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ORIGINAL ARTICLE

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What is the best approach to evaluating the reduction of the syndesmosis?

Qual a melhor maneira de se avaliar a redução da sindesmose?

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ABSTRACT

Objective: To evaluate the reliability, reproducibility, and intra- and interobserver correlation of eight tomographic methods used for assessing the reduction of the syndesmosis in high fractures of the fibula.

Methods: A total of seven patients were selected. Eight tomographic methods of measurement were used in the axial plane of the ankle at 1cm proximal to the articular surface. Three orthopaedists from the surgical team were chosen to evaluate the reliability and reproducibility of the measurements. Preoperative and postoperative tomography was used, and measurements were made at two distinct time points, with an interval of 2 months between them. All correlations were assessed using the interclass correlation coefficient (ICC).

Results: Method 3 (Zwipp) had ICC values >0.75 (excellent) in all measures by all examiners. Method 4 (Phisitkul) presented ICC values >0.95 (excellent) for the interobserver comparisons at the two time points. In the intraobserver comparison, method 4 had an ICC of 0.49 (satisfactory) in two preoperative evaluations, and the other comparisons presented an ICC >0.76 (excellent).

Conclusion: The Zwipp and Phisitkul measurements presented high reliability and reproducibility and are useful for evaluating rotational and translational movements of the fibula at the level of the syndesmosis, respectively.

Level of Evidence III; Therapeutic Studies; Comparative Retrospective Study.

Keywords: Trauma; Tibiofibular syndesmosis of the ankle; Tomography, X-Ray Computed; Open fracture reduction.

RESUMO

Objetivo: Avaliar a confiabilidade, a reprodutibilidade e a correlação intra e interobservador de oito métodos de mensuração tomográficos da redução da sindesmose nas fraturas altas da fíbula.

Métodos: Um total de 7 pacientes foram selecionados. Utilizamos 8 métodos tomográficos de mensuração, determinados nos cortes axiais do tornozelo a um centímetro proximal à superfície articular. Foram escolhidos 3 ortopedistas da equipe, para determinar a confiabilidade e a reprodutibilidade das medidas. Utilizamos tomografias pré-operatórias e pós-operatórias, com medidas feitas em 2 tempos, com intervalo de 2 meses entre elas. Todas as correlações foram avaliadas utilizando o coeficiente de correlação interclasse (ICC).

Resultados: O método 3 (Zwipp) obteve valores de ICC acima de 0,75 (excelente) em todas as medidas de todos os examinadores. O método 4 (Phisitkul) obteve ICC >0,95 em todos os tempos da comparação interobservador, considerado excelente. Já na comparação intraobservador, o método 4 obteve resultado de 0,49 (satisfatório) em 2 avaliações no pré-operatório, com demais resultados >0,76 (excelente).

Conclusão: As medidas Zwipp e Phisitkul são de grande confiabilidade e reprodutibilidade, sendo úteis respectivamente na avaliação de desvios rotacionais e translacionais da fíbula ao nível da sindesmose.

Nível de Evidência III; Estudos Terapêuticos; Estudo Retrospectivo Comparativo.

Descritores: Trauma; Sindesmose tibiofibular do tornozelo; Tomografia computadorizada por raios X; Redução aberta.

Work performed at the Hospital Mater Dei, Belo Horizonte, MG, Brazil.

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INTRODUCTION

The tibiofibular syndesmosis is the set of ligamentous structures formed by the lower anterior tibiofibular ligament, interosseous tibiofibular ligament, lower posterior tibiofibular ligament, and its deep portion, the transverse tibiofibular ligament. These ligaments ensure stability and allow movement at the ankle joint at the level of the distal tibiofibular joint[1]. Injuries in the tibiofibular ligaments may occur in isolation or associated with injuries in other ligaments, bones, or cartilages in the ankle[2]. The incidence of tibiofibular ligament injuries varies from 1-18%[2], and the most common injury is the external rotation momentum on the ankle in dorsiflexion and the foot in pronation.

Residual instability and malreduction of the syndesmosis lead to early degenerative changes of the ankle[3], and an anatomical reduction of this joint during surgical treatment is essential. However, precise criteria for assessing anatomical reduction are not universally accepted. Radiographic parameters such as tibiofibular clear space and tibiofibular overlap are commonly used to access the syndesmosis, but reliable parameters are not available to date[1,4]. The medial clear space (MCE), which is used to evaluate the competence of the deltoid ligament, is affected both by ankle positioning and the type of measurement (perpendicular or oblique MCE), which can generate calibration bias[5]. Computed tomography (CT) is better than conventional radiography in evaluating the fibular reduction in the tibial incisura[1,6], and some authors advocate the routine use of CT to assess the quality of the reduction postoperatively[7]. Several CT techniques have been described, with variable reproducibility[8,9]. However, to the best of our knowledge, no studies to date have analysed CT parameters exclusively in high fractures of the fibula. In this type of fracture, reduction and fixation of the fibula are not required, which eliminates a possible measurement bias of the CT parameters.

The objective of this study is to evaluate the reliability, reproducibility, and intra- and interobserver correlation of CT methods used for assessing the quality of the reduction of the distal tibiofibular joint in high fractures of the fibula.

METHODS

This study was approved by the Ethics Committee with registration in the Brazil Platform under the CAAE number: 64937516.5.0000.5128.

This retrospective study evaluated CT parameters of tibiofibular syndesmosis reduction in patients who underwent surgical treatment of Maisonneuve-type proximal fibular fractures between 2008 and 2017 in our service. The patients included in this study presented proximal fibular fractures by torsion (Maisonneuve type), with referral for surgical treatment regardless of the technique of reduction and fixation used, and underwent ankle CT before and after surgery. The exclusion criteria were (1) patients with Maisonneuve-type fractures treated conservatively, (2) patients with syndesmotic injuries in ankle fractures, (3) proximal fibular fractures by direct trauma, and (4) patients without a complete medical record.

A total of seven patients were selected. The anatomical relation of the distal tibiofibular syndesmosis was analysed using eight CT parameters in the axial plane of the ankle at 1 cm proximal to the articular surface, where the anterior tuberosity of the tibia is more prominent[10] and the tibiofibular incisura is well-defined[8]. These methods consisted of three angle measurements, four distance measures, and one ratio between distances (Figure 1).

Method 1, described by Nault et al.[11], measures the angle between a line that intersects the anterior and posterior tibial tuberosities and a line that crosses the fibular tuberosities. Method 2, proposed by Vasarhelyi et al., determines the opening angle of the tangents between the medial fibular border and the anterior and posterior tuberosities of the tibia at the level of the incisura[12]. Method 3 was described by Zwipp in 1994 and measures the angle formed between the tangent of the anterior tibial surface and the bisection of the vertical medial line of the fibula at the level of the tibiofibular syndesmosis[13].

Method 4, proposed by Phisitkul (2013), analyses the distance between the anterior fibular cortex and a line perpendicular to the tangent of the incisura, starting at its most anterior point[11]. Method 5, developed by Phisitkul, determines the distance between the line that intersects the incisura and the most medial section of the fibula, being negative when the fibula is located medially

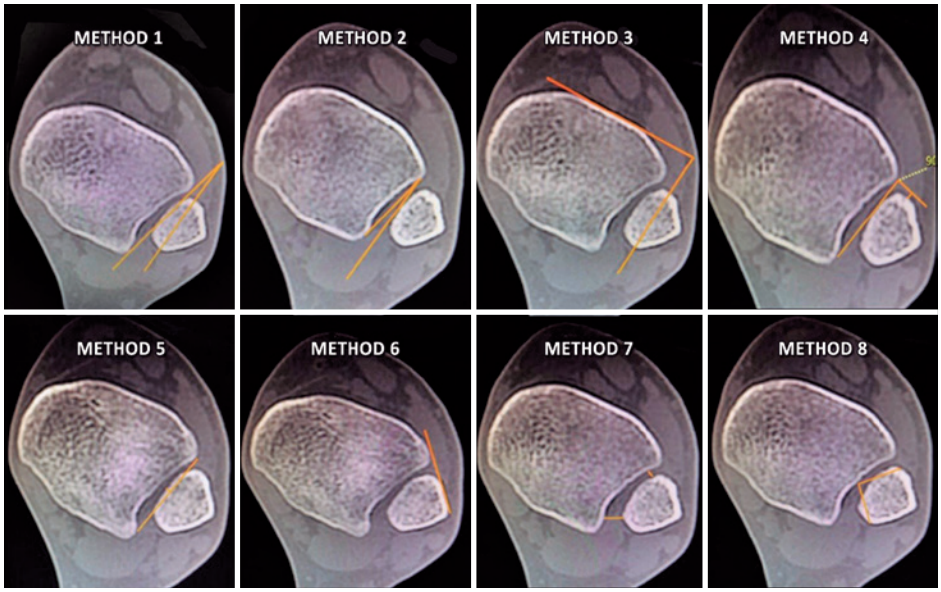

Figure 1. Computed tomographic measurement methods in the axial plane at a distance of 1 cm from the ankle joint.
Source: Authors' personal archive.

to the incisural line[14]. Method 6, described by Gifford et al. (2014), measures the tibiofibular line (TFL), which is the extension of the line that intersects the anterolateral surface of the fibula towards the anteromedial border of the tibia[14]. Method 7, proposed by Gardner in 2006, determines the difference between the distance from the fibula to the anterior and posterior facets of the incisura[15]. Method 8, described by Pelton, measures the ratio of two distances: (1) from the deepest point of the incisura to the most anterior border of the fibula, and (2) from the deepest point of the incisura to the most posterior border of the fibula[16].

For this evaluation, three orthopaedists, two lead physicians, and one trainee (R4) of the foot/ankle service were selected to determine the reliability and reproducibility of the measurements. Preoperative and postoperative CT measurements were made at two time points (M1 and M2) with a 2-month interval between measurements. The study complied with the guidelines on human and animal research.

The reliability of the measurements was assessed using the interclass correlation coefficient (ICC)[13,17]. The ICC was calculated and compared between the three observers (interobserver comparison) and between the measures repeated by each observer (intraobserver comparison) for each evaluated method. The ICC was defined as poor (<0.40), satisfactory (0.41-0.75), and excellent (>0.76)[17].

RESULTS

The interobserver comparison (Table 1) indicated that the preoperative M1 measurements achieved excellent reproducibility (ICC>0.76) for methods 3, 4, 5, 7, and 8, acceptable reproducibility (ICC=0.41–0.75) for methods 1 and 2, and poor reproducibility (ICC<0.40) for method 6. The ICC was excellent for methods 1, 3, 4, 5, and 7 for the M1 postoperative measurements. The ICC was satisfactory for methods 6 and 8 and poor for method 2.

For the preoperative measurements performed at M2, the ICC was excellent for methods 1, 3, 4, 5, 7, and 8 and acceptable for methods 2 and 6. For postoperative M2 measurements, with the exception of method 2, whose ICC was satisfactory, all the analysed methods presented a small variability, and the ICC was considered excellent.

The intraobserver comparison (Table 2) between preoperative measurements at M1 and M2 by examiner 1 (trainee) indicated that methods 3 and 8 presented a higher ICC, and reproducibility was classified as excellent. The reproducibility of methods 2, 4, and 7 was considered acceptable. The reproducibility of methods 1, 5, and 6 was poor. For the comparison of the postoperative measurements made by this examiner, the reproducibility was excellent for methods 2, 3, 4, 6, 7, and 8 and satisfactory for methods 1 and 5.

In the comparison of the two preoperative measurements made by examiner 2 (lead physician), the reproducibility of all methods, except method 1, was excellent. The measurements performed in the postoperative period indicated

Table 1. Interclass correlation coefficient values for interobserver comparisons

	Interobserver comparison			
	First time point		Second time point	
	Preoperative	Preoperative	Postoperative	Postoperative
Method 1	0.57	0.87	0.77	0.94
Method 2	0.68	0.34	0.55	0.49
Method 3	0.98	0.95	0.98	0.99
Method 4	0.95	0.96	0.96	0.94
Method 5	0.98	0.99	0.99	1.00
Method 6	0.11	0.48	0.45	0.92
Method 7	0.89	0.89	0.75	0.84
Method 8	0.85	0.61	0.87	0.96

ICC: Interclass correlation coefficient.
Source: Prepared by the author based on the results of the study.

Table 2. Interclass correlation coefficient values for intraobserver comparisons

	Intraobserver comparison					
	Examiner 1		Examiner 2		Examiner 3	
	Preoperative	Postoperative	Preoperative	Postoperative	Preoperative	Postoperative
Method 1	0.16	0.60	0.07	0.99	0.98	0.98
Method 2	0.50	0.89	0.86	0.97	0.16	0.87
Method 3	0.93	0.80	1.00	1.00	0.89	0.98
Method 4	0.49	0.98	0.83	0.99	0.49	0.79
Method 5	0.12	0.49	0.87	1.00	0.76	0.99
Method 6	0.13	0.97	0.98	1.00	0.94	0.98
Method 7	0.67	0.95	0.99	0.71	0.99	0.95
Method 8	0.99	1.00	0.97	0.91	1.00	1.00

ICC: Interclass correlation coefficient.
Source: Prepared by the author based on the results of the study.

that the reproducibility of all methods, except for method 7, was excellent.

The ICC of the preoperative measurements made by examiner 3 (lead physician) revealed that the reproducibility of methods 1, 3, 5, 6, 7, and 8 was excellent. For the postoperative measurements, the reproducibility of all methods was classified as excellent (ICC>0.75).

DISCUSSION

It is well established that the anatomical reduction of the syndesmosis in the treatment of high ligamentous injuries of the fibula is essential to obtain adequate functional results[13]. The radiographic techniques routinely used to assess reduction are two-dimensional analyses and are not reliable. Previous studies have shown that CT is useful and precise for identifying intraoperative[18] and postoperative[11-13,16,19] reduction. However, there is no consensus on a group of gold-standard measures to assess syndesmotic joint congruence because the reliability and reproducibility of measurements in the literature are divergent[8,9,12].

The CT parameters described by Zwipp in 1994 (method 3) to evaluate rotational movements of the fibula in the incisura presented ICC>0.75 in all measurements by all examiners, and therefore, this method was considered the most reliable and reproducible. A previous study evaluated the reliability and accuracy of four CT parameters for syndesmotic reduction of simulated Weber C-type ankle fractures in nine cadaver ankles and found that Zwipp's method was the most reliable and accurate[9].

Among the parameters that evaluate translational movements of the tibiofibular syndesmosis (methods 4, 5, and 6), the method described by Phisitkul (method 4) was the most reliable and reproducible. In the interobserver comparison, the obtained ICC was >0.95 (excellent) at all time points. The ICC for the intraobserver comparison was 0.49 (acceptable) in two preoperative evaluations, whereas the ICC for the other comparisons was excellent (>0.76). These results are similar to those of other studies, whereby the ICC values were satisfactory or excellent[11,20]. Phisitkul et al. obtained an interobserver ICC of 0.92 and intraobserver

ICC of 0.97, emphasizing the importance of assessing translational movements in the anteroposterior plane, which is considered the most problematic plane when attempting to achieve anatomical reduction of the tibiofibular syndesmosis[7,15,20].

This study is the first to compare a considerable number of CT techniques to assess the reduction of the syndesmosis exclusively in Maisonneuve-type injuries, which reduces the risk of measurement bias in cases in which there was a poor reduction of the distal fibula after its synthesis, interfering in the level of reduction of the tibiofibular syndesmosis. The main limitation of the study was the small sample size, which was due to the low incidence of this type of injury in the analysed population (1-18%)[2].

CONCLUSION

The Zwipp and Phisitkul CT measurement methods are highly reliable and reproducible and are useful in evaluating rotational and translational movements, respectively. However, more studies are needed to determine to what extent each of these measurements represents functional implications in patients treated for proximal fibular fractures.

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REFERENCES

1. Beumer A, Valstar ER, Garling EH, Niesing R, Ranstam J, Lofvenberg R, et al. Kinematics of the distal tibiofibular syndesmosis: radiostereometry in 11 normal ankles. Acta Orthop Scand. 2003;74(3):337-43.
2. Hopkinson WJ, St. Pierre P, Ryan JB, Wheeler JH. Syndesmosis sprains of the ankle. Foot ankle Int. 1990;10(6):325-30.
3. McKinley TO, Tochigi Y, Rudert MJ, Brown TD. Instability-associated changes in contact stress and contact stress rates near a step-off incongruity. J Bone Joint Surg Am. 2008;90(2):375-83.
4. Takao M, Ochi M, Oae K, Naito K, Uchio Y, Surgeon O. Diagnosis of a tear of the tibiofibular syndesmosis the role of arthroscopy of the ankle. J Bone Joint Surg Br. 2003;85(3):324-9.
5. Baumfeld D, Baumfeld T, Cangussú J, Macedo B, Silva TAA, Raduan F, et al. Does foot position and location of measurement influence ankle medial clear space? Foot Ankle Spec. 2017;11(1):32-6.
6. Harper MC. An anatomic and radiographic investigation of the tibiofibular clear space. Foot ankle Int. 1993;14(8):455-8.
7. Miller AN, Carroll EA, Parker RJ, Boraiah S, Helfet DL, Lorich DG. Direct visualization for syndesmotic stabilization of ankle fractures. Foot Ankle Int. 2009;30(5):419-26.
8. Dikos GD, Heisler J, Choplin RH, Weber TG. Normal tibiofibular relationships at the syndesmosis on axial CT imaging. J Orthop Trauma. 2012;26(7):433-8.
9. Knops SP, Kohn MA, Hansen EN, Matityahu A, Marmor M. Rotational malreduction of the syndesmosis: reliability and accuracy of computed tomography measurement methods. Foot Ankle Int. 2013;34(10):1403-10.
10. Beumer A, Swiestra BA. The influence of ankle positioning on the radiography of the distal tibial tubercules. Surg Radiol Anat. 2003;25(5-6):446-50.
11. Nault ML, Hébert-Davies J, Laflamme GY, Leduc S. CT scan assessment of the syndesmosis: a new reproducible method. J Orthop Trauma. 2013;27(11):638-41.
12. Vasarhelyi A, Lubitz J, Gierer P, Gradl G, Rösler K, Hopfenmüller W, et al. Detection of fibular torsional deformities after surgery for ankle fractures with a novel CT method. Foot Ankle Int. 2006;27(12):1115-21.
13. Phisitkul P, Ebinger T, Goetz J, Vaseenon T, Marsh JL. Forceps reduction of the syndesmosis in rotational ankle fractures: A cadaveric study. J Bone Joint Surg Am. 2012;94(24):2256-61.
14. Gifford PB, Lutz M. The tibiofibular line: an anatomical feature to diagnose syndesmosis malposition. Foot Ankle Int. 2014;35(11):1181-6.
15. Gardner MJ, Demetrakopoulos D, Briggs SM, Helfet DL, Lorich DG. Malreduction of the tibiofibular syndesmosis in ankle fractures. Foot Ankle Int. 2006;27(10):788-92.
16. Pelton K, Thordarson DB, Barnwell J. Open versus closed treatment of the fibula in maissoneuve injuries. Foot Ankle Int. 2010;31(7):604-8.
17. Shrout PE, Fleiss JL. Intraclass correlations: uses in assessing rater reliability. Psychol Bull. 1979;86(2):420-8.
18. Franke J, Recum J Von, Suda AJ, Gr PA, Wendl K. Intraoperative three-dimensional imaging in the treatment of acute unstable syndesmotic injuries. J Bone Joint Surg Am. 2012;94(15):1386-90.
19. Gardner MJ, Graves ML, Higgins TF, Nork SE. Technical considerations in the treatment of syndesmotic injuries associated with ankle fractures. J Am Acad Orthop Surg. 2015;23(8):510-8.
20. Ebinger T, Goetz J, Dolan L, Phisitkul P. 3D model analysis of existing CT syndesmosis measurements. Iowa Orthop J. 2013;33:40-6.