The Effect of the Lumbar Pedicle and Pediculocorporal Junction Histology on the Pedicle Screw Insertion Technique

Murat Yilmaz*, Beyza Alkis, Kemal Yucesoy
School of Medicine, University of Dokuz Eylul, Balcova, Izmir, Turkey

Abstract

BACKGROUND: Posterior lumbar pedicle screw instrumentation has gained wide acceptance in the treatment of the various spinal lesions requiring fusion. Inserting screws into the pedicles take a great deal of skill, as the dense bony parts are not large, and a mistake could push a bone fragment into the spinal nerves, causing pain, loss of mobility, and other damage.

AIM: The aim of this study was to investigate the histological and gross-anatomical properties of the pediculocorporal junction, which can have important clinical implications on the insertion technique of the pedicle screws.

MATERIALS AND METHODS: Human cadaveric lumbar spinal segments that were fixed with formaldehyde were used in the study. Twenty pedicles from ten lumbar spinal segments (L3–L5) were prepared for histological and gross-anatomical investigation. Thin slice cuts were taken from the specimens and examined histologically and macroscopically.

RESULTS: There were not any differences in the histological characteristics of the pedicles and the pediculocorporal junction. The thin, compact osseous formation, or web-like connective tissue formation were not identifiable in the pediculocorporal junction.

CONCLUSIONS: All kinds of pedicle screws may be inserted just after preparation of the insertion point with an awl or just decortication of the entrance point with a rongeur. This can also reduce the pilot hole preparation technique-related complications like perforation of the pedicle walls.

Introduction

Posterior lumbar pedicle screw instrumentation has gained wide acceptance in the treatment of various spinal lesions requiring fusion [1]. Inserting screws into the pedicles take a great deal of skill, as the dense bony parts are not large, and failure may push a bone fragment into the spinal nerves, causing pain, loss of mobility, and other neural damages. Pilot hole preparation and tapping are frequently used to prepare the tunnel for the pedicle screws; however, these maneuvers may lead to the perforation of the pedicle or corpus walls [2]. Self-tapping various cylindrical screws are currently in the clinical use to eliminate the need for tapping with a tunneler [3].

There are different fixation systems, surgical instruments, and insertion techniques, which have been developed for the safe insertion of the pedicle screws [1]. One of the main issues regarding the pedicle screw enforcement should be the histological properties of the pedicles, and especially the pediculocorporal junction, which has not been studied before. Any osseous web formation or histological change at this junction may influence the technique for the screw insertion [4], [5].

The aim of the present study was to investigate the histological and gross-anatomical properties of the pediculocorporal junction, which can have important clinical implications on the insertion technique of the pedicle screws.

Materials and Methods

Study design

This study was approved by the University Clinical Center Review Board. Human cadaveric lumbar spinal segments that were fixed with formaldehyde were used in the study.

Twenty specimens, including a part of the corpus, pediculocorporal junction, and some parts of the pedicle, were prepared for the examination with the light microscope. About 10% of HNO₃ compound were prepared in 70% ethyl alcohol and used for the decalcification process. Decalcification procedure lasted for 2 days, and then, specimens were embedded.
in paraffin blocks. Each paraffin block was sectioned with 5–6 µm thickness and five sections were obtained for each specimen (100 sections were obtained from 20 specimens). Specimens were stained with hematoxylin & eosin and examined with blinded histologists.

**Outcome parameters**

The parameters studied were the histological properties and densities of the osseous tissue in the anterior (corporal), pediculocorporal junction, and posterior (pedicle) parts of the specimens. The properties of the bone marrow were also examined in three different segments of the specimens. Preparations were examined with a light microscope (Olympus BH-2 Tokyo, Japan) and images transferred to the computer using a high-resolution camera (JVC TK-890-E, Japan) and Aver TV Studio (Version 4.21.0.0, Aver Media Technologies, Inc.).

**Statistical analysis**

Data were analyzed using the Statistical Package for the Social Sciences 19.0 for Windows (SPSS Inc., Chicago, IL). Parametric tests were applied to data of normal distribution and non-parametric tests were applied to data of questionably normal distribution. All differences associated with a chance probability of 0.05 or less were considered statistically significant.

**Results**

Twenty human cadaveric lumbar spinal specimens were used in the study.

Gross-macroscopic examination of the specimens revealed that the trabecular formation of the spongious bone was dense in the posterior part and getting to some extent weaker and scarcer in the anterior (corporal) part (Figure 1). There was not any lamina or zone throughout the specimens starting from the corpus to the end of the pedicle. Bone marrow and adipose tissues of the osseous trabecula were the same in all parts of the specimens.

The light microscopic examination revealed no differences in terms of the properties of the osseous tissue in the sequential slices of all specimens (Figure 2). There were also no histological differences among specimens obtained from the different spinal segments.

**Discussion**

The pedicle constitutes a relatively small part of the vertebral mass; however, it is clinically one of the most crucial elements of the spine [6]. The pedicle, a tubular bone, contains a spongy matrix surrounded by a cortical shell, participates in the formation of anterior and posterior vertebral columns from the corpus to the facets and it acts as a bridge that transmits the load on the spine to adjacent levels [7]. This unique anatomy of the pedicles provides an excellent implantation site for reconstructive spinal surgeries.

Lowe et al. hold that anterior column integrity is significantly involved in spinal reconstruction [8]. Implant subsidence is not only related to the biomechanical properties of vertebral endplates but also to the implant morphology, structure, and whether the endplate is preserved in operation. Hou and Luo stated that the central region with more and larger pore structures is weaker than the peripheral region of the lumbar endplate, and the strongest site is the posterolateral region in front of the pedicles [9]. Keller et al. tested 1 cm cubes of trabecular bone taken from the superior and inferior surfaces of lumbar vertebrae and found that there was regional variation in the strength and stiffness, which changed with disk degeneration [10]. In his classic study on the vertebral endplate, Perey conducted indentation tests with a relatively large, flat indenter. He demonstrated that the strength decreases with age.
He also concluded that there were no differences in the strength between the central, lateral, and anterior regions of the endplate, although he did not present the data [11]. The main concern in drilling a tunnel before the insertion of a pedicle screw is to prepare a passage passing through any compact lamellar osseous zones of the pedicle or pediculocorporal junction [12]. According to the findings of the present study, it can be a possibility to omit this step during surgery as the whole macroscopic, and histological architecture of the bone was found to be similar throughout the passage of the pedicle screw [13].

It is a common clinical finding that most of the pedicle fractures related to pedicle screws occur at the lateral wall of the pedicle [14]. In an in vitro study, Panjabi et al. inserted screws of different diameters into thoracic and lumbar pedicles [15]. With increasing screw diameter, they found changes in the pedicle structure (i.e., pedicle expansion, pedicle fracture, or cutout of the screw thread). Although there were as many lateral cutouts as there was medial, indicating that the entrance points for the screws were in the center of the pedicle, they saw 72% of pedicle fractures laterally and only 28% medially. The idea of cutting the pedicle to investigate its internal structure is not new. Foster cut the pedicle into 1 mm thin slices and obtained measurements of the cancellous and cortical dimensions along with the pedicle height and width [16]. However, they studied only two human specimens. They showed that the cortical shell thicknesses were between 10% and 30% of the pedicle height and between 15% and 40% of the pedicle width.

The main limitation of the present study was the relatively small size of our series. Second, some details of the history of the cadavers that may influence the results may not be completely documented. Due to these restrictions, associations should be interpreted with caution.

Conclusions

As the histological characteristics of the pedicle, pediculocorporal junction, and corpus are alike, the use of a tunneler during the spinal fusion operations can be omitted. All kinds of pedicle screws, including self-tapping ones, can be attempted to be inserted just after preparation of the insertion point with an awl or just decortication of the entrance point with a rongeur. This can also reduce the long awl and tunneler-related complications like perforation of the pedicle walls. Further randomized, prospective, and controlled trials on larger series are necessary for making more precise interpretations.

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