

MECHANICAL RESISTANCE EVALUATION OF THREE DIFFERENT SCHANZ SCREWS TO TORSION FORCES IN MONOLATERAL EXTERNAL FIXATION ASSEMBLIES

MARCELO MERCADANTE¹, KODI KOJIMA¹, RALPH CHRISTIAN¹, JOSÉ OCTÁVIO HUNGRIA¹, JOSÉ SOARES HUNGRIA NETO¹, ALEXANDRE BRÁS DE CAMARGO², HÉLIO M. SAMANO³, ROMULO S. F. SANTOS³, JAN VATAVUK⁴, ANTONIO G. DE MELLO JUNIOR⁵, ANDRÉA DIAS BERTOLANI⁶, CARLOS EDUARDO B. DE FREITAS⁶.

SUMMARY

Objective: The objective of this study was to evaluate the mechanical force of three different assemblies of a linear external fixator using 4.5 mm and 5.5 mm Schanz screws with a 3.2 mm-diameter root, and another screw with 5.5 mm diameter with a 4.5mm root.

Material and methods: The linear external fixator was assembled in a 500 mm-long polypropylene tube, with a 45-degree oblique angle cut in the center of the cylinder, with two Schanz screws in each segment. Eighteen assemblies were studied, divided into three groups of six pieces each. In the group 1, 4.5mm-diameter Schanz screws were used, in the group 2, 5.5mm-diameter Schanz screws, both with 3.2mm root were used. In the group 3, 5.5mm-diameter Schanz screws with a diameter root of 4.5mm were used. The mechanical tests were performed in a MT-100 torsion machine, and the resistance measurements were performed at 4.5°, 9.0°, 13.5°, and 18° of torsion.

Results: The 4.5mm Schanz screws with 3.2 mm root showed an average torsion resistance at 4.5°, 9.0°, 13.5° and 18.0°, respec-

tively of: 12.0 N/mm, 21.0 N/mm, 33.0 N/mm, and 46.0 N/mm. The 5.5mm Schanz screw with 3.2 mm root, showed as average resistance: 13.2 N/mm, 25.3 N/mm, 40.0 N/mm, and 51.2 N/mm, respectively. The tests with 5.5 mm Schanz screws with 4.5 mm root showed an average resistance of: 15.2 N/mm, 33.5 N/mm, 53.0 N/mm, and 70.0 N/mm. Statistical analysis with the Variance Analysis test and the Bonferroni's test showed the absence of statistically significant differences among groups with root diameter of 3.2mm (4.5 mm and 5.5 mm). There was a statistically significant difference between the group with the 5.5mm Schanz screws with 4.5 mm root and the other two groups.

Conclusions: 1- There was no statistically significant difference among assemblies of linear external fixator using 4.5mm and 5.5mm Schanz screws with 3.2mm root. 2- The linear external fixator with 5.5mm Schanz screws with 4.5mm root, showed a stronger mechanical resistance to the torsion, statistically significant, regarding the other two groups.

Keywords: External fixators; Biomechanics; Bone nails.

INTRODUCTION

The ideal external fixator to be used in the Emergency Room of Orthopaedics and Traumatology Services shall be of easy application, cheap, versatile, minimally ornate, preferably modular and must provide enough stability among fractured fragments, allowing initial treatment, up to the eventual conversion to definitive bone union.

From the stability point of view, when submitted to functional requirements, linear external fixators present a better stability the more separate they are from each other in the same fragment, Schanz screws and the placement of two connection bars between the screws^(1,2). But, when we assess torsion resistance, the weakest points are the isolated Schanz screws resisting to these forces, regardless of being supported by one or two connection bars⁽³⁾.

This study aims to compare the mechanical resistance of linear Schanz screws-mounted external fixators of three different diameters: 4.5mm and 5.5 mm with a 3.2-mm root, models comprised in implant boxes used in clinical practice, and the screws of 5.5 mm with thicker root, of 4.5-mm diameter, at the threaded segment.

RESULTS

The results of torsion tests with the three linear external fixator assemblies, with 4.5-mm diameter, and 5.5 mm with 3.2-mm root, and 5.5 mm with 4.5-mm root, are shown on Table 1.

Graph 1 shows the results of mechanical tests.

Table 2 shows the results of the statistical analysis performed among groups for significance evaluation among tests results by using the Variance Analysis test (ANOVA) and the Bonferroni test.

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Correspondences to: Departamento de Ortopedia e Traumatologia da Irmandade da Santa Casa de Misericórdia de São Paulo. - Grupo de Ortopedia e Traumatologia Pediátrica ("Pavilhão Fernandinho Simonsen") - Dr. Cesário Motta Jr. 112, CEP 01277-900 - Vila Buarque - São Paulo - SP - E-mail: mtmcsv@uol.com.br

1. Doctor Orthopaedic at the Department of Orthopaedics and Traumatology, Medical Sciences College, Santa Casa de São Paulo
2. Doctor Orthopaedic, Associate to Trauma Group, Department of Orthopaedics and Traumatology - Santa Casa de Misericórdia de São Paulo
3. Doctor Orthopaedic, post-graduation trainee at Trauma Group, Department of Orthopaedics and Traumatology - Santa Casa de Misericórdia de São Paulo
4. Materials Engineer, professor at Engineering College, Mackenzie Presbyterian University
5. Mechanical Engineer, professor at Engineering College, Mackenzie Presbyterian University
6. Student at Engineering College, Mackenzie Presbyterian University

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DISCUSSION

The use of an external fixator with linear assembly in patients suffering trauma, particularly in open fractures and polytraumatism cases^(4,5,6,7), usually functions as temporary stabilization, being the conversion to internal fixation recommended within the first two weeks⁽⁸⁾. Despite the short application time, the assembly must have enough stability to allow painless patients' motion, not making subsequent procedures difficult due to its display, enabling an early rehabilitation and, mainly, facilitating care to soft parts at the infirmary.

Linear mounts of modular monoplanar fixators are mechanically less stable than bi- or multiplanar assemblies^(1,9), but their use is still frequent due to versatility, fast setup, low cost, as well as to a small number of elements required at the moment of setup.

Many studies show that the linear external fixator stability is related to the kind of assembly made. Maximum stability is achieved with a larger distance of the Schanz screws from each other and with the placement of two connector bars⁽²⁾. However, this is true when the resistance of the assembly is considered when submitted to axial forces.

In external fixator assemblies available in our environment, when submitted to an axial load, the same behavior was noticed⁽⁹⁾, but when resistance to torsion forces is assessed, there was no difference between the placement of one or two bars, because the system failed at Schanz screws that bent⁽³⁾.

Therefore, regarding resistance to torsion forces, the most important element in stabilization is the Schanz screw.

In this study, commercially available Schanz screws were used, with diameters of 4.5 mm and 5.5 mm with a 3.2-mm root, from the external fixation system ROFA[®] (Impol Instrumental e Implantes Ltda). Schanz screws with 5.5 mm and a thicker root, measuring 4.5 mm, were manufactured especially for the tests.

A similar mechanical behavior was observed in torsion tests between Schanz screws of 4.5 mm and 5.5 mm with 3.2-mm root

(Table 1, Graph 1, and Table 2), with no statistically significant difference between both groups.

Tests with Schanz screws of 5.5 mm with 4.5-mm root showed a higher mechanical resistance, statistically significant when compared to the other two screws (Table 1, Graph 1, and Table 2). With 18.0° of torsion, the resistance is at least 40% stronger than other Schanz screws.

In the search for an explanation for this result, many measurements were performed on Schanz screws. It was noted that all screws had the same total length (240 mm) and the same thread length (50 mm). Screw size name, 4.5 mm or 5.5 mm, was given according to the flat shaft and to the diameter of screw thread, but both had a 3.2-mm root.

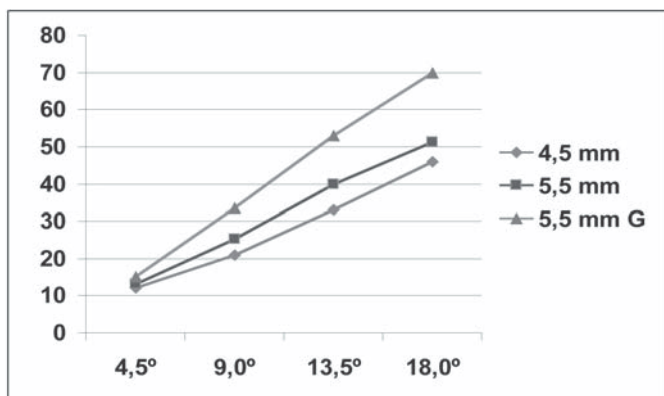
As the placement of Schanz screws in polypropylene tubes was made so that its tip did not protrude at the opposite side, as desired in application clinical situation, screws were not inserted up to the flat part, with part of the thread remaining out of the body of evidence. This segment, located between the bone and the largest part of the screw, has been demonstrated as the weak point of the system, becoming deformed upon torsion forces. As both screws with 4.5 mm and 5.5 mm had a root of 3.2 mm, their similar biomechanical behavior is explained, showing that there is no advantage in the use of a screw with a greater external diameter above the thread to achieve a stronger resistance of the monolateral fixator assembly with those screws.

Screws with a wider root - 4.5 mm in diameter - that were manufactured for this test also presented total length of 240 mm and thread length of 50 mm. With a greater root, the mechanical resistance showed a statistically significant increment. The use of thicker screws but with the same diameter of root did not cause a resistance increase to the assemblies, which only occurred when screws with greater roots were used, not available routinely in implant boxes of modular fixators.

If those results are transferred to the clinical practice, we can say that, for increasing mechanical resistance to torsion of a

Torsion in degrees		4.5 mm	5.5 mm	5.5 mm thick
4.5°	M	12.0	13.2	15.2
	SD	1.6	2.4	3.7
	EPM	0.7	1.0	1.5
9.0°	M	21.0	25.3	33.5
	SD	1.9	3.9	6.5
	EPM	0.8	1.6	2.6
13.5°	M	33.0	40.0	53.0
	SD	2.4	3.3	8.9
	EPM	1.1	1.4	3.6
18.0°	M	46.0	51.2	70.0
	SD	3.5	2.1	11.1
	EPM	1.5	0.9	4.5

Table 1 - Result of torque (N/mm) measured with 4.5°, 9.0°, 13.5° and 18.0° of body of evidence torsion, with a linear external fixator mounted with Schanz screws with 4.5 mm, 5.5 mm and 3.2 root, and 5.5 mm and 4.5 mm root diameters.



Graph 1 – Graph showing the mean torque (N/mm) measured with 4.5°, 9.0°, 13.5°, and 18.0° of body of evidence torsion with a linear external fixator mounted with Schanz screws with 4.5 mm, 5.5 mm, and 5.5 mm diameter with thick root.

	4,5 mm	5,5 mm	5,5 mm G	ANOVA
4,5°	12,0	13,2	15,2	p = 0,153
9,0°	21,0	25,3	33,5	p = 0,000 *
	p > 0,05		p < 0,05 *	
13,5°	33,0	40,0	53,0	p = 0,000 *
	p > 0,05		p < 0,05 *	
18,0°	46,0	51,2	70,0	p = 0,000 *
	p > 0,05		p < 0,05 *	

Table 2 – Results of statistical analysis with the ANOVA test among the three groups and Bonferroni's test of a group compared to the others (p= / 0.05).

linear external fixator, it is required to increase root diameter of Schanz screws to be used. An alternative would be the manufacture of Schanz screws with shorter threads, allowing them to be inserted up to the flat shaft, staying inside bone cortical. The latter option implies in difficulties to application in clinical practice due to morphological diversities among patients, in addition to the need of using larger diameter drills. This variation in Schanz screws features is out of the scope of this study, and should be addressed in further studies.

CONCLUSIONS

- 1- Linear external fixators mounted with Schanz screws with 4.5 mm and 5.5 mm diameter and threaded segment root of 3.2 mm are not different regarding torsion resistance.
- 2- Linear external fixators mounted with Schanz screws of 5.5 mm with 4.5-mm root at the threaded segment present mechanical resistance to torsion statistically superior to screws with 3.2-mm roots.

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