Influencing factors of maximum retraction of maxillary central incisor and its clinical significance in orthodontic treatment

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Abstract: The position of the maxillary central incisor (MCI) directly affects the appearance of the patient's profile. For patients with bimaxillary protrusion or maxillary protrusion, orthodontic treatment often adopts a large number of retractions of the maxillary anterior teeth to improve the profile. However, the retraction of MCI is limited, and the maximum retraction depends on the distance between the root of MCI and the incisor canal(IC). This distance is not a constant value and is affected by many factors. This article reviews the influencing factors of the maximum retraction of MCI and its clinical significance in orthodontic treatment.

Keywords: Maxillary central incisor; Incisive canal; Maximum retraction; influencing factor

Introduction

The position of MCI has an important impact on the profile and aesthetics of orthodontic patients[1]. For patients with bimaxillary protrusion or maxillary protrusion, a large number of retractions of MCI are used to improve the profile appearance to achieve ideal orthodontic effects [2]. However, the range of tooth movement is limited, and the tooth needs to move within the cancellous bone. If the tooth is in contact with cortical bone, local pressure will lead to complications such as iatrogenic root resorption[3]. It is generally believed that the palatal bone plate of the maxilla is the posterior boundary of the retraction[4]. However, with the application of CBCT, it has been found that there is a special structure between the upper central incisor and the palatal bone plate, the incisive canal, and this structure is more closely related to MCI. During the palatal movement of the upper central incisor, it may first touch the incisive canal instead of the palatal bone plate. Therefore, it is proposed that the positional relationship between the MCI and the IC is related to the root resorption during anterior teeth retraction[5,6]. Due to the existence of IC, the maximum retraction of MCI is less than previously recognized, so the wall of IC can be considered as the limit of the retraction of MCI. The maximum retraction of MCI depends on the positional relationship between MCI and IC. The relationship is affected by many factors. Understanding the maximum retraction amount of orthodontic patients is helpful to make a treatment plan and adjust the tooth movement during the operation, avoid contact between MCI and IC to the greatest extent, and reduce the incidence of iatrogenic root resorption, bone fenestration, bone dehiscence and other complications. This article reviews the influencing factors of the maximum retraction of MCI and its clinical guiding significance.

1. Boundary and maximum amount of palatal movement of MCI

The retraction of MCI is limited by both anchorage and bone conditions. Traditional orthodontic anchorage allows the maximum retraction of MCI to be 5.78m, while in recent years; the widely used implant anchorage can increase the maximum retraction to 8mm[7]. The application of implant anchorage achieved absolute anchorage control so that the retraction of MCI was basically not affected by anchorage conditions. However, tooth movement needs to be carried out in the cancellous bone, so the bone structure is still the most important factor limiting the retraction of MCI. Anatomically, the incisive canal is closer to the upper central incisor. Cho et al[8] found that the diameter of IC was larger than the minimum distance between the roots of bilateral upper central incisors in more than 60% of the samples, and they considered that the root had the risk of touching the wall of IC when MCI was retracted to the maximum extent. There are also many clinical reports of root resorption caused by invasion of the IC[9,10].

Therefore, the position between MCI and IC is related to the root resorption of MCI, and the wall of IC should be considered as a safe boundary for the retraction of MCI.

The maximum retraction of MCI is the maximum distance that MCI can move palatally without cortical bone contact, but this distance is not constant. According to the existing research and analysis, the anteroposterior distance between MCI and IC is about 4 to 6mm[11]. Yu et al.[12] found that when the retraction of MCI exceeded 4mm, root resorption occurred in 53% of the cases due to invasion of IC. Khurana et al.[13] also found that when the MCI was retracted more than 4mm, the probability of root resorption was much higher than that of patients with retraction less than 2mm. The maximum retraction of MCI depends on the position between MCI and IC, which is affected by many factors and has individual differences.

2. Factors influencing the maximum retraction of MCI

2.1 Shape and position of the incisive canal

IC is located between MCI and maxillary palatal bone plate, usually between the roots of the left and right maxillary central incisors. It is a tubular structure surrounded by cortical bone in the maxilla that connects the oral cavity with the nasal cavity. The diameter of the incisive canal generally does not exceed 6mm. When it exceeds 10mm, pathological changes such as cysts or tumors should be considered[14].

Some studies have suggested that with the increase of the volume and diameter of IC, the probability of MCI invading the wall of IC increases significantly. Through clinical comparison, the volume and surface area of the incisor canal in the exposed group (138.7 mm^3, 191.5 mm^2) were significantly larger than those in the unexposed group (83.3 mm^3, 136.5 mm^2) [15]. In addition, the morphology of the incisive canal has a certain effect on the diameter of IC and the distance between IC and MCI in different sections [15]. There are four common shapes of the incisive canal: conical (35.4%), cylindrical (31.0%), hourglass (24.8%), and banana (8.8%) [16]. Among them, the distance of the cylindrical shape is the largest, while the distance of the banana-shaped shape is the smallest. Therefore, it is believed that among the four types mentioned above, banana-shaped patients are the most prone to root resorption [17].

Besides the incisive canal morphology, the position of MCI within the maxilla is an important factor. It is generally believed that IC is located in the middle of the left and right upper central incisors. However, Ya et al[18] found that the midpoint of the apical line of the bilateral upper central incisors did not coincide with the center of the IC in 40.7% of the samples. Jia et al. [19] found that the incisive canal was more inclined to the right upper central incisor at the level of the nasopalatal foramen and the incisive foramen. Pan et al. [9] also made similar findings and believed that even without midline deviation; more attention should be paid to the position between IC and the right upper central incisor. In the vertical direction, the position of the incisive canal also affects its relationship with the upper central incisor. Clinically, the position of the central incisor canal in the resorption group (2.86±1.10 mm) was lower than that in the non-resorption group (4.07±1.72 mm)[9]. When the position of IC is low, it will increase the risk of contact with the MCI. Therefore, clinical attention should be paid not only to the shape and volume of IC, but also to the position and height of IC.

2.2 Sagittal and vertical skeletal facial patterns

Skeletal patterns play an important role in diagnosis, treatment planning, and growth prediction. From the sagittal perspective, the skeletal facial types can be divided into skeletal classes I, II, and III. Donget al. [20]found that the diameter of the incisor canal in skeletal Class I and II was larger than that in skeletal Class III in both sagittal and coronal planes, indicating that the maxillary central incisors in skeletal Class I and II were more likely to contact the incisor canal than those in skeletal Class III patients. Cho et al.[8] found that the anteroposterior distance between the root of MCI and IC was (4.90±1.30) mm at the apical level and (5.20±1.16) mm at the palatal opening level in skeletal ClassI adult patients. The results of Ke et al. [21] are also close to it. Ni et al. [22]found that the distance between MCI and IC in adult skeletal Class II patients was (3.07±1.35) mm at the apical level and (3.27±1.02) mm at the palatal opening plane. By comparing the results of the above studies, it was found that the distance between MCI and IC in the skeletal class II was smaller than that in the skeletal class I in each horizontal section.The MCI in skeletal Class II was supposed to move more palatally, while IC in skeletal Class II had a larger diameter, and the distance between MCI and IC was smaller. Therefore, the risk of contact with the incisor canal during movement was higher.

From the vertical direction, it can be divided into low, average, and high angles. Al-rokhami et al.[23]compared the average distance between MCI at different heights and IC at the corresponding positions and found that: The distance of the low-angle group was the largest, followed by the average-angle group, and the high-angle group was the smallest, which were 4.78±1.17 (mm), 4.36±1.18 (mm), and 3.86±0.90 (mm), respectively [23], indicating that the upper central incisor could move in the palatal direction in high-angle patients. In addition, the volume and diameter of IC are not affected by the vertical skeletal facial type [24, 25], but the inter-root distance between the bilateral upper central incisors of the low-angle patients is greater than that of the high-angle patients [26], indicating that the probability of the upper central incisors of the low-angle patients to contact the high-angle patients is lower. Al-rokhami et al. [23] compared the inter-root distance of MCIs and the diameter of IC and found that the percentage of IC greater than the root distance of MCIs was 65% in the high-angle group, while this data only accounted for 55.65% in low-angle group.

For skeletal Class II patients, different vertical skeletal patterns directly affect the design of treatment plans. The low-angle group had a shorter lower 1/3 of the face, a flat mandibular plane, strong masticatory muscle, strict extraction criteria, and less retraction of MCI. However, the high-angle group hasa long lower 1/3 of the face, a steep mandibular plane, weak masticatory muscle, loose tooth extraction criteria, and larger retraction[27]. However, the safe range of palatal movement of MCI is the smallest in the high-angle group, and the probability of contacting IC is the highest during movement. Therefore, when skeletal Class II patients need a large amount of retraction, it is necessary to understand the posterior boundary of palatal movement, especially in the high-angle group.

2.3 The axial inclination of MCI and the position of the root in the alveolar bone

Because the crown moves in opposite directions to the root, the axial inclination of MCI also affects the positional relationship between MCI and IC. Zheng et al. [28]divided the samples into three groups according to the inclination of MCI: the labial group, the upright group, and the lingual group. By comparing the percentage of the diameter of IC greater than the root distance of MCIs, it was found that the percentage of the labial group was greater than that of the lingual group, and the labial tilt group was considered to be more susceptible to the influence of IC. Ni et al.[22] found that the root of the labially inclined MCI was closer to the incisor canal and palatal bone plate, while the root of the lingually inclined MCI was closer to the labial bone plate. Tian et al. [29] also made similar findings. Based on the above, in skeletal Class II patients with controlled root retraction, Class II 1s tends to be more likely to contact IC than Class II 2s, and proper lingual movement of the central incisor should be considered to keep the root away from the incisive canal. On the contrary, in skeletal Class III patients, attention should be paid to avoid excessive compensation when MCI is compensated for labial inclination, resulting in the root touching the incisor canal. In addition, according to the sagittal position of MCI within the jaw, it can be roughly divided into labial, central, and palatal, with the labial group being the most common. According to reports, the incidence of the labial group is 78.8%-95.4% [30], while the palatal root is rare (0.0%-1.8%) [31, 32]. Andrews et al.[33]found that in skeletal Class II patients, the distance between MCI and the labial side of the alveolar process was greater than that between the palatal side, with a ratio of about 2:1. In general, the root of MCI is basically located in the anterior part of the maxillary alveolar bone, close to the labial bone plate. Therefore, if the upper central incisor is found in the center of the upper alveolar bone or on the palatal side, attention should be paid to the position of its root in the jaw bone. If the root is located on the palatal side of the jaw, attention should be paid to avoid IC during the root movement.

2.4 Gender and age

Through quantitative analysis of the distance between IC and MCI at the apical level, Dai et al. [34]found that the measured value of females was significantly lower than that of males, which was mainly because males had better maxillary development and physique than females. Some scholars have found that there are gender differences in the shape of the incisor canal, mainly manifested as the wider diameter and longer length of the male incisor canal [24]. However, some scholars hold the opposite view and believe that there is no obvious relationship between the shape of IC and gender [35, 36]. Al-rokham et al. [23] found that compared with females (62.9%), only 56.5% of male patients had the diameter of IC larger than the distance between the roots of bilateral upper central incisors. In conclusion, although the size of the IC is larger in men, MCI is not more likely to contact the wall of IC, because the distance between the roots of MCIs is wider than the diameter of IC in males and the jaw is more developed than the female.Whether and how gender affects the maximum retraction needs to be further studied.

Soumya et al. [35] found that the length and diameter of the incisive canal increased with age, and the diameter and length of the young were significantly smaller than those of the old. Costa et al. [25] also found that the volume of the

incisional canal increased with age, especially after the age of 50. The risk of upper central incisor roots contacting the wall of IC increases with age. Meanwhile, Dai et al. [34] found that with the increase of age, the minimum distance between the root 1/2 of MCI and IC as well as the minimum distance between the apical point and the IC gradually increased. This may be due to the fact that the age-related changes in the maxilla are not simple linear changes. During the development period, the maxillary changes are mainly manifested as the deposition of the labial bone plate, the absorption of the palatal bone plate, and the increase of maxillary volume. In the aged group, the labial bone plate is absorbed, the palatal bone plate is deposited, and the maxillary volume decreases. Linjawi et al. [37] also found that the Angle between IC and the palatal plane increased with age in adolescence and decreased with age after middle age. Therefore, when evaluating the effect of age on the maximum retraction of MCI, it is necessary to consider the age-related changes of IC and the maxilla.

3. Clinical significance of maximum retraction of MCI in orthodontic treatment

3.1 Fill the defects of the pre-treatment examination

At present, most of the pre-treatment clinical examinations of orthodontics are two-dimensional imaging examinations, such as panoramic radiographs and lateral cephalograms. However, two-dimensional imaging examinations are affected by the adjacent anatomical structures and overlap each other, so it is often difficult to find IC and to show its positional relationship with MCIs. However, CBCT can eliminate the interference of adjacent tissues and vividly display the relationship of each anatomical structure in the three-dimensional direction [38, 39], which is conducive to doctors knowing the anatomical structure around MCIs before surgery and determining the position of the posterior boundary of the maximum retraction. The position relationship between MCI and IC is affected by many factors, and the maximum retraction amount o varies among individuals. Therefore, CBCT is necessary for patients who need a large number of anterior teeth retractions to determine the maximum retraction amount and avoid iatrogenic root resorption.

3.2 Influence the design of orthodontic treatment plan and the adjustment of tooth movement

Profit et al.[40]took the palatal bone plate as the posterior boundary of retraction and proposed that the maximum retraction of MCI could be 7mm according to the idea of "envelope of discrepancy", which was opposed by Ono et al. [41]. However, according to the existing studies, the anteroposterior distance from the root of MCI to the wall of IC is less than 7mm [11, 21]. The boundary of the retraction of MCI has changed. The maximum retraction amount has important guiding significance for the design of the orthodontic treatment plan. For patients with obvious maxillary protrusion or bimaxillary protrusion, the maximal amount should be considered. If the actual maximal amount is significantly less than the ideal amount, orthodontic-surgical treatment should be given priority, and the orthodontic treatment should be carefully selected since the limit of compensatory treatment should not be challenged. Excessive pursuit of the compensation of MCI and neglect of the cortical bone constraint on the palatal side will eventually lead to root invasion into IC and root resorption.

Anatomically, the distance between the root of MCI and the wall of IC is the smallest at the level of the incisor foramen, the root 1/3, and the mesial palatal side of the root is most likely to contact with the wall of the IC[9,28]. On the contrary, the distance between the root and the wall of IC increases with the increase in height. At the root tip, the distance from the incisive canal is the furthest, and the diameter of the incisive canal is smaller than the distance between the roots of bilateral upper central incisors at this level [15, 17]. Therefore, the most dangerous place is the mesial palatal side of the root 1/3, not the apex. During orthodontic treatment, attention should be paid to the relationship between the apical 1/3 root and the wall of IC. The angle of the MCI should be adjusted in time to avoid IC, especially in skeletal Class II patients with maxillary protrusion or skeletal Class I patients with bilateral protrusion who need a large amount of retraction.

3.3 Reconstruction of IC after retraction

Although there are a few patients who will have a certain degree of reconstruction of IC with orthodontic tooth movement, the reconstruction of IC is a self-protection mechanism under external harmful stimulation. The amount of root resorption of MCI can be reduced by reconstruction, but it cannot be prevented[5]. Some scholars have proposed that IC can be reconstructed by the minimization of the incisive canal or the unilateral neurovascular technique [42,43]to expand the posterior boundary. However, it has been reported that the above two kinds can lead to local sensory hyperfunction or hypofunction in patients[43]. Therefore, whether they are suitable for clinical promotion remains to be evaluated.

4. Conclusion

The maximum retraction of MCI represents the maximum safe range of palatal movement of MCI, which has important guiding significance to orthodontic treatment plans and adjustment of tooth movement during treatment. The position between the MCI and IC is affected by many factors and varies among individuals. CBCT can help doctors to have a better understanding of the posterior boundary of the retraction and avoid the complications such as iatrogenic root resorption during treatment, which is helpful to achieve the goal of healthy treatment.

Reference

1. SARVER D M. The importance of incisor positioning in the esthetic smile: the smile arc. American journal of orthodontics and dentofacial orthopedics: official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics, 2001, 120(2): 98-111.
2. XU Y, XIE J. Comparison of the effects of mini-implant and traditional anchorage on patients with maxillary dentoalveolar protrusion [J]. The Angle orthodontist, 2017, 87(2): 320-7.
3. FELLER L, KHAMMISSA R A, THOMADAKIS G, et al. Apical External Root Resorption and Repair in Orthodontic Tooth Movement: Biological Events. BioMed research international, 2016, 2016(4864195.
4. HORIUCHI A, HOTOKEZAKA H, KOBAYASHI K. Correlation between cortical plate proximity and apical root resorption. American journal of orthodontics and dentofacial orthopedics: official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics, 1998, 114(3): 311-8.
5. NAKADA T, MOTOYOSHI M, HORINUKI E, et al. Cone-beam computed tomography evaluation of the association of cortical plate proximity and apical root resorption after orthodontic treatment. Journal of oral science, 2016, 58(2): 231-6.
6. CHUNG C J, CHOI Y J, KIM K H. Approximation and contact of the maxillary central incisor roots with the incisive canal after maximum retraction with temporary anchorage devices: Report of 2 patients. American journal of orthodontics and dentofacial orthopedics: official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics, 2015, 148(3): 493-502.
7. LIOU E J, CHANG P M. Apical root resorption in orthodontic patients with en-masse maxillary anterior retraction and intrusion with miniscrews. American journal of orthodontics and dentofacial orthopedics: official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics, 2010, 137(2): 207-12.
8. CHO E A, KIM S J, CHOI Y J, et al. Morphologic evaluation of the incisive canal and its proximity to the maxillary central incisors using computed tomography image. The Angle orthodontist, 2016, 86(4): 571-6.
9. PAN Y, CHEN S. Contact of the incisive canal and upper central incisors causing root resorption after retraction with orthodontic mini-implants: A CBCT study. The Angle orthodontist, 2019, 89(2): 200-5.
10. IMAMURA T, UESUGI S, ONO T. Unilateral maxillary central incisor root resorption after orthodontic treatment for Angle Class II, division 1 malocclusion with significant maxillary midline deviation: A possible correlation with root proximity to the incisive cana. Korean journal of orthodontics, 2020, 50(3): 216-26.
11. MATSUMURA T, ISHIDA Y, KAWABE A, et al. Quantitative analysis of the relationship between maxillary incisors and the incisive canal by cone-beam computed tomography in an adult Japanese population. Progress in orthodontics, 2017, 18(1): 24.
12. YU J H, NGUYEN T, KIM Y I, et al. Morphologic changes of the incisive canal and its proximity to maxillary incisor roots after anterior tooth movemen. American journal of orthodontics and dentofacial orthopedics: official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics, 2022, 161(3): 396-403.e1.
13. KHURANA S, PARASHER P, MUKHERJEE P, et al. Cone beam computed tomographic-Based retrospective study on Newark population for the assessment of distance between incisive canal and maxillary central incisors: Clinical implication. Indian journal of dental research: official publication of Indian Society for Dental Research, 2020, 31(2): 175-9.
14. WU L J, YAO L T, ZHANG C X, et al. Morphological Characteristics of Incisive Canal by Cone Beam Computer Tomograph. Journal of Oral Science Research, 2020, 36(07): 693-7.

15. CHUNG C J, NGUYEN T, LEE J H, et al. Incisive canal remodeling following maximum anterior retraction reduces apical root resorptio. Orthodontics & craniofacial research, 2021, 24 Suppl 1(59-65.
16. MILANOVIC P, SELAKOVIC D, VASILJEVIC M, et al. Morphological Characteristics of the Nasopalatine Canal and the Relationship with the Anterior Maxillary Bone-A Cone Beam Computed Tomography Study. Diagnostics (Basel, Switzerland), 2021, 11(5):
17. ARNAUT A, MILANOVIC P, VASILJEVIC M, et al. The Shape of Nasopalatine Canal as a Determining Factor in Therapeutic Approach for Orthodontic Teeth Movement-A CBCT Study. Diagnostics (Basel, Switzerland), 2021, 11(12):
18. YAN D, SHI Y J, GE Y, et al. Quantitative study of the relationship between the incisive canal and maxillary central incisors. Stomatology, 2021, 41(07): 627-30+39.
19. JIA X, HU W, MENG H. Relationship of central incisor implant placement to the ridge configuration anterior to the nasopalatine canal in dentate and partially edentulous individuals: a comparative study. PeerJ, 2015, 3(e1315.
20. DONG G H, GAN K, WANG N, et al. CBCT Study on Relationship between Sagittal Skeletal Patterns and Incisive Canal. Henan Medical Research, 2020, 29(01): 27-9.
21. KE H F, LIU L, YUAN Z Y, et al. The relative position between incisive canal and the maxillary central incisors studied by CBCT. Journal of Practical Stomatology, 2018, 34(03): 385-8.
22. NI J L, QIN J W, ZHANG Y, et al. Study on the relationship between the roots of maxillary central incisors and the incisive canal in skeletal Ⅱ adults. Journal of Nanjing Medical University (Natural Sciences), 2021, 41(01): 103-8.
23. AL-ROKHAMI R K, SAKRAN K A, ALHAMMADI M S, et al. Proximity of upper central incisors to incisive canal among subjects with maxillary dentoalveolar protrusion in various facial growth patterns. The Angle orthodontist, 2022, 92(4): 529-36.
24. COSTA E D, DE OLIVEIRA REIS L, GAêTA-ARAUJO H, et al. Comparison of distance of upper central incisor root and incisive canal in different sagittal and vertical skeletal patterns and sex: A retrospective CBCT study. International orthodontics, 2021, 19(3): 462-70.
25. COSTA E D D, NEJAIM Y, MARTINS L A C, et al. Morphological Evaluation of the Nasopalatine Canal in Patients With Different Facial Profiles and Ages. Journal of oral and maxillofacial surgery: official journal of the American Association of Oral and Maxillofacial Surgeons, 2019, 77(4): 721-9.
26. XU H Y, ZHANG W B. A study of three-dimensional relationship between the maxillary central incisor roots and the incisive canal in skeletal Class Ⅱ malocclusion in adults. Chin J Orthod, 2019, 04): 203-8.
27. PEPICELLI A, WOODS M, BRIGGS C. The mandibular muscles and their importance in orthodontics: a contemporary review. American journal of orthodontics and dentofacial orthopedics: official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics, 2005, 128(6): 774-80.
28. Zheng Y, Xie M, Wei L Y. A cone-beam CT study on position relationship between upper central incisors and incisive canal of adults with skeletal class II average-angle pattern malocclusion. Journal of Guangxi Medical University, 2021, 38(08): 1541-5.
29. TIAN Y L, LIU F, SUN H J, et al. Alveolar bone thickness around maxillary central incisors of different inclination assessed with cone-beam computed tomography. Korean journal of orthodontics, 2015, 45(5): 245-52.
30. SHRESTHA R, LIU X, CHEN S, et al. Correlation of anterior overbite with root position and buccal bone thickness of maxillary anterior teeth: a CBCT study. Surgical and radiologic anatomy: SRA, 2019, 41(8): 935-42.
31. JUNG Y H, CHO B H, HWANG J J. Analysis of the root position of the maxillary incisors in the alveolar bone using cone-beam computed tomography. Imaging science in dentistry, 2017, 47(3): 181-7.
32. XU D, WANG Z, SUN L, et al. Classification of the Root Position of the Maxillary Central Incisors and its Clinical Significance in Immediate Implant Placement. Implant dentistry, 2016, 25(4): 520-4.
33. ANDREWS W A, ABDULRAZZAQ W S, HUNT J E, et al. Incisor position and alveolar bone thickness. The Angle orthodontist, 2022, 92(1): 3-10.
34. DAI J T, LI P, LI AN, et al. Study on the positional relation of incisive canal and maxillary central incisor root by Cone-beam Computed Tomography. Chinese Journal of Aesthetic Medicine, 2014, 23(22): 1904-8.
35. SOUMYA P, KOPPOLU P, PATHAKOTA K R, et al. Maxillary Incisive Canal Characteristics: A Radiographic Study Using Cone Beam Computerized Tomography. Radiology research and practice, 2019, 2019(6151253.

36. MAGAT G, AKYUZ M. Are morphological and morphometric characteristics of maxillary anterior region and nasopalatine canal related to each other? Oral radiology, 2022,
37. LINJAWI A I, MARGHALANI H Y A. Relationship between maxillary central incisors and incisive canal: a cone-beam computed tomography study. Folia morphological, 2022, 81(2): 458-63.
38. KAPILA S D, NERVINA J M. CBCT in orthodontics: assessment of treatment outcomes and indications for its use. Dentomaxillo facial radiology, 2015, 44(1): 20140282.
39. VENKATESH E, ELLURU S V. Cone beam computed tomography: basics and applications in dentistry. Journal of Istanbul University Faculty of Dentistry, 2017, 51(3 Suppl 1): S102-s21.
40. Proffit WR, Ackerman JL. Diagnosis and treatment planning.In: Graber T, Swain B, editors. Current orthodontic concepts and techniques. St Louis: Mosby; 1982. p. 3–100.
41. ONO T. Should the "envelope of discrepancy" be revised in the era of three-dimensional imaging?. Journal of the World federation of orthodontists, 2020, 9(3s): S59-s66.
42. PEñARROCHA D, CANDEL E, GUIRADO J L, et al. Implants placed in the nasopalatine canal to rehabilitate severely atrophic maxillae: a retrospective study with long follow-up. The Journal of oral implantology, 2014, 40(6): 699-706.
43. URBAN I, JOVANOVIC S A, BUSER D, et al. Partial lateralization of the nasopalatine nerve at the incisive foramen for ridge augmentation in the anterior maxilla prior to placement of dental implants: a retrospective case series evaluating self-reported data and neurosensory testing. The International journal of periodontics & restorative dentistry, 2015, 35(2): 169-77.