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Research progress on nasopalatine canal type and its relationship with central incisor position

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Abstract: *In recent years, the study of planting technology has received extensive attention and has achieved remarkable results at present. For example, implants are used to restore missing teeth and microimplants are used to adduct anterior teeth with large absolute anchorage to achieve satisfactory orthodontic treatment. However, in clinical practice, whether in the process of restorative treatment or orthodontic treatment, due to the existence of nasopalatine canal, an important bony tubular structure, it increases the risk of implant failure in anterior maxilla implant therapy; it also increases the risk of root resorption caused by excessive anterior adduction and root invasion of nasopalatine canal during orthodontic treatment[1] . Based on this, this paper systematically combs, summarizes and reviews the research status of the nasopalatine canal and its position with the central incisors in recent years in order to provide reference and enlightenment for subsequent researchers.*

Keywords: *Nasopalatine canal; central incisors; dental root resorption; implants; perforation*

1. Introduction

Nasopalatine canal (NPC), also known as incisor canal, is an important bony tubular structure in the maxillary anterior region that begins at the midpalatal suture after the maxillary central incisor and is a conduit between the nasal cavity and oral cavity. Following the maxillary central incisors, the opening in the oral cavity is called the incisive foramen (IF); the opening in the nasal cavity is also called the Stenson s foramina (SF) and contains the nasopalatine nerve, nasopalatine artery, and fibrous connective tissue inside. Studies have shown that there are many morphological and dimensional variations in the nasopalatine canal, which may have important clinical implications in local anesthesia, orthodontic treatment, maxillary surgery, and implant surgery of the anterior jaw[2] .

2. Clinically important influence of nasopalatine canal

2.1 Effect of nasopalatine canal on orthodontic treatment

The maxillary anterior protrusion is considered to be one of the most common malocclusion deformities[3] . There are many methods to correct maxillary anterior protrusion, but in order to maximize flattening and alignment of the dentition and improve the more convex facial pattern, patients with severely protruding anterior teeth require maximum adduction of the anterior teeth. If the root moves out of the cortical bone during maxillary anterior teeth movement, bone dehiscence, bone fenestration and even root resorption may occur. Maximal adduction of maxillary central incisors is the palatal cortical bone of the maxilla. However, in recent years, craniomaxillofacial anatomical studies have shown that the distance from the maxillary central incisors to the nasopalatine canal is less than the distance from the palatal cortical bone[4] . Moreover, as the distance between the root of the maxillary anterior teeth and the nasopalatine canal decreases, the amount of root resorption also gradually increases, with the risk of midshaft resorption being greatest at the apical third[5] .

2.2 Effect of nasopalatine canal on implant therapy

Dental implant restorations have become one of the most common restorative modalities, and during the implant procedure, if the implant encroaches on the nasopalatal canal it can lead to a series of complications such as intraoperative bleeding, short-term postoperative sensory disturbances, and the

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formation of a non-osseous bond between the implant and the nasopalatal canal[6] . Alkanderi[7] and colleagues used virtual implants to interpret and evaluate the importance of the distance between the nasopalatine canal and the central incisor, providing a reference for immediate clinical implant placement to avoid nasopalatine canal penetration by implants.

3. Classification and characteristics of nasopalatine canals

As early as 1984, Du Xizhe[8] studied the nasopalatine canal morphology through the adult skull of 140 cases. It divides the incisive foramen (the opening of the nasopalatine canal in the oral cavity) into three categories: round, oval, and irregular. The incisive foramen was approximately round in 57.20%; oval in 40.10%; irregular in 2.70%; the mean sagittal diameter of the incisive foramen was 5.99 plus or minus 0.14 mm; and the mean distance of the incisive foramen from the alveolar ridge palatal aspect between the maxillary central incisors was 5 .14 plus or minus 0.18 mm. Because the X-ray and CBCT were not yet mature and popular at that time, it was not possible to investigate the nasopalatine canal morphology in the bone, as well as its relationship with the roots of the central incisors. Michael M[9] 's investigation of the nasopalatine canal found that the diameter of the Stansen foramen (opening of the nasopalatine canal in the nasal cavity) was 3.49 mm and the incisor foramen was significantly wider, 4.45 mm in diameter. The mean length of the nasopalatine canal was 10.99 mm. The dimensions of the buccal plate showed an increase in width from the bony roof to the bony roof, with corresponding mean values of 6.5 mm, 6.59 mm, and 7.6 mm. The difference in the diameter of the incisor foramen between the two conclusions may be related to the different measurement tools and measurement methods.

With the gradual maturation of CBCT, in 2013, Sekerci A[10] used CBCT to analyze the characteristics of the nasopalatine canal in a pediatric population, and it classified the nasopalatine canal into six types: funnel, banana, hourglass, conical, dendritic, and cylindrical. Funnel nasopalatine canals were found in 26.9% of children followed by banana type in 19.6%. There was no difference in shape between genders, and the mean nasopalatine canal length was longer in boys than in girls. In 2014, Li Xiaomin[11] used CBCT to classify the shape of the nasopalatine duct into five types: ① Type I: lower width and upper narrowing, ② Type II: lower width and upper narrowing, ③ Type III: irregular, ④ Type IV: homogeneous columnar, and ⑤ Type V: fine linear. They found that the most common nasopalatine canal morphologic type in the midsagittal plane of the maxilla was homogeneous columnar (30.5%), while fine linear (6.5%) was the least common. Hakbilen S[12], a Turkish scholar, classified the nasopalatine canal into six morphologies: cylindrical, conical, hourglass, funnel, branch, and banana. Morphological assessment of their nasopalatine canals revealed: 26.17% nasopalatine canals were tapered, 24.71% were hourglass, 16.80% were cylindrical, 15.83% were funnel-shaped, 11.14% were banana-shaped, and 5.33% were dendritic. In sagittal sections, there was a significant difference in nasopalatine canal length between males and females. Wu Lianjun[13] investigated 500 patients by CBCT. Of these, 33.56% were cylindrical, 27.15% were conical, 10.00% were funnel-shaped, 15.78% were hourglass, 12.26% were banana-shaped, and 1.25% were dendritic. Aleksandra Arnaut[14] divided nasopalatine canal morphology into banana type, hourglass type, funnel type, and cylindrical type in 133 patients (70 males and 63 females), and CBCT studies of nasopalatine canal in the sagittal plane revealed that the most representative nasopalatine canal type was funnel type (34.59%), followed by cylindrical type (28.57%), and hourglass type (24.81%), while banana type was observed in only 12.03% of patients. It also found no apparent differences in gender and nasopalatine canal length between the different palatal canal types, which is slightly different from the findings of Pavle Milanovic[15] and Bahsi, I[16] . Pavle Milanovic[15] found that banana nasopalatine canals had the lowest incidence in both sexes, but funnel nasopalatine canals had the highest incidence in male subjects (36.51%), while in females, the most common nasopalatine canals were cylindrical (36%). Sudheer A[17], an Indian scholar, found that both males and females were the most common cylindrical nasopalatine canals, the least common being the hourglass type, and the length of the nasopalatine canals was generally greater in males than in females, and gradually decreased with increasing age. Guo Ming[18] studied the anatomical shape of nasopalatine canal from the perspective of different ethnic groups, and found that: the median and low labial bone thickness, labial bone length and nasopalatine canal of nasopalatine canal in Uygur were slightly greater than those in Han nationality. The above studies showed that there were differences in the distribution of nasopalatine canal types and the characteristics of nasopalatine canal between genders in different regions.

Currently, there is no clear uniform classification of nasopalatine canal type and measurement internationally. Nasopalatine canal morphology is highly variable, and these different findings may arise

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due to factors such as race, geographic location, environment, age, habits, and genetics that influence nasopalatine canal type and characteristics.

4. Positional relationship between nasopalatine canal and central incisors

Eun-Ae Cho[19] 's study of the positional relationship between the maxillary central incisor and nasopalatine canal found that the anteroposterior distance between the maxillary central incisor root and the incisor canal was approximately 5-6 mm, which is consistent with Mohamad Aslam Baidar Gul l[20] . More than 60% of subjects had incisor canal widths greater than the interroot distance. A comparative study of the relationship between the position of the nasopalatine canal and the middle incisors in terms of different ages and genders by Jingtao Dai[21] found that that the position of the root of the central incisors from the nasopalatine canal was closer in female patients than in male patients; the distance from the root of the maxillary incisors to the nasopalatine canal gradually increased with age. Yan Dong[22] conducted a more refined study and found that the distance from the root of the maxillary central incisor to the nasopalatine canal was significantly greater at the apical level than at the level of the incisor foramen. It also found nasopalatine canal width was less than width of nasopalatine canal at apical level and then was less than width of nasopalatine canal at incisor level. Both investigated the distance between the nasopalatine canal and the root of the central incisor, but did not take into account the differences in the structure of the anterior region of the maxilla in different bone surface patterns.

Wang Texas[23] studied the relationship between the nasopalatine canal and the root of the central incisors from the perspective of different facial patterns, and concluded that there are large individual differences between the nasopalatine canal, and that conventional lateral cephalograms do not accurately predict the proximity between the incisor canal and the root of the incisors, so CBCT examination is recommended to accurately assess the positional relationship between the incisor canal and the maxillary central incisors when planning a large number of adducted anterior teeth.

Ke Huafeng[24] measured the distance from nasopalatine canal to maxillary central incisors in 40 adults with skeletal and dental Class I occlusion relationships, and found that more than 45% of patients had nasopalatine canal width greater than the interradicular distance of central incisors. And the anteroposterior distance between the root of maxillary central incisors and nasopalatine canals in patients with skeletal Class I was 4.5 to 5.5 mm, at the apical level is 4.80 plus or minus 1.27 mm, and at the palatal opening level is 5.10 plus or minus 1.02 mm. Zheng Yi[25] only studied the distance between the nasopalatine canal and the root of the central incisor in adult patients with skeletal Class II average angle and found that there was no significant difference in the width of the incisor canal and the interroot distance of the maxillary central incisor between genders. Ni Jieli[26] showed that the distance between the root of maxillary central incisors and the incisor canal in adult skeletal Class II patients was 3.07 plus or minus 1.35 mm at the apical water and 3.27 plus or minus 1.02 mm at the level of the palatal opening, which was slightly different from the results studied by Ke Huafeng. It can be seen that the distance between the bony Class II maxillary central incisors and the nasopalatine canal is smaller than that between the bony Class I, possibly because the maxilla is more hyperdeveloped in the sagittal and vertical directions in patients with bony Class II compared with those with Class I and III.

Xu Haiyang[27] also conducted a classification study of patients with skeletal II according to different sagittal bone surface patterns and found that patients with skeletal Class II high angle should pay special attention when adducting upper anterior teeth, in which the distance between the incisor root and nasopalatine canal is closer than that between the mean angle and low angle, and the risk of root resorption caused by root contact with nasopalatine canal during adduction is also higher.

Costa E D[28] categorized 127 patients by sagittal, vertical and gender. They found that regardless of facial skeletal type and profile, nasopalatine canal width was significantly greater in males (mean = 2.85 mm; SD = 1.18) compared to nasopalatine canal width in females (mean = 2.40 mm; SD = 1.04). Distance between the medial point of the central incisor root and the opening of the nasopalatine canal was greater in the region close to the root apex of the upper central incisors (mean = 3.84 mm; standard deviation = 1.44) than in the incisor foramen (2.44 mm; standard deviation = 0.04) ($P < 0.05$) . Distances between the upper central incisor roots and the nasopalatine canal were hardly influenced by sagittal and vertical skeletal patterns as well as gender.

Aleksandra Arnaut[14] was the first to relate different nasopalatine canal types to central incisor position, and analysis of the relationship between nasopalatine canal length in an different planes and central incisor distance according to nasopalatine canal types confirmed that banana-type nasopalatine

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canals had the closest distance to the root of central incisors and a greater probability ratio of nasopalatine foramen perforation during adduction of maxillary anterior teeth.

5. Conclusions

In summary, the study of nasopalatine canal and its relationship with central incisors has always been of great significance, and with the continuous development of science and technology, the study of nasopalatine canal is also deepening. Because the variation of nasopalatine canal is large, scholars at home and abroad have classified nasopalatine canal, but international authoritative organizations have not yet uniformly and clearly classified nasopalatine canal types.

Clinically, the closer the nasopalatine canal is to the central incisor, the higher the risk of root resorption caused by root contact or even invasion of the nasopalatine canal during implant failure and large adduction of the anterior teeth during implant placement. The morphological characteristics of the nasopalatine canal are closely related to its positional relationship with the central incisors. Therefore, before implantation or orthodontic planning, the surgeon should understand the morphological characteristics of the nasopalatal canal and its position in relation to the central incisors by using preoperative 3D imaging data to select the appropriate surgical timing, develop a suitable orthodontic treatment plan, and choose the appropriate implant diameter. Digital technology is used to reduce the risk of root resorption of the anterior teeth and the rate of perforation of the nasopalatal canal.

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