TAPPING PILOT HOLE: MECHANICAL ANALYSIS OF SHEEP VERTEBRA AND THE ARTIFICIAL BONE MODEL

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ABSTRACT

Objective: To determine the effect of pilot hole tapping, together with other variables such as pilot hole diameter, in relation to inner screw diameter and preparation method, on the insertion torque and pullout resistance of the screws used for anterior fixation of the cervical spine. Method: Twenty polyurethane test bodies and 30 thoracic vertebrae (T1-T5) were tested. Four holes were drilled into each test body: two of them with a diameter of 2.0 mm and two with a diameter of 2.5 mm. The holes were drilled using a bit or probe, according to the experimental group. Each experimental group was divided into two equal subgroups, with and without pilot hole tapping. In all, there were eight experimental groups: four using polyurethane specimens and four using sheep vertebrae. Cortical screws of 3.5 mm in outer diameter and 14 mm in length were inserted into the pilot holes. The insertion torque was measured during screw implantation and mechanical pullout tests were then performed using an Emic® universal testing machine, with the Tesc 3.13 software, load cells of 1000 N, force application rate of 0.2 mm/min, preloading of 5 N and accommodation time of 10 seconds. The property evaluated in the mechanical tests was the maximum pullout force. Results and Conclusion: Pilot hole tapping significantly decreased the insertion torque and pullout force of the screws in all the experimental groups.

Keywords – *Spine; Bone screws; Biomechanics; Torque; Orthopedic fixation devices*

INTRODUCTION

Fixation of the cervical spine is used to provide mechanical stability to this vertebral segment during the process of arthrodesis consolidation(1). The stability of the cervical fixation depends on several factors such as the bone mineral density, screw insertion torque and screw pullout resistance(26).

The insertion torque and pullout resistance of screws may be influenced by tapping the pilot hole, although there are divergences in the literature on this topic(710). The negative effects of pilot hole tapping on pullout resistance have been demonstrated especially on low-hardness test bodies and on trabecular bone(7,11). In the lumbar spine, pilot hole tapping significantly reduced the resistance to pulling out pedicle screws(12,13). However, Ronderos *et al*(9) observed that tapping the pilot hole did not increase the axial pullout force when the anterior cervical screws were anchored in the posterior cortical bone of the vertebral body. Carmouche *et al*(14) observed that tapping reduced the resistance to pulling out pedicle screws fixed in the human lumbar spine and did not change the resistance to pulling out implants in the thoracic spine.

The aim of this study was to evaluate the influence of tapping the pilot hole, along with other variables such as the hole diameter, in relation to the inner diameter of the screw and the pilot hole preparation method, on the insertion torque and pullout resistance of screws used for anterior fixation of the cervical spine.

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We declare that there is no conflict of interests in this article

METHOD

This study was conducted on polyurethane test bodies that formed an artificial bone model, and on vertebrae from shorn Santa Inês sheep of mean weight 38 ± 5 kg and mean age 12 ± 3 months. Twenty test bodies of the artificial bone model were used, of length 40 mm, width 40 mm and height 40 mm, with a density of 0.32 g/cm^3 (Nacional Ltda.), and 30 sheep vertebrae from the T1-T5 segment, with a density of 0.6 ± 0.03 g/cm^2. The density of the vertebrae was obtained by means of dual-energy X-ray absorptiometry (DXA) and the QDR system with software version 11 – 2:5 (Hologic 4500 W, Waltham, MA, USA).

Four holes were made in each test body: two with a diameter of 2.0 mm and two with a diameter of 2.5 mm. These holes were made with a bit or a probe, according to the experimental group. In each experimental group, half of the holes of the same diameter were tapped, using a tapping device of 3.5 mm in diameter (Synthes®). In the other holes, the screws were inserted without prior tapping.

Cortical screws of outer diameter 3.5 mm, inner diameter 2.5 mm and length 14 mm (Synthes®) were inserted in the pilot holes (Figure 1).

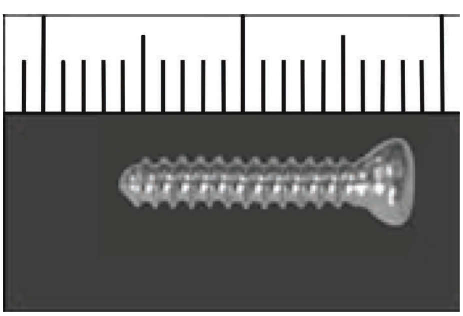

Figure 1 – Screw used in the study

Eight experimental groups were formed: four using the artificial bone model and four using sheep vertebrae. The groups using the artificial bone model were as follows: I (hole drilled with a bit of 2.0 mm in diameter); II (hole drilled with a bit of 2.5 mm in diameter); III (hole drilled with a probe of 2.0 mm in diameter); and IV (hole drilled with a probe of 2.5 mm in diameter). The groups using the vertebrae were as follows: V (hole drilled with a bit of 2.0 mm in diameter); VI (hole drilled with a bit of 2.5 mm in diameter); VII (hole drilled with a probe of 2.0 mm in diameter); and VIII (hole drilled with a probe of 2.5 mm in diameter).

The insertion torque of the implants was measured using an MK digital micro-torque meter (model TI-500/MK-MT-1), 1 N.m, with a resolution capacity of 0.001 N.m. The Graphic III software was used for the data analysis.

The mechanical tests were performed using an Emic® universal testing machine with a load cell capacity of 1,000 N, and the data were analyzed by means of the Tesc 3.13 software.

To perform the pullout mechanical tests, the screw head was fixed to the test machine by means of connectors that allowed multidirectional movements and an axial load was applied without applying any torque. Preloading of 5 N was applied for a 10-second period in order to accommodate the system. The axial traction force was then applied at a constant 0.2 mm/min until the implant had been pulled out (Figure 2).

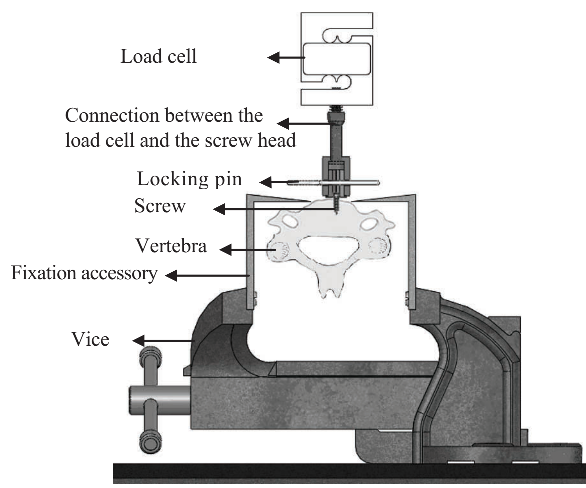

Figure 2 – Layout of the accessories used in the mechanical tests

Ten mechanical tests and ten insertion torque measurements were made on each experimental group using the artificial bone model (10 tapped and 10 non-tapped). In total, 80 mechanical tests and 80 insertion torque measurements were made. For the experimental groups using the vertebral body, 15 mechanical tests and 15 insertion torque measurements were made (15 tapped and 15 non-tapped), making a total of 120 mechanical tests and 120 insertion torque measurements. The mechanical property evaluated in the mechanical tests was the maximum pullout force.