the time frame of 2 to 4 years (average 36.96±12.05 months). Patients were divided into groups according to the presence or absence of pain in the anterior knee, the type of tibial fractures, the location of the nail in the proximal tibia metaphysis. The evaluation of the outcomes was carried out with the SF-36 questionnaire and the knee X-ray. The significance of differences in the samples was determined by the Pearson's and Student's criteria, and Fisher's exact criterion. ***Results.*** The incidence of pain in the anterior knee was 46%. This complication led to a decrease in the patients' quality of life to a greater extent and in most parameters than in the patient without pain, namely, physical components of health by 10% (p = 0.024), physical activity by 8.8% (p = 0.024), role-based functioning due to physical condition by 14.1% (p = 0.001). The intergroup analysis revealed that the extension of the end of the nail beyond the proximal tibial metaphysis was one of the factors that determeded the development the pain (p<0.05). There were differences in the frequency of pain in groups with different depths of immersion of the nail into the proximal metaphysis (p<0.05). The closer to the tibial plateau the proximal end of the nail was located, the more often the pain occurred in the postoperative period. In the patients with type C diaphyseal fractures, pain in the knee was much more common than in patients with type A and B fractures (p<0.05). ***Conclusion.*** The quality of life of the patients with pain in the anterior knee after locked nailing was characterized by a decrease in physical activity and role functioning in society. The main cause of the pain was the projection of the nail beyond the bone borders of the tibial metaphysis or the location of its proximal end in the subchondral area. The type of diaphyseal tibia fracture according to the AO / ASIF classification was a factor that determined the incidence of pain in the anterior knee.

Keywords: knee pain, tibial fractures, intramedullary nailing, osteosynthesis complications.

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Introduction

Intramedullary osteosynthesis is considered to be the "gold standard" for the treatment of diaphyseal tibia fractures. Although, it have been published a large number of research described adverse outcomes of this method. One of the most common complications associated with intramedullary osteosynthesis of the tibia is the pain in the anterior knee [1, 2, 3, 4]. This complication is an important obstacle to everyday activities and sports. The etiology of the pain remains unclear, but there are suggestions of its multifactorial origin [5, 6, 7, 8]. The development of the pain in the knee after tibia nailing may be influenced by more than 20 factors. In the opinion of many authors, the main causes of the pain may be the protrusion of the proximal end of the nail, the size of the tibial plateau, the level of physical activity, and the patients' age [6, 9, 10, 11]. The treatment of this complication is difficult since the removal of the nail causes only a slight improvement or no improvement at all [12, 13, 14].

The purpose of the study was to assess the quality of life of the patients with pain in the anterior knee after locked nailing of the diaphyseal tibia fractures, and also to assess the effect of the position of the proximal end of the nail in the tibial metaphysis and the type of tibial fracture on the pain development.

Material and Methods

The results of the treatment of 70 patients with consolidated diaphyseal tibia fractures after closed locked nailing of the tibia without the medullary canal reaming. The nail was placed through the patellar ligament. The patients' age was 43.10±1.78 years. The men were predominated — 44 (63.0%), women were 26 (37%). The follow-up time was 36.96±12.05 months. At the time of the examination, the nail was removed in two patients. According to the AO/ASIF classification, there were 42 diaphyseal tibia fractures type A, 20 — type B, and 8 — type C. The information concerning the pain in the anterior knee was obtained by questioning. The respondents answered the question: "Do you feel pain in the anterior knee of the operated limb?" The following answers concerning the pain quality were suggested: permanent, at rest, intermittent, at any load, under certain loads, no pain. On the basis of the data obtained, two groups of patients were formed: 34 with pain in the anterior knee and 36 without pain.

The quality of life of the respondents was evaluated using the SF-36 questionnaire [15]. The questionnaire was filled in person. All respondents were informed about the aims of the study and the further use of its results. The results were presented as scores. A higher score indicated a better quality of life. The indicators of each scale varied from 0 to 100 points, where 100 signified the complete health.

Statistical analysis

Statistical processing of the data was carried out using the Microsoft Excel package and the Statistica 6.1 program. Data with the normal distribution (after the Kolmogorov-Smirnov's test and assessing the variances equality using the Levene's test) were presented as mean (M) with standard deviation and evaluated using the Student's t-test. The percentages were compared with non-parametric methods, namely the Pearson's and Fisher's exact criteria. Correction for multiple comparisons was not carried out. The critical value of significance level for the null statistical hypothesis was taken equal to 0.05.

Results

Of the 70 patients participated in the study, 32 (46%) complained the pain in the anterior knee under certain loads. They experienced mild or moderate pain when trying to squat, kneel on an operated knee, running, walking at a distance of more than a kilometer. The constant pain required the nail removal was observed in 2 (3%) of the patients.

The average age of patients with pain in the knee was 36.9±2.09 years, without pain — 41.6±1.91 years (p = 0.102). The group with pain consisted of 22 men and 12 women, the group without pain — of 22 men and 14 women (p = 0.756). The intergroup differences by sex and age were not statistically significant (p>0.05), i.e., he groups were comparable by gender and age. The assessment of the respondents quality of life was carried out using the SF-36 questionnaire. In patients with pain in the anterior knee, the lowest value was found on the "Emotional role functioning" (64.8±19.66), the highest value was found on the "Social role functioning" (92.7±13.75) and "General health perception" scales (88.9±17.72). A similar picture of the scales indicators was observed in the group without pain in the knee. Hence, there were no significant differences in the two groups according to the mentioned scales (p>0.05). The SF-36 questionnaire, that is, the subjective assessment of both mental and physical health, revealed statistically significant differences in the physical health indicators in the groups. The statistically significant differences were found for the following indicators: "Physical components of health" — 10% (p = 0.024), "Physical functioning" — 8.8% (p = 0.024), "Bodily pain" — 13.8% (p = 0.007), and "Physical role functioning" — 14.1% (p = 0.001). All of them reflected the degree to which the health condition limited the performance of everyday physical activities (self-care, walking, climbing stairs, carrying heavy loads, etc.). In the group with pain in the knee, the indicator on the scale "Emotional role functioning" was 12.5% lower than in individuals without pain (p = 0.036). On the other scales, which characterized the mental health, no statistically significant differences were found — p>0.05 (Table 1).

Thus, in the patients with pain in the anterior knee, the indicators of long-term quality of life were reduced to a greater extent and by a greater number of parameters than in individuals without pain.

To assess the position of the proximal end of the nail in the tibial metaphysis, all patients underwent knee X-ray in a lateral projection from a distance of 120 cm. These X-rays were marked with two horizontal lines. The first line went along the contour of the tibial plateau, the second — divided

Table 1

Quality of life indicators for the patients according to the SF-36 questionnaire

Indicator	Scores		*p*
	Group with pain (n = 34)	Group without pain (n = 36)	
Physical functioning	73.60±14.38	82.40±17.40	0.024
Physical role functioning	68.30±18.75	82.40±15.15	0.001
Bodily pain	67.30±22.16	81.10±19.51	0.007
General health perception	88.90±17.72	90.00±19.11	0.803
Social role functioning	92.70±13.75	94.70±12.46	0.527
Emotional role functioning	64.80±19.66	74.10±16.55	0.036
Mental health	86.90±17.91	85.60±15.51	0.747
Vitality	70.50±22.11	74.90±16.27	0.349
Physical components of health	47.60±9.94	52.60±7.98	0.024
Mental component of health	49.10± 13.05	52.80± 8.01	0.160

The p-value was calculated using the Student's criterion.

the distance between the first line and the tibial tuberosity into two equal parts. Thus, three zones were formed from top to bottom: zone 1, zone 2, zone 3 (Fig. 1).

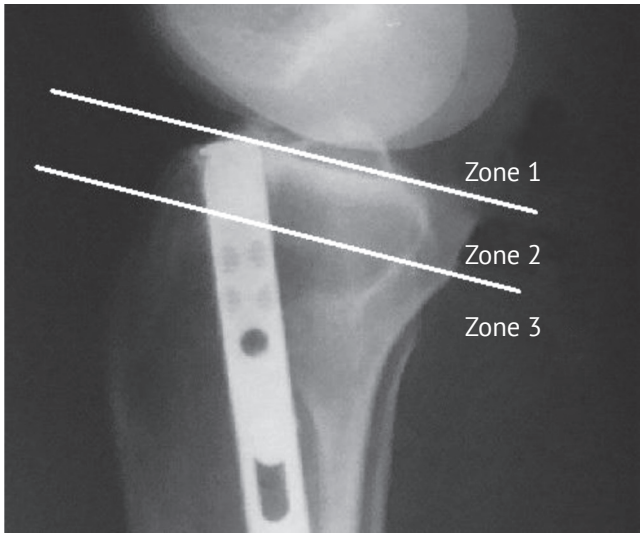

Fig. 1. X-ray of the knee in lateral projection with three areas marked by lines

The intergroup analysis of the incidence of pain development, depending on the position of the proximal end of the nail in different zones of the knee, indicated the presence of statistically significant differences in the compared samples for a number of parameters (Table 2).

It was established that the pain in the anterior knee was more common in the position of the proximal end of the nail in zone 1 and zone 2 than in zone 3. There were no differences in the frequency of pain development when the proximal end of the nail was located above the tibial plateau (zone 1) or in the subchondral region (zone 2).

Thus, the more proximal the nail was located in the area of the knee joint, the more often the pain in the anterior knee occurred. The lowest pain incidence was determined at the position of the proximal end of the nail in zone 3, the highest — in zones 1 and 2.

The degree of the forward nail protrusion beyond the border of the tibial metaphysis was determined by the X-ray as the length of the segment (X) in millimeters perpendicular to the drawn line along the front surface of the proximal tibial metaphysis to the apex of the outer part of the proximal end of the fixator (Fig. 2).

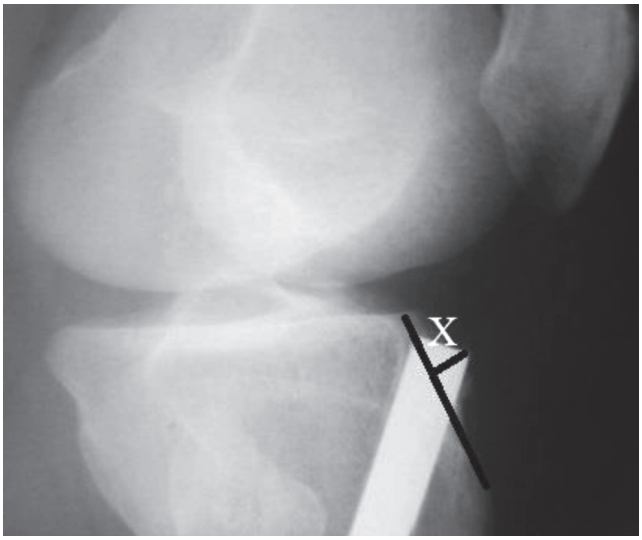

Fig 2. The degree (X mm) of the forward protrusion of the nail beyond the tibia proximal metaphysis

Table 2

Distribution of the patients by the position of the proximal end of the nail in various areas of the knee

Patients' group	Nail position			*p*
	Zone 1 [1]	Zone 2 [2]	Zone 3 [3]	
With pain	4	20	10	$p^{1-2} = 0.145$ $p^{1-3} = 0.019$ $p^{*2-3} = 0.043$
Without pain	0	15	21	

The *p*-value was calculated using the Fisher's exact test.
The *p**-value was calculated using the Pearson's test.

Based on the measurements, the patients were divided into 2 groups. In the first group, the nail protruded forward beyond the boundaries of the metaphysis. Two subgroups were distinguished in the first group, depending on the size of the nail protrusion, the subgroup with protrusion more than 5 mm and the subgroup with protrusion from 0 to 5 mm. In the second subgroup, the end of the nail did not protrude beyond the boundaries of the metaphysis, i.e., the end of the nail was inside the metaphysis.

The intergroup analysis revealed that the pain in the anterior knee developed 2 times more often when the end of the nail protruded forward beyond the boundaries of the proximal tibia metaphysis than in case of its location inside the metaphysis. The degree of the forward nail protrusion did not have a statistically significant effect on the pain incidence (Table 3).

The analysis of the nail end position at different levels of the metaphysis and beyond its boundaries in the group of patients with pain in the knee revealed that only in 11 (32.0%) patients the nail protruded beyond the boundaries of the tibia metaphysis. In the remaining 23 (68.0%) of the patients the nail was completely immersed in the metaphysis (Table 4).

Most often in the study group, the pain was detected when the nail end was located in the subchondral region (zone 2) — 15 patients (45.0%). The lowest number of patients with pain were determined when the nail was located in zone 3–8 patients (23.0%). Concerning the influence of a type of the diaphyseal tibia fracture on the development of the knee pain, it was found a significantly higher pain incidence in the patients with type C fractures (90% of patients) compared with types of fractures A and B (40% of patients). The difference between the groups with type A and B fractures was not statistically significant (Table 5).

Table 3

The degree of the forward protrusion of the nail beyond the tibia proximal metaphysis in various patient groups

Group	Degree of the nail protrusion, mm			*p*
	Protruded beyond the metaphysis [3]		Immersed in the methaphysis [4]	
	>5 mm [1]	from 0 tp 5 mm [2]	<0 мм	
With pain	6	5	23	$p^{1-2} = 0.604$ $p^{3-4} = 0,042$
Without pain	3	1	32	

The p-value was calculated using the Fisher's exact test.

Table 4

Distribution of the patients with pain in the knee by the position of the proximal end of the nail relative to the tibial metaphysis

Zone of the nail position	Degree of the nail protrusion, mm			Total
	>5 mm	0–5 mm	<0 mm	
Zone 1	3	1	0	4
Zone 2	2	3	15	20
Zone 3	1	1	8	10
Total	6	5	23	34

Table 5

The number of patients with various types of the diaphyseal tibia fractures in the groups with and without pain

Group	Type of fracture according to the AO/ASIF classification			*p*
	A[1]	B[2]	C[3]	
With pain	17	8	7	$P^{1-2} = 0.972$ $P^{1-3} = 0.021$ $P^{2-3} = 0.038$
Without pain	25	12	1	

The *p*-value was calculated using the Fisher's exact test.

Discussion

The pain in the anterior knee is a frequent complication after the locked nailing of diaphyseal tibia fractures, differing from 9 to 86% in various studies, and the exact cause of the pain is unclear [16, 17, 18]. Many factors, such as damage to the articular surfaces and menisci, the location of the insertion point of the nail, trauma to the infrapatellar branches of the saphenous nerve, weakness of the thigh muscles, a small plateau of the tibia, and the presence of the nail in the bone marrow canal can contribute to pain [19, 20, 21, 22, 23]. We did not find any works of the domestic authors on the study of this problem.

Soraganvi et al. found that the closer the point of the nail insertion to the articular surface of the proximal tibia, the greater the risk of damage to the intraarticular structures. The degree of protrusion of the nail end correlated with the pain in the anterior knee [18]. A number of authors found that the pain in the anterior knee was associated with the nail placing anterior to the tibial metaphysis and the nail location at different levels of the metaphysis in height [9, 16, 24, 26]. However, the absolute values of the protrusion were not presented. Tahririan et al. concluded that the protrusion of the proximal end of the nail anteriorly more than 5 mm and the proximity of the tibial articular surface were associated with the pain in the anterior knee. They recommend the employment of an extra-articular insertion point, immersion the tip of the nail and avoidance the proximity of the tip of the nail to the tibial plateau [13]. Some authors believed that the subchondral location of the nail insertion point increased the incidence of the pain [26, 27].

We found that the distance of the proximal end of the nail above the tibial plateau to zone 1 ($p = 0.019$) and its location in the subchondral region in zone 2 ($p = 0.043$) were more often associated with the development of the pain than the position in zone 3. The immersion depth of the proximal end of the nail in the metaphysis significantly affected the pain incidence: the closer the end to the plateau, the higher incidence of pain in the postoperative period ($p = 0.043$). This can be seen from the results of the study: in more than a half of the patients with pain, the end of the nail was located in zone 2, while only in a quarter of them the end protruded beyond the bony borders of the metaphysis. The pain in the anterior knee was most often detected in the patients with the position of the proximal end of the nail in zone 2. The safest was the position of the nail end in zone 3.

The protrusion of the proximal end of the nail anterior to the front surface of the tibial metaphysis was also a significant factor of the pain development ($p = 0.042$). The degree of the nail protrusion anteriorly was not statistically significant in the likelihood of pain development ($p = 0.604$). Thus, the closer the nail to the tibial plateau and the anterior surface of tibial metaphysis, the higher the pain incidence. Our results were completely consistent with the literature data including large series of observations [9, 16, 25].

Given the results of our study, in order to reduce the pain incidence, it is necessary to form a channel in the metaphysis, when placing the nail, as close as possible to the tibial tuberosity, immerse the proximal end beneath the anterior cortical metaphysis, thus positioning the end of the nail in zone 3.

Court-Brown et al. reported a statistically significant difference between the incidence of the knee pain in the young and active patients and in the elderly after nailing [3]. A number of authors indicated a more frequent development of this complication in women [1, 20]. The authors paid much attention to the choice of access to the insertion point of the nail through or near the patellar ligament [20, 22, 28, 29, 30]. Rai et al. in a randomized controlled trial found that the pain in the anterior knee was not associated with the mentioned accesses. Both accesses were equally safe, and their choice depended on the surgeons' preferences [20]. In our study, the nail protruded beyond the borders of the tibial metaphysis only in 32% of patients with the pain. In other cases, the other factors were the cause of this complication. We found that the type of diaphyseal tibia fracture was one of the factors affecting the development of pain in the anterior knee. In patients with comminuted type C fractures, according to the AO/ASIF classification, pain in the anterior knee was statistically significantly more often than in patients with type A and B fractures ($p = 0.021$; $p = 0.038$). 90% of the patients with type C fractures noted the pain in the knee in the postoperative period and only 40% of the patients with type A and B fractures. It should be noted that the nail, according to the results of an X-ray examination, in the patients with type C fractures in no case did not protrude beyond the bone borders of the proximal tibia metaphysis. The causes for the development of the pain in comminuted fractures of type C may be the less stability of the nail fixation in the medullary canal and the large amplitude of nail displacement (mobility) in the tibial metaphysis. In the available literature, we could not find any studies on the relationship of pain in the anterior knee after nailing and the type of diaphyseal fracture. In this regard, we consider as a promising direction the study of a specific mechanism of the pain development, especially with type C fractures. The treatment of the knee pain after nailing is a difficult task. Most authors report that the nail removal did not lead to the pain relief, and in some cases even led to pain increase [9, 19, 28]. Removal of the nail was effective in the cases in which it leaned against the patella or its ligament [28]. Evaluation of the health status and the knee functioning after the nailing is an important point to understand the importance of research of the pain syndrome. According to a number of studies, the patients with pain in the knee joint had limitations in daily and recreational activities, and decreased range of motion in the knee [9, 12, 16]. The current study showed that in subjects with the knee pain, according to four scales of the SF-36 questionnaire characterized the physical component of health, the quality of life indicators were reduced following more than two years after the injury. The role-based functioning due to the physical condition involves the assessment of a degree to which the declined physical condition interferes with the performance of work or other daily activities (time consuming, amount of work reducing, quality of work lowering, etc.) [15]. Low rates on this scale indicate a limitation in the patients' daily activities ($p<0.001$). The patients with the pain had significant limitations performing all types of physical activity, and experienced moderate pain.

Conclusion

Thus, the quality of life of the patients with diaphyseal tibia fractures after blocked nailing was largely determined by the development of pain in the anterior knee in the postoperative period. This pain significantly limited the patients' performance of everyday physical activity and did not allow them to return to the same lifestyle. This calls on us to continue searching a solution to this problem.

The protrusion of the proximal end of the nail outside the bone borders of the tibial metaphysis significantly increased the incidence of pain in the anterior knee.

The anterior knee pain was most often associated with the position of the proximal end of the nail over the tibial plateau (zone 1) and in the subchondral region (zone 2). The smallest number of the pain syndrome developed in the position of the nail end in zone 3.

In the blocked nailing, the type of diaphyseal tibia fracture, according to the AO/ASIF classification, was a factor determined the incidence of the anterior knee pain. In the fractures of type C, this incidence of the pain was 2 times higher than in the fractures of type A and B.

Publication ethics

Patients gave voluntary informed consent to participate in the research study

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