

LOCALIZATION OF THE TIBIAL ENTRY POINT

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ABSTRACT

Objective: To assess the intramedullary nail entry point in the proximal region of the tibia, through a questionnaire. *Methods:* 230 participants undergoing treatment for tibial fractures were interviewed. The questionnaire was created with three sections that could be answered in a "Yes" or "No" format and a fourth section that had two figures representing anteroposterior (AP) and lateral view x-rays that could be answered in an "A", "B" or "C" format. *Results:* The most frequent reason was "ease of access" (67.8%), followed by "better nail insertion access" (60.9%) and, in third place, "to prevent knee pain" (27.4%). The reasons for choosing the access so as to "prevent knee pain" and "avoid tendinitis" had a significant relationship with points "A" and "C" of the schematic AP x-ray figure, especially "C" (medial tibial crest). There were no significant differences between the types of access to the patellar ligament in the schematic AP and lateral x-ray figures between age groups. *Conclusion:* The greater the age was, the larger the proportion choosing the question "to avoid valgus deformity" was. The reasons from a medical (practical) perspective related to the type of access in the transpatellar ligament, while the reasons from a patient (functional) perspective related to medial parapatellar access. Transpatellar access was chosen by most of the participants (66.5%).

Keywords – Fracture fixation, intramedullary; Tibial fractures; Patellar ligament

INTRODUCTION

Fractures of the tibial diaphysis remain the commonest injury treated by orthopedic surgeons. Intramedullary nails have become the treatment of choice both for unstable closed fractures and for low-energy exposed fractures^(1,2). A variety of entry points in the proximal region of the tibia have been described, but the ideal location remains a topic of discussion^(1,3-6). Several surgical accesses can be used to obtain the entry point, including medial and lateral parapatellar access and transpatellar incision^(1,4,7). According to the literature, authors have reported complications such as pain in the anterior region of the knee, ligament instability, necrosis of the retropatellar fat, cartilage and

meniscus lesions, reflex sympathetic dystrophy, gait abnormality and tenosynovitis as possible cause of the surgical procedure⁽⁷⁻¹⁴⁾. However, sometimes the pain is not relieved by removing the nail, and the transpatellar incision has been partially implicated as the cause of these complications^(7-10,12). The aim of the present study was to investigate the intramedullary nail entry point in the proximal region of the tibia, by means of a questionnaire answered at the Brazilian Congress of Orthopedics and Traumatology.

METHODS

During the 40th Brazilian Congress of Orthopedics and Traumatology, which took place in Rio Grande do

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Sul in 2008, 230 participants who treat tibial fractures were interviewed to obtain information. The questionnaire was formulated with three sections that could be answered in a “yes” or “no” format and a fourth section containing two figures representing anteroposterior (AP) and lateral view radiographs that could be answered in an “A”, “B” or “C” format. The participants were divided into three categories according to age group (25-35, 36-45 and > 45 years), in order to find out whether the surgeon’s experience would influence the results.

The orthopedists were asked whether they treated fractures of the tibial diaphysis using an intramedullary nail. If so, they were asked whether they used one or more accesses. In relation to the patellar ligament, they were asked whether they used a medial, lateral or transpatellar access. They were also asked what the reason was for their selection of access to the patellar ligament (see annexed questionnaire)

Participation was voluntary and the responses were confidential. The results were calculated and subjected to statistical analysis.

General profile of the sample

The aim was to describe the profile of the 230 participants in accordance with the questionnaire for evaluating the entry point for the intramedullary nail in the tibia. Table 1 furnishes the frequency (n) and percentage (%) of the responses to the questionnaire, for the whole sample.

STATISTICAL ANALYSIS

The statistical tests applied were the chi-square (χ^2) or Fisher exact test, to compare proportions between data of categorical nature. The results were presented in tables and expressed by means of frequencies (n) and percentages (%). The criterion used for determining the significance was the level of 5%. The statistical analysis was processed using the statistical software of the SAS® System, version 6.04.

RESULTS

Among the reasons for choosing the surgical access, it was seen that the most frequent reason was “ease of access” (67.8%), followed by “better access for nail insertion” (60.9%) and, in third place, “to prevent knee pain” (27.4%). Figure 1 illustrates the distribution of the reasons for selecting the access in the patellar ligament.

Table 1 – Description of the questionnaire for 230 respondent participants

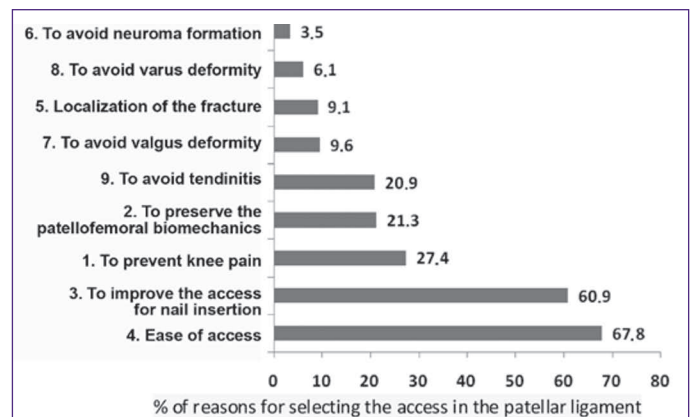
Variable	Category	n	%
Age group ^a	25 to 35 years	95	42.0
	36 to 45 years	71	31.5
	> 45 years	60	26.5
Access for nail emplacement	Single access	201	87.4
	Several types	29	12.6
Patellar ligament	Medial	64	27.8
	Transpatellar	153	66.5
	Lateral	13	5.7
Reason for selecting the ligament access	1. To prevent knee pain	63	27.4
	2. To preserve the patellofemoral biomechanics	49	21.3
	3. To improve the access for nail insertion	140	60.9
	4. Ease of access	156	67.8
	5. Localization of the fracture	21	9.1
	6. To avoid neuroma formation	8	3.5
	7. To avoid valgus deformity	22	9.6
	8. To avoid varus deformity	14	6.1
	9. To avoid tendinitis	48	20.9
Radiographic reference – 1 ^b	A	32	14.4
	B	149	66.8
	C	42	18.8
Radiographic reference – 2 ^b	A	61	27.4
	B	120	53.8
	C	42	18.8
Comments	Yes	13	5.7
	No	217	94.3

^a No information in relation to four patients.

^b No information in relation to seven patients.

Source: Orthopedics and Traumatology Service, Hospital Santa Teresa, Petrópolis, RJ.

From the responses of the 230 participants, it was investigated whether there were any significant differences



Source: Orthopedics and Traumatology Service, Hospital Santa Teresa, Petrópolis, RJ.

Figure 1 – Percentages of the reasons for choosing the access in the patellar ligament

rences in the proportions of reasons for access choice between the age groups, and what types of access were used in relation to the patellar ligament and the reference locations on the schematic radiographs.

Tables 2, 3, 4 and 5 show the frequencies (n) and percentages (%) of the reasons for choosing the access

Table 2 – Statistical analysis on the reasons for choosing the access, according to age group

Age group	25 to 35 years		36 to 45 years		> 45 years		p
	n	%	n	%	n	%	
Reason for selecting the access							
1. To prevent knee pain	28	29.5	15	21.1	20	33.3	0.27
2. To preserve the patellofemoral biomechanics	18	19.0	12	16.9	18	30.0	0.14
3. To improve the access for nail insertion	60	63.2	46	64.8	32	53.3	0.35
4. Ease of access	66	69.5	51	71.8	37	61.7	0.43
5. Localization of the fracture	8	8.4	5	7.0	8	13.3	0.43
6. To avoid neuroma formation	2	2.1	1	1.4	4	6.7	fc
7. To avoid valgus deformity	3	3.2	8	11.3	11	18.3	0.007
8. To avoid varus deformity	4	4.2	4	5.6	6	10.0	fc
9. To avoid tendinitis	19	20.0	13	18.3	16	26.7	0.47

fc: Few cases.
Source: Orthopedics and Traumatology Service, Hospital Santa Teresa. Petrópolis, RJ.

Table 3 – Statistical analysis on the reasons for selecting the access to the patellar ligament

Patellar ligament	Medial		Transpatellar		Lateral		P*
	n	%	n	%	n	%	
Reason for selecting the access							
1. To prevent knee pain	38	59.4	16	10.5	9	69.2	< 0.0001
2. To preserve the patellofemoral biomechanics	27	42.2	14	9.2	8	61.5	< 0.0001
3. To improve the access for nail insertion	23	35.9	112	73.2	5	38.5	< 0.0001
4. Ease of access	29	45.3	122	79.7	5	38.5	< 0.0001
5. Localization of the fracture	4	6.3	16	10.5	1	7.7	0.32
6. To avoid neuroma formation	2	3.1	5	3.3	1	7.7	fc
7. To avoid valgus deformity	5	7.8	16	10.5	1	7.7	0.54
8. To avoid varus deformity	3	4.7	10	6.5	1	7.7	fc
9. To avoid tendinitis	33	51.6	5	3.3	10	76.9	< 0.0001

fc: Few cases.
* Comparison between medial and transpatellar.
Source: Orthopedics and Traumatology Service, Hospital Santa Teresa. Petrópolis, RJ.

Table 4 – Statistical analysis on the reasons for selecting the access, according to the radiographic reference location – schematic figure of the AP radiograph

Radiographic reference 1	Point A		Point B		Point C		p
	n	%	N	%	n	%	
Reason for selecting the access							
1. To prevent knee pain	10	31.3	31	20.8	20	47.6	0.002
2. To preserve the patellofemoral biomechanics	9	28.1	27	18.1	12	28.6	0.21
3. To improve the access for nail insertion	16	50.0	96	64.4	23	54.8	0.22
4. Ease of access	19	59.4	108	72.5	25	59.5	0.14
5. Localization of the fracture	2	6.3	15	10.1	4	9.5	0.88
6. To avoid neuroma formation	2	6.3	4	2.7	2	4.8	fc
7. To avoid valgus deformity	2	6.3	14	9.4	6	14.3	0.55
8. To avoid varus deformity	2	6.3	10	6.7	2	4.8	fc
9. To avoid tendinitis	11	34.4	19	12.8	16	38.1	< 0.0001

fc: Few cases.
Source: Orthopedics and Traumatology Service, Hospital Santa Teresa. Petrópolis, RJ.

Table 5 – Statistical analysis on the reasons for selecting the access, according to the radiographic reference location – schematic figure of the lateral radiograph

Radiographic reference 2	Point A		Point B		Point C		p
	n	%	n	%	n	%	
Reason for selecting the access							
1. To prevent knee pain	15	24.6	33	27.5	13	31.0	0.77
2. To preserve the patellofemoral biomechanics	11	18.0	26	21.7	11	26.2	0.61
3. To improve the access for nail insertion	34	55.7	73	60.8	28	66.7	0.53
4. Ease of access	40	65.6	84	70.0	28	66.7	0.81
5. Localization of the fracture	5	8.2	12	10.0	4	9.5	0.92
6. To avoid neuroma formation	1	1.6	4	3.3	3	7.1	fc
7. To avoid valgus deformity	2	3.3	9	7.5	11	26.2	< 0.0001
8. To avoid varus deformity	1	1.6	5	4.2	8	19.1	fc
9. To avoid tendinitis	14	23.0	23	19.2	9	21.4	0.82

fc: Few cases.
Source: Orthopedics and Traumatology Service, Hospital Santa Teresa. Petrópolis, RJ.

route according to the age group (25-35, 36-45 and > 45 years), types of access in relation to the patellar ligament (medial, transpatellar and lateral) and radiographic reference locations, in accordance with Figures A, B and C

Table 6 – Statistical analysis on the type of access in relation to the patellar ligament and radiographic reference, according to age group

Variable	Category	25 to 35 years		36 to 45 years		> 45 years		P
		n	%	n	%	n	%	
Patellar ligament	Medial	26	27.4	20	28.2	17	28.3	0.78
	Transpatellar	62	65.3	49	69.0	39	65.0	
	Lateral	7	7.4	2	2.8	4	6.7	
Radiographic reference Figure 1	Point A	15	15.8	6	9.0	10	17.5	0.33
	Point B	65	68.4	49	73.1	33	57.9	
	Point C	15	15.8	12	17.9	14	24.6	
Radiographic reference Figure 2	Point A	26	27.4	19	28.4	15	26.3	0.65
	Point B	55	57.9	35	52.2	28	49.1	
	Point C	14	14.7	13	19.4	14	24.6	

Source: Orthopedics and Traumatology Service, Hospital Santa Teresa, Petrópolis, RJ.

of the annexed questionnaire, respectively, along with the corresponding descriptive level in the statistical test (p). The statistical analysis was performed using the χ^2 or Fisher exact test.

It was not possible to analyze the reasons “to avoid neuroma formation” and “to avoid varus deformities” because of the low frequencies observed.

It was seen that there was a statistical difference between the age groups only in relation to the reason “to avoid valgus deformity” ($p = 0.007$), i.e. the older the age group was, the higher the proportion of the participants choosing this reason was. There were no significant differences in the proportions of the other reasons, at the 5% level.

For analysis purposes, access to the lateral ligament was not taken into consideration because of the low frequency observed ($n = 13$). It was seen that reasons from a medical (practical) perspective, such as “better access for nail insertion” and “ease of access”, were significantly related to transpatellar access. On the other hand, reasons from a patient (functional) perspective, such as “to prevent knee pain”, “to preserve the biomechanics” and “to avoid tendinitis” were significantly correlated with the medial parapatellar access.

It was found that there was a significant relationship between the reasons for access choice, such as “to prevent knee pain” ($p = 0.002$) and “to avoid tendinitis” ($p < 0.0001$), and the points A and C on the schematic figure of the AP radiograph, particularly the point C (medial

tibial crest). No significant differences in the proportions of the other reasons were found between the locations of the schematic figure of the AP radiograph, at the 5% level. Although without significance, reasons for the access from a medical perspective predominated, such as “better access for insertion” and “ease of access”, at the radiographic reference location point B.

It was seen that there was a significant relationship only between the reason “to avoid valgus deformity” ($p < 0.0001$) and the radiographic reference location point C on the schematic figure of the lateral radiograph. There were no significant differences in the proportions of the other reasons between the radiographic reference locations, at the 5% level.

Table 6 furnishes the frequencies (n) and percentages (%) of the type of access, in relation to the patellar ligament (medial, transpatellar and lateral) and the radiographic reference location (Figures A, B and C) of the questionnaire, according to the age group (25-35, 36-45 and > 45 years), and the corresponding descriptive level of the statistical test (p). The statistical analysis was performed using the χ^2 test.

It was observed that there was a significant difference between the reference location on the schematic figure of the AP radiograph ($p < 0.0001$) and the type of access in relation to the patellar ligament, i.e. the lateral access predominated at point A, the transpatellar access at point B and the medial at points C and B, in this order. It was noted that there were no significant differences in the types of access in relation to the patellar ligament ($p = 0.78$), in the schematic figures of the AP radiograph ($p = 0.33$) and lateral radiograph ($p = 0.65$), between the age groups, at the 5% level.

DISCUSSION

Intramedullary nails are the treatment of choice for unstable closed fractures of the tibial diaphysis and for exposed low-energy fractures^(2,15). Success in emplacing the tibial nail depends on the location and on the insertion angle⁽¹⁶⁾. The ideal entry point for tibial nails has been the subject of much discussion. Freeman and Johnson⁽¹⁶⁾ demonstrated that the angle between the longitudinal axis of the nail and the proximal fragment is more important than the insertion point, for maintaining the bone alignment after nail treatment for a proximal fracture of the tibia. However, an inappropriate entry point may lead to deviation of the nail against the proximal cortex. Alms⁽³⁾ recommended using a lateral entry

point above the anterosuperior extrasynovial surface. Chapman⁽¹⁷⁾ determined an entry point above the anterior tuberosity of the tibia, via a transpatellar route. Tornetta *et al*⁽⁶⁾ described an anatomical safety zone for emplacement of a nail, in an area of approximately 22.9 mm. That study indicated that lesions of the lateral or medial meniscus might be responsible for the pain in the knee. McConnell *et al*⁽⁵⁾ demonstrated that the ideal entry point would be medial to the lateral tibial spine in AP view and immediately adjacent to the anterior margin of the joint surface in lateral view.

In the present study, the surgeon's experience was analyzed according to the reasons for selecting the access, in relation to three age groups (25-35, 36-45 and > 45 years). In all of the age groups, achieving "the best access for nail insertion" and "ease of access" were major concerns. However, it was observed that there was greater concern in relation to valgus deformity, i.e. the older the age group was, the higher the proportion choosing this reason was. Lang *et al*⁽¹⁸⁾ observed that defective consolidation with valgus in tibial fractures was caused by a medial entry point and a nail insertion angle directed laterally in the proximal fragment.

For the point of entry in the tibia to be accessed, the incision can be lateral or medial parapatellar or transpatellar. Several authors have reported high incidence of knee pain with the transpatellar access, after insertion of the intramedullary nail, and have suggested that a paratendinous access would help to diminish this symptom^(7,8,10,11,13,19,20). Our results demonstrate that, independent of the age group, most participants used the transpatellar access and that only 27.4% expressed concern regarding knee pain. However, among the participants who chose the medial parapatellar access, 59.4% expressed concern about preventing knee pain. Within the general context, it was seen that the reasons for choosing the access were divided into two perspectives. In the first of these, which we have called medical (practical), reasons like "better access for nail insertion" (60.9%) and "ease of access" (67.8%) were selected and were correlated with the transpatellar type of access. In the second, called the patient (functional) perspective, concern regarding the final result was expressed through choosing reasons like "to prevent knee pain" (27.4%), "to preserve the patellofemoral biomechanics" (21.3%) and "to avoid tendinitis" (20.9%). These reasons were correlated with use of the medial parapatellar access. Althausen *et al*⁽²¹⁾ reserved transpatellar access for tibias

with an ideal entry point located in the central position and behind the patellar tendon, in proximal fractures of the tibia, thus leaving parapatellar access for other fracture patterns. They also recommended using nails with low curvature (Herzog curve), in order to achieve the best alignment possible.

McConnell *et al*⁽⁵⁾ demonstrated that the ideal entry point was medial to the lateral tibial spine in AP view and immediately adjacent to the anterior margin of the joint surface in lateral view. Samuelson *et al*⁽²²⁾ found good results using a medial parapatellar access and also using the transpatellar access when they avoided the insertion site lateral to the tibial tubercle. Althausen *et al*⁽²¹⁾ concluded that there were anatomical variations between the patellar tendon and the lateral tibial spine. This variation would imply that a routine surgical access might not give the ideal direction for the entry point. Pre-operative assessment using fluoroscopy might direct the surgeon towards the best access for reaching the entry point. Our results demonstrate that most of the participants chose point B from the schematic figure of both the AP and the lateral radiograph (66.8% and 53.8%, respectively). Only 13 participants (5.7%) made any comments regarding the nail insertion site. It was seen that there was a relationship between the reasons from the patient (functional) perspective, such as "to prevent knee pain" and "to avoid tendinitis", and the points A and C, while the reasons from the medical (functional) perspective, such as "better access for insertion" and "ease of access", predominantly correlated with point B of the schematic figure of the AP radiograph. With regard to the reasons for selecting the access according to the schematic figure of the lateral radiograph, there was only a relationship between the reason "to avoid valgus deformity" and point C.

CONCLUSION

It was found that the older the age group was, the higher the proportion choosing the reason "to avoid valgus deformity" was. The reasons from the medical (practical) perspective, such as "better access for nail insertion" and "ease of access" were correlated with the transpatellar access, while the reasons from the patient (functional) perspective, such as "to prevent knee pain", "to preserve the biomechanics" and "to avoid tendinitis" were correlated with the medial parapatellar access. The transpatellar access was chosen by the majority of the participants (66.5%).

ANNEX

Questionnaire for evaluating the entry point for intramedullary nails in the tibia

Name:

Institution:

Age:

Access for emplacement of intramedullary nail:

- Use of a single access
- Use of several types of access

In relation to patellar ligament:

- Medial
- Transpatellar
- Lateral

Reason for selecting the access in the patellar ligament:

- To prevent knee pain
- To preserve the patellofemoral biomechanics
- Better access for nail insertion
- Ease of access
- Localization of the fracture
- To avoid neuroma formation
- To avoid valgus deformity
- To avoid varus deformity
- To avoid tendinitis
- Others _____

Radiographic reference for the point of entry of the intramedullary nail



- A
- B
- C

Comments: _____



- A
- B
- C

Comments: _____

REFERENCES

1. Court-Brown CM, Christie J, McQueen MM. Closed intramedullary tibial nailing. Its use in closed and type I open fractures. *J Bone Joint Surg Br.* 1990;72(4):605-11.
2. Tornetta P 3rd. Technical considerations in the surgical management of tibial fractures. *Instr Course Lect.* 1997;46:271-80.
3. Alms M. Medullary nailing for fracture of the shaft of the tibia. *J Bone Joint Surg Br.* 1962;44:328-39.
4. Buehler KC, Green J, Woll TS, Duwelius PJ. A technique for intramedullary nailing of proximal third tibia fractures. *J Orthop Trauma.* 1997;11(3):218-23.
5. McConnell T, Tornetta P 3rd, Tilzey J, Casey D. Tibial portal placement: the radiographic correlate of the anatomic safe zone. *J Orthop Trauma.* 2001;15(3):207-9.
6. Tornetta P 3rd, Riina J, Geller J, Purban W. Intraarticular anatomic risks of tibial nailing. *J Orthop Trauma.* 1999;13(4):247-51.
7. Yu SW, Tu YK, Fan KF, Su JY. Anterior knee pain after intramedullary tibial nailing. *Changcheng Yi Xue Za Zhi.* 1999;22(4):604-8.
8. Court-Brown CM, Gustilo T, Shaw AD. Knee pain after intramedullary tibial nailing: its incidence, etiology, and outcome. *J Orthop Trauma.* 1997;11(2):103-5.
9. Hardy JR, Gregg PJ, Wood C. Knee pain after tibial nailing. *J Bone Joint Surg Br.* 1996;78(3):510-1.
10. Keating JF, Orfaly R, O'Brien PJ. Knee pain after tibial nailing. *J Orthop Trauma.* 1997;11(1):10-3.
11. Koval KJ, Clapper MF, Brumback RJ, Ellison PS Jr, Poka A, Bathon GH, et al. Complications of reamed intramedullary nailing of the tibia. *J Orthop Trauma.* 1991;5(2):184-9.
12. McCormack D, Mulcahy D, McElwain J. Knee pain after tibial nailing. *J Bone Joint Surg Br.* 1996;78(3):511.
13. Orfaly R, Keating JE, O'Brien PJ. Knee pain after tibial nailing: does the entry point matter? *J Bone Joint Surg Br.* 1995;77(6):976-7.
14. Hernigou P, Cohen D. Proximal entry for intramedullary nailing of the tibia. The risk of unrecognized articular damage. *J Bone Joint Surg Br.* 2000;82(1):3341.
15. Gregory P, Sanders R. The treatment of closed, unstable tibial shaft fractures with unreamed interlocking nails. *Clin Orthop Relat Res.* 1995;(315):48-55.
16. Freedman EL, Johnson EE. Radiographic analysis of tibial fracture malalignment following intramedullary nailing. *Clin Orthop Relat Res.* 1995;(315):25-33.
17. Chapman MW. Fractures of the tibia and fibula. In: *Operative orthopaedics.* 2nd ed. Philadelphia: J. B. Lippincott Company; 1993.
18. Lang GJ, Cohen BE, Bosse MJ, Kellam JF. Proximal third tibial shaft fractures. Should they be nailed? *Clin Orthop Relat Res.* 1995;(315):64-74.
19. Väistö O, Toivanen J, Paakkala T, Järvelä T, Kannus P, Järvinen M. Anterior knee pain after intramedullary nailing of a tibial shaft fracture: an ultrasound study of the patellar tendons of 36 patients. *J Orthop Trauma.* 2005;19(5):311-6.
20. Toivanen JA, Väistö O, Kannus P, Latvala K, Honkonen SE, Järvinen MJ. Anterior knee pain after intramedullary nailing of fractures of the tibial shaft. A prospective, randomized study comparing two different nail-insertion techniques. *J Bone Joint Surg Am.* 2002;84(4):580-5.
21. Althausen PL, Neiman R, Finkemeier CG, Olson SA. Incision placement for intramedullary tibial nailing: an anatomic study. *J Orthop Trauma.* 2002;16(10):68790.
22. Samuelson MA, McPherson EJ, Norris L. Anatomic assessment of the proper insertion site for a tibial intramedullary nail. *J Orthop Trauma.* 2002;16(1):23-5.