STUDY OF THE TIBIAL ROTATIONAL DEVIATION

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SUMMARY

Objective: to evaluate the postoperative rotational deviation of diaphyseal tibial fractures in patients treated with non-reamed, interlocking intramedullary nailing and bridge plate, using computerized tomography for measurement. Method: one hundred and thirteen patients with diaphyseal tibial fractures were treated; 42 fractures were treated with non-reamed, interlocking intramedullary nailing, and 71 fractures were treated with bridge plate. Tibial rotation measurements were obtained by using the CT scan. All of the fractures were classified by the AO scale, by their presentation (closed and open) and the percentage of deviation on internal and external rotation. Results: no significant difference in tibial rotation was found as a function of fracture location, internal or external rotation, and types A or B of fractures. However, in the case of type C fractures and open fractures, the treatment with non-reamed, interlocking intramedullary nailing resulted in a much smaller rotation in comparison to the treatment with bridge plate ($p = 0.028$ and $p = 0.05$, respectively). Conclusions: rotational deviations, regardless of the location of the diaphyseal tibial fractures, are associated to the trauma energy, thus presenting a greater challenge to control it by using the bridge plate.

Keywords: *Tibia; Tomography X-Ray; Fracture fixation intramedullary.*

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INTRODUCTION

Tibia is the bone most commonly affected by fractures(1). Each treatment modality has its inherent complications associated with the specific stabilization method(2,3). According to stability concepts, unstable and tibial shaft-deviated fractures may be treated by the principle of relative stability(4). Therefore, they must be treated with blocked intramedullary nails or bridge plates, showing good functional outcomes and low complication rates when compared to casted immobilization, open reduction with internal fixation and external fixators(2,5-7). Among the complications that may occur after tibial shaft fractures treatment, the rotational deformity is not much regarded; however, it may present cosmetic problems and produce arthrosis or other functional complications(8,9).

The objective of this study was to assess the incidence of rotational deviation in tibial shaft fractures treated with blocked intramedullary nail and bridge plate, using computed tomography as the evaluation method.

METHODS

During a period comprehending 2002 and 2005, 113 patients with unilateral tibial shaft fractures were treated at Hospital Santa Teresa, Petrópolis (RJ). The inclusion criteria were the following: all patients with tibial shaft fractures to which intramedullary nails and bridge plate were indicated, as well as patients being treated with previous external fixator. The exclusion criteria were as follows: patients with previous tibial shaft fractures, bilateral tibial fracture, femoral ipsilateral fracture, and previous conditions such as brain palsy sequels, poliomyelitis, imperfect osteogenesis, etc. Other exclusion criteria were: pregnancy or other reasons preventing patients from being submitted to computed tomography.

The research was divided into two groups: in the first group, stabilization was provided with non-threaded blocked intramedullary nail, and, in the second group, bridge plates were employed. In the 1st group (intramedullary nail), 32 male and 10 female patients were included. Age ranged from 16 to 71 years old; mean: 32.6. Fracture sites included: tibial proximal third (one patient), tibial medium third (30 patients), tibial distal third (seven patients), and segmented in four patients. According to the AO classification of fractures, 20 patients had type-A fractures, 12 type B, and 10 type C. Open fractures were classified according to the method described by Gustilo et al.(10): 11 patients had grade-I open fractures, nine grade-II, and seven grade-III. In 15 patients, we rated fractures as closed. The percentage of internal rotational deviations was 28.57% and 54.76% of external rotational deviations.

In the 2nd group (bridge plate), 57 male and 14 female patients were included. Age ranged from 13 to 76 years old; mean: 35.7. Fracture sites included: proximal third in four patients, medium third in 29 patients, distal third in 33 patients, and five segmented fractures. According to the AO classification of fractures, 29 patients had type-A fractures, 28 type B, and 14 type C. Open fractures were classified according to the method described by Gustilo et al.(10): 5 patients had grade-I open fractures, 11 grade-II, and eight grade-IIIA. In 47 patients, we rated fractures as closed. The percentage of internal rotational deviations was 28.17%, 59.15% external, and 12.68% null.

The X-ray study involved computed tomography images of both tibiae, and compared to quantify the degree of tibial rotation with both techniques. The employed technique was that of Jakob et al.(11) in which patients were kept at supine position with legs fixed and patellas in parallel to the table and resting on supports in order to prevent against movements during the test. Tomography takes

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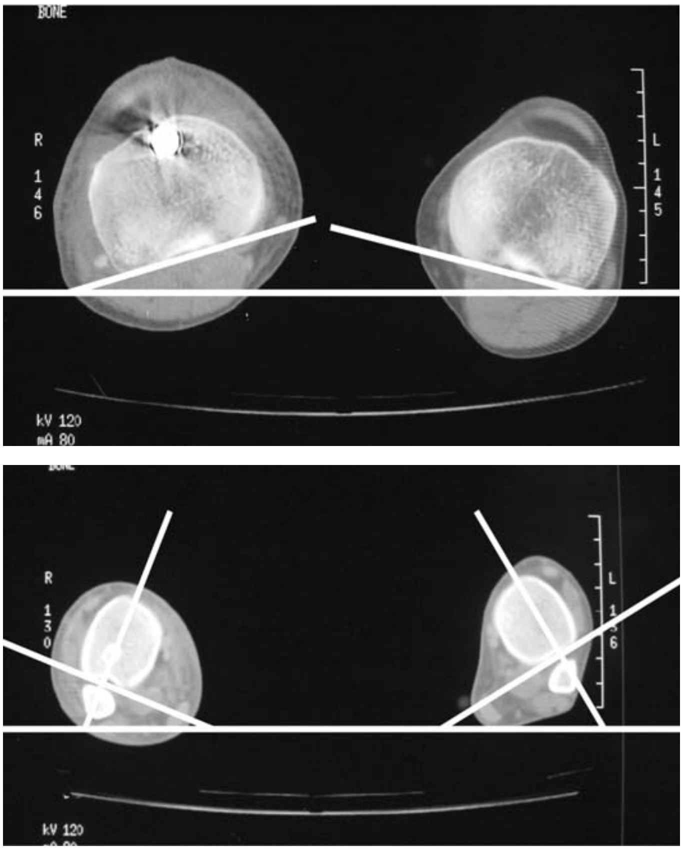
had 2mm in size, on the proximal region above tibiofibular joint and on the proximal region of tibiotarsal joint (Figures 1 and 2). The proximal reference line was tangentiated to the dorsal edge of the tibia, proximally to fibular head[12]. The distal reference line was made perpendicularly to tibiofibular joint, at the tibial pestle region[11]. Tibiofibular rotation was defined as the angle between both axes and compared with the unaffected contra lateral limb. The internal rotational deformity was rated with a negative value, while external deformities were rated with a positive value. Rotational deformity was defined as values above 10° when compared to the normal contra lateral limb[3,13,14].



Figures 1 and 2 *– Tomography images of the tibial proximal and distal regions with correspondent measurements.*

STATISTICAL METHODOLOGY

The statistical analysis was made by the Mann-Whitney test in order to check for the existence of rotational differences on the tibia (in degrees) between techniques (intramedullary nail vs. bridge plate) for the different fracture subtypes, and; for comparison among the three groups (A, B and C-types), the Kruskal-Wallis Variance analysis was performed.

The comparison of the internal and external rotation ratio between both techniques was assessed by the chi-squared test ($\chi 2$).

For comparing the mean age between both techniques, the Student's t test was applied to independent samples.

Non-parametric tests were used, because the rotational difference didn't show a normal distribution (Gaussian) due to data dispersion and lack of distribution symmetry. The criterion adopted for determining significance was the 5% level.

RESULTS

Of the 113 patients with tibial shaft fractures, 71 were treated with bridge plate (62.8%), and 42 with intramedullary nail (37.2%). The mean age of the total sample was 34.6 years, showing a rotational difference of 5.1°, ranging from 0º to 16º. However, when we use the intramedullary nail, we found four patients with deviations above 10° of tibial rotation, ranging from 11º to 14º (average: 12.5º). In the bridge plate technique, seven patients showed rotational deviations above 10°, ranging from 12º to 16º (average: 14º).

Table 1 provides the demographic and clinical characteristics of the total sample. Closed and open fractures have also been reported, as well as the AO classification and the percentage of internal and external rotation.

Table 1 *– Overall descriptive analysis of qualitative data.*

Variable	Category	n	%
Technique	Plate	71	62.8
	Nail	42	37.2
Gender	male	89	78.8
	female	24	21.2
Type	Type A	49	43.4
	Type B	40	35.4
	Type C	24	21.2
Site	Medium	59	52.2
	Distal	40	35.4
	Segmented	7	6.2
	Proximal	7	6.2
Side	Right	60	53.1
	Left	53	46.9
Rotation	Null	16	14.2
	ER	65	57.5
	IR	32	28.3
Fracture	Closed	62	54.9
	Open	51	45.1

Source: Hospital Santa Teresa, Prof. Dr. Donato D'Ângelo's Service, Petrópolis.

We investigated the existence of any significant difference in age and rotational difference (in degrees) when patients were treated with intramedullary nail and bridge plate. We found a significant difference in rotation between the nail and the plate (p= 0.036). This means that the technique employing intramedullary nails showed a rotational difference significantly lower than the technique using the bridge plate. No significant difference was found for mean age (p= 0.29) between both techniques (Table 2).

Table 2 *– Statistical analysis of age and rotation according to both techniques.*

Variable	Technique	n	Mean	SD	Median	Minimum	Maximum	p
Age	Plate	71	35.7	15.1	32	13	76	0.29
	Nail	42	32.8	13.7	30.5	16	71	
Difference	Plate	71	5.6	3.9	5	0	16	0.036
Rotational	Nail	42	4.2	3.8	2.5	0	14	

SD: Standard Deviation

Source: Hospital Santa Teresa, Prof. Dr. Donato D'Ângelo's Service, Petrópolis.

We assessed rotation on patients treated with intramedullary nail and bridge plate in the different subgroups. We found a significant difference in rotation between the nail and the plate only for Type C (p= 0.017) and in the open fracture subgroup (p= 0.05). This means that the technique using intramedullary nails showed a significantly lower rotation when the bridge plate was employed. No significant difference was found at the 5% level between both techniques for the remaining fracture subgroups. Due to the very small number of patients on the proximal and segmental subgroups, no statistical analysis could be performed (Table 3).

***Table 3** – Statistical analysis of tibial rotation on subgroups, according to both techniques.*

Subtype	Technique	n	Mean	SD	Median	Minimum	Maximum	p
Type A	Plate	29	4.9	4.0	4	0	16	0,68
	Nail	20	4.6	4.3	3	0	14	
Type B	Plate	28	5.6	3.9	5	0	12	0,24
	Nail	12	4.3	3.3	3	2	12	
Type C	Plate	14	7.3	3.5	7	2	16	0,017
	Nail	10	3.5	3.7	2.5	0	10	
Medium	Plate	29	5.6	4.0	4	0	16	0,34
	Nail	30	4.8	4.2	4	0	14	
Distal	Plate	33	5.7	3.9	4	0	16	0,11
	Nail	7	3.3	2.2	2	2	8	
Closed	Plate	47	5.3	3.7	4	0	12	0,24
	Nail	15	4.3	4.5	2	0	14	
Open	Plate	24	6.3	4.4	6	0	16	0,05
	Nail	27	4.2	3.5	3	0	12	
SD: Standard Deviation								

Source: Hospital Santa Teresa, Prof. Dr. Donato D'Ângelo's Service, Petrópolis.

Tables 4, 5 and 6 demonstrate if a significant difference existed on rotation between the different fracture subgroups when patients were treated specifically with intramedullary nail and bridge plate. No significant difference was found in terms of rotation between the fracture subgroups studied, both for the technique employing intramedullary nail and the one using bridge plates.

***Table 4** – Statistical analysis of tibial rotation according to types A, B and C.*

Technique	Subtype	n	Mean	SD	Median	Minimum	Maximum	p
Plate	Type A	29	4.9	4.0	4	0	16	0.13
	Type B	28	5.6	3.9	5	0	12	
	Type C	14	7.3	3.5	7	2	16	
Nail	Type A	20	4.6	4.3	3	0	14	0.73
	Type B	12	4.3	3.3	3	2	12	
	Type C	10	3.5	3.7	2.5	0	10	
SD: Standard Deviation								
[a] Kruskal-Wallis' ANOVA								

***Table 5** - Statistical analysis of tibial rotation according to site.*

Technique	Subtype	n	Mean	SD	Median	Minimum	Maximum	p
Plate	Medium	29	5.6	4.0	4	0	16	0,96
	Distal	33	5.7	3.9	4	0	16	
Nail	Medium	30	4.8	4.2	4	0	14	0,56
	Distal	7	3.3	2.2	2	2	8	
SD: Standard Deviation								

***Table 6** - Statistical analysis of tibial rotation on closed and open fractures.*

Technique	Subtype	n	Mean	SD	Median	Minimum	Maximum	p
Plate	Closed	47	5.3	3.7	4	0	12	0,40
	Open	24	6.3	4.4	6	0	16	
Nail	Closed	15	4.3	4.5	2	0	14	0,88
	Open	27	4.2	3.5	3	0	12	
SD: Standard Deviation								

Source: Hospital Santa Teresa, Prof. Dr. Donato D'Ângelo's Service, Petrópolis.

We also checked for any significant difference in internal rotation (IR) and external rotation (ER) ratio between intramedullary nails and bridge plates. No significant difference was found for null, internal and external rotation ratio between both techniques investigated (p = 0.82)(Table7).

***Table 7** – Distribution of null, internal (IR) and external rotation (ER) and between techniques.*

Rotation	Technique		
Frequency	Plate	Nail	Total
Null	9	7	16
	12.68	**16.67**	
ER	42	23	65
	59.15	**54.76**	
IR	20	12	32
	28.17	**28.57**	
Total	71	42	113

Source: Hospital Santa Teresa, Prof. Dr. Donato D'Ângelo's Service, Petrópolis.

DISCUSSION

Clinical manifestations after tibial shaft fractures treatment, regardless of the kind of treatment, are subtle and, most of times, remain unperceived. Many methods are reported in literature to measure tibial rotation; however, most were shown to be non-reproducible[15,16].

In most of the studies, rotational deviation was defined as a rotational difference above 10° (ranging from 5 to 15°) when compared to the contra lateral limb[3,13,14]. The incidence of this deformity in literature, when correlated to intramedullary nail, ranges from 0% to 6% and, concerning bridge plate, no statistics has been defined so far [17,18]. However, in all these cases, the method employed was either clinical or not reported. In order to appropriately quantify such incidence rate, we decided to postoperatively assess tibial reduction with both techniques using computed tomography in a prospective patient series.

Tibial rotation assessment with computed tomography was first reported by Jakob et al.[11] in 1980. A similar method was proposed by Jend et al.[12]. Both studies confirmed the accuracy of measurements and showed an accrued reproducibility after angle measurements, with 95% of the sample being located at 3° to 7°[11,12].

Rotational deviation after intramedullary nail insertion is seldom reported; however, literature shows an incidence ranging from 0% to 15%, when clinically assessed[3,13,14]. Puloski et al.[19] showed tibial rotation by means of computed tomography on tibial shaft fractures treated with blocked intramedullary nail and suggested that over 20% of the patients developed tibial rotation above 10° when measured by computed tomography.

Although this study has addressed the tomography evaluation of tibial shaft fractures, clinical changes are known to cause functional restraints, osteoarthrosis development, and gait changes. Puloski et al.[20] and Krettek et al.[19] demonstrated that the injury pattern may influence results. High-energy, comminuted fractures, significant deviations of bone fragments and distal third fractures seem to predispose patients to rotational deformities. Our results evidence that a significant difference occurred on rotation when we compare techniques using intramedullary nails and bridge plate in Type-C fractures ($p = 0.017$) and in the open fracture subgroup ($p = 0.05$). This means that the technique using intramedullary nail showed a significantly lower tibial rotation than the technique employing bridge plates. Consistently to literature, we could also evidence that high-energy and/ or comminuted fractures were more susceptible to rotational deviations. The authors didn't find rotational changes on tibial distal fractures, as demonstrated by Puloski et al.[19]. A potential reason for these deviations when using bridge plates was the challenge of finding parameters for plate modeling. Therefore, a tibial model must be kept at the operating room or, in cases of unilateral fracture, an aluminum model should be used in order to measure the angle on the contra lateral leg.

Two critical factors can be outlined in this study. The first one is related to the fact that few proximal and segmented tibial fractures were available in this study, rendering a careful statistical analysis impossible to be performed. As it is well reported by literature, the worst outcomes are associated to tibial proximal fractures when treated with intramedullary nails. The second factor is related to the fracture reduction method. Depending on the reduction method (manual traction, calcaneus traction with Kirschner's wires, orthopaedic table use, or distracters or external fixators use), the end result may change when treated with intramedullary nails [18].

CONCLUSION

We conclude that when computed tomography is employed as a method for measuring tibial rotation, high-energy tibial shaft fractures (open fractures) and comminuted (type- C), treated with the bridge plate technique present a stronger rotational deviation when compared to fractures treated with intramedullary nails.

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