EVALUATION OF TERMINAL VERTEBRAL PLATE ON CERVICAL SPINE AT DIFFERENT AGE GROUPS AND ITS CORRELATION WITH INTERVERTEBRAL DISC THICKNESS

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ABSTRACT

Objective: To evaluate, by means of histomorphometry, terminal vertebral plate thickness, intervertebral disc thickness and its correlation on different age groups, seeking to identify its correlation. Methods: C4-C5 and C5-C6 cervical segments removed from human cadavers of both genders were assessed and divided into five groups of 10-year age intervals, from 21 years old. TVP and intervertebral disc thickness evaluation was made by means of histomorphometry of histological slides stained with hematoxylin and eosyn. Lower C4 TVP, upper C5 TVP, and upper C6 TVP were compared between each other and to the interposed intervertebral disc thickness between relevant TVP. Results: The thickness of terminal vertebral plates adjacent to the same ID did not show statistic differences. However, the comparison of upper and lower vertebral plates thickness on the same cervical vertebra (C5), showed statistical difference on all age groups studied. We found a statistical correlation coefficient above 80% between terminal vertebral plate and adjacent intervertebral disc, with a proportional thickness reduction of both structures on the different cervical levels studied, and also on the different age groups assessed. Conclusion: Terminal vertebral plate shows a morphologic correlation with the intervertebral disc next to it, and does not show correlation with the terminal vertebral plate on the same vertebra.

Keywords – Spine; Intervertebral disc; Cadaver

INTRODUCTION

The intervertebral disc (ID) is an avascular structure composed of collagen fibers, proteoglycans, and water¹. The nutrition of the intervertebral disc occurs through diffusion of nutrients through the vertebral end plate². The vertebral end plate (VEP) is an anatomical
between 31 and 40 years, group 3, aged between 41 and 50 years, group 4, aged between 51 and 60, and group 5, aged between 61 and 70 years.

The vertebral segments chosen for the study were: C4-C5 and C5-C6, considering their degree of mobility and the incidence of degenerative disc disease in these segments (PTGDI).

The vertebral segments chosen for the study were collected during autopsy by cutting across the lower and upper third of the vertebral bodies adjacent to the intervertebral disc selected for the study. The next cut was made in the sagittal plane dividing the anatomical specimen in half. The two halves were sectioned by 3-mm thick parasagittal cuts, with the medial sides of each half being used for the study (Figure 1).

Before the preparation of anatomical specimens, anteroposterior (AP) and lateral radiographs were taken according to the standard technique for observing the presence of disc degeneration. The study excluded those segments that had radiographic signs of disc degeneration. Segments that presented radiographic signs of disc degeneration were excluded from the study. The evaluation of the radiographs

![Figure 1](image)

Figure 1 – Front view of the anatomical specimen containing the C5-C6 intervertebral disc and part of the adjacent vertebral bodies before (A) and after (B) making cuts in the sagittal plane.
was performed independently by a radiologist. The parameters used to assess the presence of disc degeneration were: reduction of disc space, subchondral bone sclerosis, presence of vertebral osteophytosis, subchondral resorption of bone cysts, and presence of perilesional osteopenia.

The two 3-mm thick cuts resulting from the sagittal and parasagittal cuts of the anatomical specimen were prepared for histological study by being fixed in 10% neutral formalin, decalcified with trichloroacetic acid, and embedded in paraffin. Cuts of 5μ-thick were made in the sagittal axis of the anatomical specimens, covering the adjacent vertebral bodies and the intermediate intervertebral disc. The sections were stained with hematoxylin and eosin and examined under light microscopy (Figure 2).

The thickness of the ID and the adjacent VEP – the distal upper vertebra VEP and the proximal inferior vertebra VEP – were evaluated by histomorphometry using a Zeiss® ocular integrator with 10x magnification and a 40x lens. The central third of the VEP and the ID was selected to measure the thickness. We studied the relationship between the height of the ID and the height of the adjacent vertebral end plates in the region defined for the study. This correlation was evaluated in the total group of subjects studied and the different age groups. The thickness of the analyzed structures in relation with increasing age was also studied.

Statistical study of the related parameters was performed using analysis of variance (ANOVA), using the PROC GLM procedure of SAS version 9.

The correlation between the thickness of the vertebral end plate and intervertebral disc at different ages was performed by ANOVA, using the PROC GLM procedure of SAS version 9.

RESULTS

The values of the thickness of the VEP and the ID in the cervical segments selected for the study are shown in Table 1.

The height of the C4-C5 and C5-C6 intervertebral disc decreased with increasing age, with statistically significant differences observed between the age groups studied (p < 0.05) (Chart 1).

The VEP thickness also showed decreasing values with increasing age, with a statistically significant difference (p < 0.05) observed between the age groups evaluated (Chart 2).

The thickness of the vertebral end plates adjacent to the C4-C5 and C5-C6 ID did not reveal a statistical difference (p > 0.05) in all the groups studied. However, a statistical difference was observed between the height of the distal and proximal VEP C5. Thus, the adjacent vertebral end plates at the same ID showed no difference in thickness, though they belonged to different vertebrae. Whereas the VEPs belonging to the same vertebra were in contact with distinct IDs, there were differences in their thicknesses.
The correlation coefficient between the height of the ID and the height of the adjacent VEP remained constant in the different age groups, as seen in Table 2. The reduction of ID height with increasing age was accompanied by the reduction of the height of the VEP, thereby maintaining the correlation.

**Table 1** – Mean values of the thickness of the VEP and the intervertebral disc (C4-C5 and C5-C6) in the vertebral segments studied.

<table>
<thead>
<tr>
<th>Age group</th>
<th>VEP C4 (mm)</th>
<th>ID (mm)</th>
<th>VEP C5 (mm)</th>
<th>ID (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.76 ± 0.03</td>
<td>4.33 ± 0.20</td>
<td>0.78 ± 0.02</td>
<td>0.89 ± 0.02</td>
</tr>
<tr>
<td>2</td>
<td>0.75 ± 0.02</td>
<td>4.30 ± 0.18</td>
<td>0.76 ± 0.02</td>
<td>0.86 ± 0.03</td>
</tr>
<tr>
<td>3</td>
<td>0.73 ± 0.02</td>
<td>4.27 ± 0.18</td>
<td>0.75 ± 0.02</td>
<td>0.83 ± 0.03</td>
</tr>
<tr>
<td>4</td>
<td>0.69 ± 0.03</td>
<td>4.23 ± 0.15</td>
<td>0.71 ± 0.03</td>
<td>0.77 ± 0.03</td>
</tr>
<tr>
<td>5</td>
<td>0.64 ± 0.02</td>
<td>4.08 ± 0.10</td>
<td>0.65 ± 0.02</td>
<td>0.68 ± 0.02</td>
</tr>
<tr>
<td>Total</td>
<td>0.71 ± 0.04</td>
<td>4.24 ± 0.08</td>
<td>0.73 ± 0.08</td>
<td>0.80 ± 0.07</td>
</tr>
</tbody>
</table>

**DISCUSSION**

The ID is an avascular structure and its nutrition occurs by diffusion of nutrients through the VEP\(^8\). Diffusion is not uniform through the VEP and the central region has been considered the site of the VEP in which the nutrition of the ID would be more critical and with a higher metabolic rate. This was the reason central part of the VEP and the ID was chosen for the study.

Studies of the nutrition and metabolism of the ID have shown that the central region of the VEP has a higher permeability to the diffusion of small solute molecules, while the lateral portion is relatively impermeable\(^9\). This permeability is attributed to the presence of a greater number of vascular endings in the central region of the cancellous bone of the vertebral body adjacent to the VEP. Crock et al. demonstrated that the main form of transport of small solute molecules occurs through the diffusion process through the central portion of the VEP\(^10\). However,
due to the intimate functional relationship between these structures. The established hypothesis was confirmed in the initial evaluation, and a correlation was observed between the thickness of the VEP and the height of the intermediate ID on all levels and in all age groups studied. We observed that the thickness of the VEP was not correlated in the same vertebra, but with the ID with which the VEP was in contact. This observation further supports the functional relationship between the VEP and the ID.

With increasing age, there is progressive reduction in the thickness of the ID, the VEP, and VEP permeability, resulting in the gradual reduction of disc nutrition. Progressive changes in the composition of the ID and the VEP of monkeys of increasing age were observed in association with a decreased amount of glycosaminoglycan sulfate and chondroitin sulfate, resulting in a reduction in the thickness of the VEP and ID, as well as the permeability of small solutes that nurtured the nucleus pulposus\textsuperscript{(12)}. Similar changes in ID and VEP were observed in humans\textsuperscript{(13)}. Our results confirmed this observation and the possible relationship between the ID and VEP. The proportional reduction of these structures with age was observed in our study.

The hypothesis that the thickness of the VEP is correlated with the thickness of the ID was confirmed in this study. This correlation has been established from a functional perspective, and a new approach to the understanding of phenomena related to nutrition and degeneration of ID can be established with the observed morphological results.

**CONCLUSION**

At the cervical levels assessed, progressive and proportional reduction of the thickness of the adjacent VEP and ID were observed in the different age groups studied. The vertebral end plate is morphologically correlated with the intervertebral disc with which it comes into contact, and shows no correlation with the vertebral end plate of the same vertebra.

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