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MORPHOLOGICAL ANALYSIS OF THE APEXES OF UPPER MOLARS: A STUDY BY DIGITAL MICROSCOPY

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ORIGINAL ARTICLE

ABSTRACT

Objective: This observational study aims to describe the morphology of maxillary molar apices, emphasizing the variability of shapes, including apical deltas and foramina, using a 1600x HD USB digital microscope. Methodology: Maxillary first molars extracted for orthodontic or periodontal reasons were analyzed. The teeth were cleaned and stored in saline solution until analysis. A 1600x HD USB digital microscope, connected to a computer, was used to capture images of the root apices. The images were examined for the presence of the main foramen, satellite foramina, and other anatomical variations. Results: The analyzed images revealed significant morphological variability of the maxillary molar apices. The apical foramen frequently presented lateral deviations, and multiple foramina were identified around the main foramen, indicating the presence of apical deltas. Illustrative figures present these findings. Conclusion: The morphology of the apices of maxillary molars presents significant variability, including multiple foramina and deviations of the main foramen. The use of 1600x HD USB digital microscopy proved to be an efficient tool for identifying these variations, providing support for more accurate diagnoses and more effective endodontic treatments.

Keywords: Apical foramen, Apical deltas, Maxillary molars, Digital microscopy, Root morphology.

ANÁLISE MORFOLÓGICA DOS ÁPICES DE MOLARES SUPERIORES: UM ESTUDO POR MICROSCOPIA DIGITAL

RESUMO

Objetivo: Este estudo observacional visa descrever a morfologia dos ápices de molares superiores, enfatizando a variabilidade de formas, incluindo deltas apicais e forames, por meio da utilização de um microscópio digital USB 1600x HD. Metodologia: Foram analisados primeiros molares superiores extraídos por razões ortodônticas ou periodontais. Os dentes foram limpos e armazenados em solução salina até a análise. Utilizou-se um microscópio digital USB 1600x HD, conectado a um computador, para capturar imagens dos ápices radiculares. As imagens foram examinadas quanto à presença do forame principal, foraminas satélites e outras variações anatômicas. Resultados: As imagens analisadas revelaram significativa variabilidade morfológica dos ápices dos molares superiores. O forame apical frequentemente apresentou desvios laterais, e foram identificadas múltiplas foraminas ao redor do forame principal, indicando a presença de deltas apicais. Figuras ilustrativas apresentam esses achados. Conclusão: A morfologia dos ápices de molares superiores apresenta significativa variabilidade, incluindo múltiplas foraminas e desvios do forame principal. O uso de microscopia digital USB 1600x HD demonstrou ser uma ferramenta eficiente para a identificação dessas variações, fornecendo subsídios para diagnósticos mais precisos e tratamentos endodônticos mais eficazes.

Palavras-chave: Forame apical, Deltas apicais, Molares superiores, Microscopia digital, Morfologia radicular.

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INTRODUCTION

A detailed understanding of the apical anatomy of maxillary molars is essential for the success of endodontic procedures. The apical region of these teeth is characterized by a complex network of accessory canals and apical deltas, structures that can directly influence the effectiveness of endodontic treatment. Variability in the morphology of the apical foramina, including their shape, size and location, can impact the determination of the working length and the obturation of the root canal system, even indicating regenerative endodontic procedures in the case of immature teeth with open apices, i.e., not completely finished.

Previous studies indicate that the apical foramen does not always coincide with the anatomical apex of the root, often presenting lateral deviations. Gutierrez and Aguayo (1995) observed that the foraminal openings in human teeth exhibit a variety of shapes and dimensions, highlighting the anatomical complexity of this region. Morfi (1994), using scanning electron microscopy, also demonstrated variability in the location of the apical foramen in relation to the root apex. The presence of apical deltas, characterized by a network of small canals in the apical region, is a relevant anatomical characteristic that can influence the success of endodontic treatment. Levorato et al. (2011) evaluated the shape and diameters of the main canals and the apical foramen of permanent upper molars, finding a predominance of elliptical foramina and significant variations in the dimensions of the root canals. The use of high magnification tools, such as digital microscopes, allows a more detailed analysis of these structures, aiding in the identification of anatomical variations that may go unnoticed in conventional examinations. Morphological analysis of root apices using high-resolution microscopy can provide valuable information for endodontic practice, contributing to the improvement of root canal instrumentation and obturation techniques. However, the use of these microscopes is difficult and often impossible due to the cost and difficulty for undergraduate students to access institutions that have them.

Therefore, portable electron microscopes are capable of providing excellent quality photographs that can illustrate the arrangement of these foramina in

descriptive observational studies, providing beautiful illustrative images for student learning. Given the clinical importance of apical morphology and the anatomical variability of apical foramina, this study aims to describe the foraminal anatomy of upper molars, using a 1600x HD USB digital microscope to capture and analyze detailed images of this region.

METHODOLOGY

This observational study was conducted on a sample of maxillary first molars extracted for orthodontic or periodontal reasons. The teeth were cleaned to remove soft tissue residues and stored in saline solution until analysis. To capture the images, the molars were positioned on a black wooden background, without any sectioning of the roots, allowing direct visualization of the apical region. A 1600x HD USB digital microscope, connected to a computer, was used to photograph the root apices. The images obtained were analyzed for the presence of the main foramen and surrounding foramina, as well as other relevant morphological characteristics of the apical region.

LITERATURE REVIEW

The clinical complexity of the periapical region

The morphology of the apical foramen has been the subject of several studies that seek to understand its anatomical variations and clinical implications. Gutierrez and Aguayo analyzed the foraminal openings in human teeth, highlighting the variability of shapes and dimensions found. They observed that the apical foramen does not always coincide with the anatomical apex of the root, often presenting lateral deviations. Morfis, using scanning electron microscopy, investigated the apex of human permanent teeth and demonstrated a great anatomical variation in these structures, reinforcing the complexity of the apical region. The presence of apical deltas, characterized by a network of small canals in the apical region, is a relevant anatomical characteristic that can influence the success of endodontic treatment. Barros et al. studied the morphology of the apical third of the root and canals of teeth

with hypercementosis, using different observation methods, and found a higher frequency of apical deltas in these teeth. They concluded that hypercementosis can cause a higher frequency of apical deltas, constriction in canal width and changes in the original root canal path in the apical third, which can compromise endodontic treatment.

Detection of apical deltas is a clinical challenge, as these structures may not be identified in conventional radiographic examinations due to their complexity and small size. Studies comparing the efficacy of different imaging methods in detecting apical deltas suggest that cone beam computed tomography (CBCT) may offer advantages over traditional periapical radiography. However, even CBCT may have limitations in detecting structures of reduced size, such as apical deltas.

In addition, root canal morphology can be influenced by conditions such as hypercementosis, which is the excessive deposition of cementum over the normal layer, promoting root thickening. Barros et al. observed that teeth with hypercementosis presented a significant increase in the presence of apical deltas (53.3%) and a higher frequency of root canal constrictions (55%).

Understanding these anatomical variations is essential for planning and executing endodontic procedures. The use of advanced imaging technologies, such as computed microtomography, has allowed a more detailed analysis of the morphology of the root canal system, contributing to the identification of anatomical variations that may impact the success of endodontic treatment.

In summary, the literature highlights the complexity of the morphology of the apical foramen and the presence of apical deltas as factors that may significantly influence the prognosis of endodontic treatments. The use of high-resolution imaging methods and the understanding of individual anatomical variations are fundamental for clinical endodontic practice.

Using the 1600x HD USB Digital Microscope

The 1600x HD USB digital microscope stands out as an affordable and efficient tool for capturing images for educational purposes. Its high resolution allows detailed documentation of root morphology, providing support for educational articles aimed

at undergraduate dentistry students. Recording images with this equipment enables a better understanding of the anatomical variations of upper molars, aiding in the learning of endodontic techniques. In addition, its ease of use and compatibility with computing devices make it a practical resource for the preparation of educational materials and academic research.

RESULTS

The analysis of the images revealed considerable variability in the apical morphology of the maxillary molars. It was observed that the apical foramen did not always coincide with the anatomical apex of the root, frequently presenting lateral deviations. In addition, multiple foramina were identified around the main foramen, suggesting the presence of apical deltas. These structures varied in number and distribution among the samples, including immature teeth with open apices, indicating significant anatomical complexity in the apical region of these teeth. Figures 1, 2 and 3.

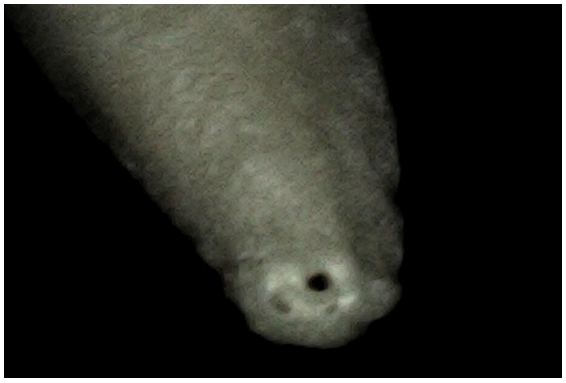

Figure 1: Main foramen with a circular shape surrounded by two elliptical satellite foramina ending the palatine root of tooth element 17.

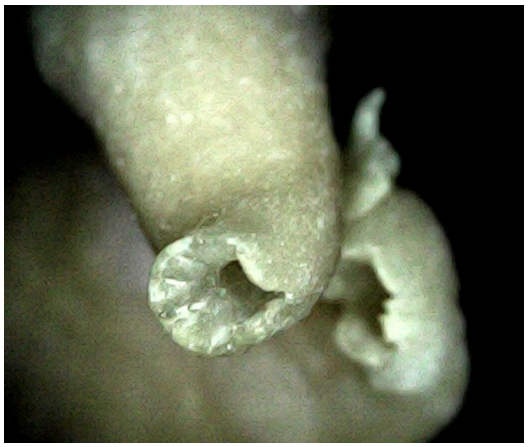

Figure 2: Vestibular roots of a tooth 16. Unfinished open apices with a distal inclination. The shape, similar to a blooming rose, indicates that the apical constriction has not been completed, as this is a tooth that was devitalized before the formative maturation of its roots. In vivo, regenerative endodontic procedures could be chosen for apical completion.

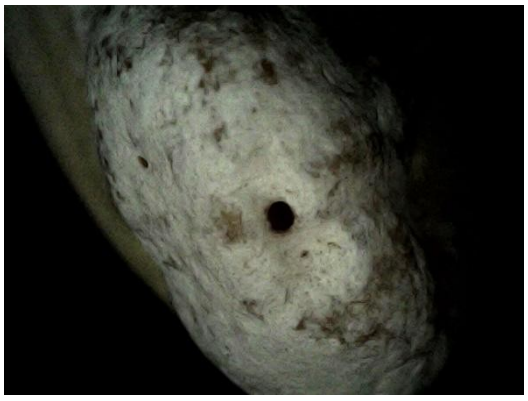

Figure 3: Single main foramen of the upper right third molar with complete fusion of its roots. Note the presence of satellite foramina corresponding to the complex apical delta due to this fusion.

Figure 4: Foramina corresponding to canals MV1 and MV2 in element 26. Note the exit facing laterally towards the internal face of the trifurcation of this dental element.

DISCUSSION

The results of this study corroborate the existing literature, which highlights the anatomical complexity of the apical region of maxillary molars. The presence of multiple foramina and the variability in the location of the main foramen reinforce the need for a meticulous approach during endodontic procedures. The use of high-resolution digital microscopes has proven effective in identifying these anatomical variations, allowing a detailed analysis that can help improve root canal instrumentation and obturation techniques.

Previous studies, such as that of Levorato et al., evaluated the shape and diameters of the main canals and the apical foramen of permanent maxillary molars, finding a predominance of elliptical foramina and significant variations in the dimensions of the root canals. These anatomical variations can directly influence the success of endodontic treatment, especially in determining the working length and adequate obturation of the root canal system.

Furthermore, the presence of apical deltas, characterized by a network of small canals in the apical region, is a relevant anatomical feature. Barros et al. studied the morphology of the apical third of the root and canals of teeth with hypercementosis, using different observation methods, and found a higher frequency of apical deltas in these teeth. They concluded that hypercementosis can cause a higher frequency of apical deltas, constriction in the canal width and changes in the original path of the

root canal in the apical third, which can compromise endodontic treatment.

Detecting apical deltas is a clinical challenge, as these structures may not be identified in conventional radiographic examinations due to their complexity and small size. Studies comparing the effectiveness of different imaging methods in detecting apical deltas suggest that cone beam computed tomography (CBCT) may offer advantages over traditional periapical radiography. However, even CBCT may have limitations in detecting small structures, such as apical deltas.

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In summary, the literature highlights the complexity of the morphology of the apical foramen and the presence of apical deltas as factors that can significantly influence the prognosis of endodontic treatments. The use of high-resolution imaging methods and the understanding of individual anatomical variations are fundamental for clinical endodontic practice.

CONCLUSION

This study highlights the importance of understanding the apical morphology of maxillary molars for successful endodontic treatment. The observed anatomical variability reinforces the need for an individualized approach to each case, using magnification tools that aid in the identification of complex structures, such as apical deltas and multiple foramina.

Morphological analysis of the apices of maxillary molars, using a 1600x HD USB digital microscope without sectioning the roots, revealed significant variability in the apical anatomy, including the presence of multiple foramina and deviations in the location of the main foramen. These findings emphasize the importance of high-resolution imaging techniques in endodontic practice, aiming at an accurate diagnosis and effective treatment.

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