OBJECTIVE: To evaluate the influence of pilot hole tapping on pullout resistance and insertion torque of pedicle screws with a conical core.

METHODS: Mechanical tests using a universal testing machine were performed on pedicle screws with a conical core that were inserted into pedicles in the fifth lumbar vertebra of calves. The insertion torque was measured using a torque meter with a capacity of 10 Nm, which was considered to be the highest torque value. The pilot holes were prepared using a probe of external diameter 3.8 mm and tapping of the same dimensions and thread characteristics as the screw.

RESULTS: Decreased insertion torque and pullout resistance were observed in the group with prior tapping of the pilot hole.

CONCLUSIONS: Pilot hole tapping reduced the insertion torque and pullout resistance of pedicle screws with a conical core that had been inserted into the pedicle of the fifth lumbar vertebra of calves.

Keywords – Spine; Bone Screws; Biomechanics
MATERIAL AND METHOD

Ten lumbar vertebrae (L5) from male calves of Friesian breed, of age six to eight weeks and mean body mass 50.9 ± 5.0 kg, were used. The vertebrae were stored at a temperature of −20°C. Before the tests were carried out, the vertebrae were removed from the freezer and kept at a temperature of 5°C for 12 hours, and then at room temperature for two hours, so that they would attain thermal equilibrium, and for the physical properties of the bone not to be abnormal. The bone mineral density of the vertebrae was assessed by means of dual X-ray absorptiometry, and a mean of 0.24 ± 0.01 g/cm² was found.

Conical core screws from the USS system (Universal Spine System-Synthes®) for vertebra fixation, of length 30 mm and external diameter 5.2 mm (Figure 1), were used. The screws were implanted in both sides of the vertebral pedicles, using a probe of external diameter 3.8 mm and tapping with the same dimensions and thread characteristics as in the implant, in accordance with the manufacturer’s recommendations (Figure 1). In the left pedicle, tapping was performed before placement of the implants, and on the right side, the implant was placed directly after making the pilot hole.

The insertion torque of the screws was evaluated by means of a torque meter with a capacity of 10 Nm and the MK software, version 1.0.0.6/2004. The highest torque value obtained while inserting the implant was taken.

The mechanical pullout tests were performed using an Emic universal testing machine, with the Tesc 3.13 software to analyze the results, a load cell with a capacity of 2,000 N and a force application velocity of 2 mm/min. In all the mechanical tests, a preload of 50 N and accommodation time of 10 seconds were used (Figure 2). The property evaluated in the mechanical tests was the maximum pullout force.

The results from the maximum pullout force were subjected to statistical analysis of normality, in order to determine the behavior of the data (ANOVA). To compare the results between the groups, the Bonferroni post hoc method was used. The significance level was taken to be 5% (p < 0.05).

RESULTS

It was found that the insertion torque and maximum pullout force were lower in the group of screws with prior tapping of the pilot hole. The results relating to the insertion torque and the pullout force of the screws inserted in tapped pilot holes and untapped pilot holes are represented in Table 1 and Figure 3.

DISCUSSION

Placement of screws in the vertebrae is a prominent technical step towards spine fixation that may or may not be preceded by tapping the pilot hole. Pilot hole tapping is an additional technical step during the surgical procedure, and it consequently increases the time required for the operation, which is only justifiable through the benefits provided. If there are no benefits, this procedure would be an unnecessary stage within the surgical procedure. In osteosynthesis of the long bones, the importance of cortical bone tapping is well esta-
observed after tapping in most of them (8).

Fixation of screws in human vertebrae to perform mechanical tests would reproduce the natural surgical conditions. However, acquisition of vertebrae to perform this test presents numerous medical-legal difficulties relating to obtaining them. Thus, we used spines from calves in this study, since this model is well accepted in the literature and is considered to be appropriate for assessing instrumentation of the spine (1,9,10).

Conical core screws were developed to increase the pullout resistance. The conical core screw used in this study had two different diameters that were joined by a zone of conical transition. The smaller diameter of the screw was closer to its tip, and the larger diameter was closer to its head. The smaller diameter facilitated screw insertion and the larger diameter provided greater stability for the implant located inside the vertebral pedicle (11).

Theoretically, the conical core of the screw compacts the adjacent spongy bone, thereby increasing the insertion torque of the implant and its pullout resistance (12).

The results obtained from the present study showed that pilot hole tapping significantly reduced the insertion torque and pullout resistance of the screws (2). This reduction in screw pullout resistance has been well demonstrated, especially in soft materials or in spongy bone, and it is related to weakening on the spongy bone at the interface between the implant and the bone tissue.

The stability of the fixation system is dependent on the implant anchorage strength in the vertebra, and pilot hole tapping may compromise the stability of the fixation system through reducing the pullout resistance of the implant.

---

**Table 1 – Insertion torque values of the screws in the groups with tapping and without tapping of the pilot hole.**

| Vertebr  | Insertion torque (Nm) | Pullout resistance |
|---------|-----------------------|--------------------|
|         | Group with tapping    | Group without tapping | Group with tapping | Group without tapping |
| 1       | 1.36                  | 2.06               | 469.13             | 501.57               |
| 2       | 1.35                  | 1.82               | 723.47             | 793.22               |
| 3       | 1.73                  | 1.94               | 456.49             | 424.08               |
| 4       | 1.32                  | 2.39               | 481.11             | 800.26               |
| 5       | 1.69                  | 2.53               | 446.62             | 558.83               |
| 6       | 1.95                  | 2.65               | 456.49             | 546.66               |
| 7       | 1.17                  | 1.49               | 478.93             | 512.14               |
| 8       | 1.6                   | 2.34               | 634.81             | 898.18               |
| 9       | 0.39                  | 2.4                | 376.88             | 448.96               |
| 10      | 2.36                  | 2.45               | 796.74             | 774.19               |
| Mean    | 1.49                  | 2.21               | 532.07             | 628.79               |
| Standard deviation | 0.52 | 0.37               | 137.21             | 168.64               |

---

**Figure 3 – Mean insertion torque and mean pullout resistance of the screws in the groups with tapping and without tapping of the pilot hole.**

---
Pilot hole tapping to implant conical core screws in the spine is disadvantageous because it increases the duration of the operation and reduces the pullout resistance of the implant.

CONCLUSION

Pilot hole tapping reduces the insertion torque and pullout resistance of pedicle screws with a conical core that have been implanted in the pedicle of the fifth lumbar vertebra of calves.

ACKNOWLEDGEMENTS

Our thanks to Fapesp for the support given towards carrying out this work.

REFERENCES

1. Öktenoglu BT, Ferrara LA, Andalkar N, Özer AF, Sarioglu AC, Benzel EC. Effects of hole preparation on screw pullout resistance and insertional torque: a biomechanical study. J Neurosurg. 2001;94(Suppl 1):91-6.
2. Pfeiffer FM, Abernathie DL, Smith DE. A comparison of pullout strength for pedicle screws of different designs: a study using tapped and untapped pilot holes. Spine (Phila Pa 1976). 2006;31(23):E867-70.
3. Zdeblick TA, Kunz DN, Cooke ME, McCabe R. Pedicle screw pullout strength. Correlation with insertional torque. Spine (Phila Pa 1976). 1993;18(12):1673-6.
4. Kuklo TR, Lehman RA Jr. Effect of various tapping diameters on insertion of thoracic pedicle screws: a biomechanical analysis. Spine (Phila Pa 1976). 2003;28(18):2066-71.
5. Schatzker J, Sanderson R, Murnaghan JP. The holding power of orthopedic screws in vivo. Clin Orthop Relat Res. 1975(108):115-26.
6. Chapman JR, Harrington RM, Lee KM, Anderson PA, Tencer AF, Kowalski D. Factors affecting the pullout strength of cancellous bone screws. J Biomech Eng. 1996;118(3):391-6.
7. Carmouche JJ, Molinari RW, Gerlinger T, Devine J, Patience T. Effects of pilot hole preparation technique on pedicle screw fixation in different regions of the osteoporotic thoracic and lumbar spine. J Neurosurg Spine. 2005;3(5):364-70.
8. Pfeiffer M, Gilbertson LG, Goel VK, Griss P, Keller JC, Ryken NC, Hoffman HE. Effect of specimen fixation method on pullout tests of pedicle screws. Spine (Phila Pa 1976). 1996;21(9):1037-44.
9. Hearn TC, Szalai JP, Surowiak JF, Schatzker J. Sample size estimates for the use of human bone in the experimental study of cancellous screw extraction mechanics. J Biomech. 1996;29(4):569-72.
10. Ronderos JF, Jacobowitz R, Sonntag VK, Crawford NR, Dickman CA. Comparative pull-out strength of tapped and untapped pilot holes for bicortical anterior cervical screws. Spine (Phila Pa 1976). 1997;22(2):167-70.
11. Lil CA, Schneider E, Goldhahn J, Haslemann A, Zeitang F. Mechanical performance of cylindrical and dual core pedicle screws in calf and human vertebrae. Arch Orthop Trauma Surg. 2006;126(10):686-94.
12. Hsu CC, Chao CK, Wang JL, Hou SM, Tsai YT, Lin J. Increase of pullout strength of spinal pedicle screws with conical core: biomechanical tests and finite element analyses. J Orthop Res. 2005;23(4):788-94.