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Clinical Application of Digital Technology in Orthodontics

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Abstract
In recent years, with the development of computer technology, digital medical technology plays an important role in the medical field. Digital technologies such as intraoral scanning digital impression and cone beam computed tomography make the examination results of patients more accurate and perfect and derive a series of intelligent tools such as virtual bracket location and artificial intelligence automatic tooth arrangement to help doctors make personalized treatment plans for patients. In addition, the application of digital technology in orthodontics achieves a realistic preview effect through virtual simulation, which facilitates the communication between doctors and patients and improves the satisfaction of patients.

KEY WORDS: Digitization; orthodontics; computer technology

INTRODUCTION
With the continuous development and application of social digital technology, it has had a great impact on the technological revolution in the field of stomatology. Digital technology uses computer technology to analyze clinical data, classification and case similarity, on the basis of which it integrates orthodontics, biomechanics, medical imaging, 3D scanning and printing technology, mathematics and other multi-disciplinary knowledge. Highlight the importance of doctors' decision-making in the design, and reduce human errors in the treatment process, making the results infinitely close to the ideal. At present, digital technology is widely used in the fields of computer-aided design / computer-aided manufacturing, computer-aided diagnosis and navigation, three-dimensional digital imaging technology, laser 3D printing, design and manufacture of personalized appliance and so on. Among them, digital dental model, cone beam computed tomography, digital occlusal reconstruction technology, digital guide plate are commonly used in orthodontics and restoration treatment [1]. In order to understand the application and development of digital technology in the field of orthodontics, this review looked up a number of literatures about digital diagnosis and treatment at home and abroad, in order to better apply it to orthodontic diagnosis and research.

1.Three-dimensional data acquisition technology in stomatology

1.1 Scanning technique of dental model
The traditional plaster model divides the crown of the plaster model through the model saw, rearranges and locates it, but the segmented plaster model is difficult to achieve multiple splicing operations and is easily damaged, and the positioning and rearrangement will be limited accordingly. However, the three-dimensional digital dental model completely shows the arrangement of the patient's teeth, as well as the dental arch, alveolar, base bone and palatal cover through the software. The traditional plaster model is difficult to disassemble and reorganize one by one [2], which will no longer be a problem in the three-dimensional model, it can locate and measure each tooth in the patient's oral cavity separately, and it is convenient to disassemble and rearrange one by one. So as to provide a more accurate digital basis for orthodontic programs [3]. Laser scanning method has been developed rapidly since it was used for three-dimensional reconstruction of tooth and jaw model at the end of 1980s. Its principle is to measure the distance between the axis of constant spiral rotation and the surface of the object by laser triangulation. According to the position and distance of the detection parts, the three-dimensional coordinates of the point are calculated, and the integrated reconstruction is carried out after computer analysis and processing [4].

In the three-dimensional digital dental model reconstructed based on laser scanning technology, the accuracy of crown width and crown height is high, the arch length is the second, and the accuracy of arch width is low [5]. The main advantages of this method are simple operation, low cost and image accuracy of 300μm. However, there are some shortcomings such as a certain scanning blind area and slow scanning speed when the model is too large and concave [4].

With the development of three-dimensional reconstruction of CT, not only the three-dimensional anatomical structure of the jaw can be displayed digitally, but also the morphological results of dental crown and root can be displayed. Using laser three-dimensional scanning to reconstruct the digital model of dentition and recording the spatial structure of dental crown arrangement can not only directly show the anatomical structure of dentition for clinicians, but also lay a foundation for computer-aided design and computer-aided manufacturing of clinical dental models. In the process of orthodontic treatment, using laser three-dimensional scanning and CT data to establish a three-dimensional digital tooth model with tooth root can not only show the anatomical structure of tooth crown and root, but also monitor the movement of tooth crown and root, which is convenient to guide the treatment process and evaluate the treatment effect [6].

1.2 Intraoral three-dimensional scanning technique

Intraoral scanning directly obtains the information in the patient's mouth through the instrument, and directly transmits the information to the orthodontic design company through the connection network for corresponding processing, diagnosis, design, and production of virtual tooth arrangement animation. so that doctors and patients can understand the orthodontic process more intuitively. The intra-oral scanning avoids the error caused by the deformation of the material, has high accuracy, and avoids the tedious steps such as mold taking and mailing, which makes the whole process more convenient [7,8].

At the same time, by obtaining dental model data directly from patients' mouth, intraoral scanning technology can avoid the problems of deformation and air bubbles in the process of traditional impression making, and can also obtain the color data of teeth and gums, which can improve the accuracy of the model data (the accuracy can reach 5~20 μ m) and reduce the clinical operation time (scanning time 5 ~ 10 min) [9]. In addition, the artificial intelligence automatic dental arrangement software (iTero, Shining 3D Tech Co. etc.), which is included in the intraoral scanning software at home and abroad, can complete the automatic dentition segmentation and automatic dental arrangement of the intraoral scanning data in tens of seconds. But this kind of artificial intelligence can only arrange the teeth neatly and evenly. However, there are many considerations missing in the real orthodontic scheme, such as: coordination of tooth mass and bone mass after direct alignment of dentition, tooth extraction, sagittal and transverse position and relationship of upper and lower teeth, vertical control, facial aesthetic ratio and so on. Doctor intervention is still needed to establish accurate results of dental arrangement [10]. With the continuous development of scanning technology, it can even realize the tracking and simulation of patients' facial dynamic data, digitization and information technology will play a more and more important role in orthodontic diagnosis and treatment.

1.3 Facial 3D scanning technique

In orthodontic clinical work, attention is paid not only to the changes of tooth and occlusal relationship, but also to the changes of maxillofacial soft tissue. However, at present, the direct contact method is often used in the quantitative measurement of maxillofacial soft tissue changes in clinics, and the measurement accuracy is low, so it is impossible to compare different treatment stages. Because the laser three-dimensional scanning technology is mainly used to scan the spatial shape structure of the object and obtain the spatial coordinates of its surface, it can scan the surface of human tissues and organs and use its data to accurately reconstruct the three-dimensional digital model of the surface profile of human tissues and organs [11].

The establishment of soft tissue digital model by laser three-dimensional scanning of maxillofacial region has the advantages of intuition, convenience, simplicity, strong repeatability and so on. The overlap of digital models in different periods can clearly and intuitively show the changes of maxillofacial soft tissue, and can quantitatively measure points, planes, angles and radians in the software; at the same time, it is convenient, non-radioactive, and patients can be collected many times, and the results are digitally preserved. Through the establishment of three-dimensional digital models of soft and hard tissues and teeth and jaws of the maxillofacial region, and with the help of interactive technology, three kinds of digital information of the reconstructed skull, facial image and dental jaw model can be accurately integrated. Help orthodontists to make a more comprehensive and accurate judgment and analysis of dental and maxillofacial deformities, and provide rich data for teaching and scientific research.

1.4 Cone beam CT (CBCT) technology

Cone beam CT (Cone Beam Computed Tomography,CBCT) is a cone beam projection computer recombination tomography equipment. Different from the traditional two-dimensional imaging, it can reflect the relationship between each tooth and bone from a three-dimensional point of view, which promotes the development of stomatology [12].

CBCT is a new three-dimensional imaging technology, which has the advantages of simple operation, fast scanning speed and high X-ray utilization rate. Traditional two-dimensional images such as curved section film and frontal and lateral cephalogram can be obtained from CBCT images, and doctors can measure cephalometry through cephalogram. The traditional lateral X-ray film of the head is affected by the distance between the bilateral facial tissue and the radiation probe, and the phenomena of image magnification, overlap and distortion are more serious, which makes the image clearer. After CBCT reconstruction, the clear and real tissue structure can be displayed in multiple directions and on multiple planes, and the angle can be changed arbitrarily to observe the position and shape of teeth and jaws in all directions to obtain a more accurate and clear image [13]. At the same time, the radiation dose of CBCT is much lower than that of CT examination, and the radiation dose is about 20% of that of traditional CT, which is safe [14]. In addition, the three-dimensional model of the skull obtained by three-dimensional CT scanning is suitable for surgical simulation, molding, template making and so on, which can help clinicians better understand the inducing mechanism of dental deformities, and then provide a basis for the specific implementation of clinical orthodontic treatment [15].

CBCT is designed to overcome some of the limitations of traditional computed tomography (CT) and provide high-resolution 3D images at relatively low dose and cost [16]. However, CBCT still provides higher doses than two-dimensional scans. With the rapid development of CBCT technology, there is still a growing gap between the rational use of CBCT and the existing scientific evidence. This is especially true among children, who are more vulnerable to radiation doses and whose diagnosis is often challenging [17,18].

1.5 Recording and analysis technique of mandibular movement trajectory

Mandibular movement has always been the common object of various disciplines of stomatology, and it is also the external manifestation of oral functional activities such as chewing, swallowing, language, expression and so on. Temporomandibular joint, masticatory muscle group, tooth occlusal contact and so on need to coordinate to ensure normal mandibular movement, so it is very necessary to record the track of mandibular movement accurately [19].

Electronic facial arch, also known as mandibular movement analyzer, MMA, can accurately record data, use sensors to find the exact position of the hinge axis, and guide patients to do corresponding mandibular movement. The sensor records the patient's motion data and transmits it to the computer. The computer uses the software system to analyze and process the joint motion data, and uses various joint analysis data built in the software to get the frame setting data [20].

For orthodontics, orthodontic treatment is a complex and long-term process. The real-time recording system of mandibular movement can well detect the changes in the process of orthodontics, analyze the effects of orthodontic treatment on patients' joints and oral jaw system, and help clinicians to make an analysis [21]. The research of Aslanidou K, He S [22-23] and others shows that this system can also assist doctors to analyze the changes of patients' oral and maxillofacial system during the whole orthodontic process, and can quantitatively display some indexes, accurately analyze the orthodontic treatment of each patient, and promote the progress and innovation of related technology.

Therefore, in clinical work, orthodontic treatment should not only pay attention to beauty, but also pay attention to the stability and coordination of mandibular system movement.

1.6 Stereoscopic photography technology

3dMD is a three-dimensional photography system based on the principle of binocular vision. More than two digital images of the same object can be obtained at the same time by more than two cameras in different positions, and the image can be transferred to the computer to reconstruct the three-dimensional image of the object. The image can be rotated and moved at will in the three-dimensional space to help the observer observe the object from any angle. It can also be measured and analyzed in the supporting auxiliary software [24].

Eidson et al.[25] measured the lip position before and after orthodontic appliance movement by using 3dMD system, and found that the average difference of measurement did not reach the clinically detectable level (set at 1. 5 mm), which proved that the lip position did not change significantly after fixed appliance movement. Schaaf et al.[26] 3dMD system was used to evaluate the curative effect of early helmet cranial deformities in children. Maal et al.[27] used three-dimensional photography to track and record the changes of facial soft tissue after botulinum injection. Shen Shunyao et al.[28] used 3dMD photography system to evaluate the variation of maxillofacial soft tissue in patients with hemifacial shortness syndrome. Xin Pengfei et al.[29] used 3dMD system to plan the preparation of skin flap in patients with forehead skin defect, and good surgical results were obtained. Gao Pengcheng et al.[30] analyzed the facial images of patients with different facial deformities by three-dimensional photographic system, and measured the linear measurement items commonly used in orthodontic clinic, and it was found that the measurement error was within the clinically acceptable range (the facial measurement accuracy of about 1.0 mm for orthodontic surgery combined with orthodontic surgery). Recently, 3dMD face dynamic system based on four-dimensional technology has been put into use, which can obtain high-quality 3D images at high frame rate and quantify the nuances of soft tissue when patients speak [31].

The application of 3dMD in orthodontics has advantages, it can be used to measure facial line distance and evaluate facial soft tissue, it can effectively eliminate the angle error in the process of traditional photo shooting, eliminate the possible difference of occlusal position between different angle photos [32], and can obtain images accurately and quickly, provide multi-dimensional observation angle, and obtain and save data economically and effectively. The image overlap at the critical time cut-off point can also visualize the originally long and abstract treatment process.

To sum up, as a modern ideal 3D photography system, 3dMD has the advantages of accuracy, safety, reliability, convenience and so on.

1.7 Computer convolution image analysis technology

Computer vision related technologies, including convolution neural network (Convolutional Neural Network,CNN) and deep learning algorithm and so on. The repeated application of CNN in all kinds of computer vision research has made remarkable progress in speed and accuracy compared with the traditional image classification methods. Deep learning model has the ability to automatically learn deep and more discriminative features from data. Compared with traditional image recognition methods, such as manually designed feature extraction and classifier, deep learning has higher accuracy and stronger adaptability [33].

Lee et al.[34] used GoogLeNet and Inception v3 network to detect dental caries with an accuracy of 0.820 ~ 0.890, and evaluated the effectiveness of this method. Miki et al.[35] used the trained AlexNet model to classify teeth, and successfully marked the tooth categories on cone beam computed tomography images. Tang Qing et al.[36] constructed the computer automatic cephalometric measurement system by using cascaded convolution neural network and proved the accuracy of its automatic fixed point and measurement. Zhang Yujie proved that dental segmentation based on deep convolution neural network can automatically classify dental video and 3D point cloud data point by point, saving a lot of medical resources. Liu Nali proposed an automatic tooth shape design method based on convolution neural network, which mainly solved the problem of tooth shape design and subsequent model deformation in the tooth design workflow.

To sum up, computer vision-related technology has made remarkable achievements in the field of stomatology, and this technology can also help clinical orthodontic diagnosis and treatment. For example, in the intelligent dental arrangement system, the depth learning algorithm is used to automatically mark the head landmarks in the X-ray X-ray image to assist the measurement of aesthetic indexes, such as facial aesthetic index, dental aesthetic index, lip aesthetic index and so on, and the recognition ability of digital oral impression instrument software can be improved by using computer vision related technology.

1.8 Nuclear magnetic resonance technology (MRI)

In orthodontic treatment, the measurement of hard tissue parameters such as maxillofacial bone, teeth and maxillofacial soft tissue parameters is of great value for orthodontic planning and prognosis estimation. At present, the most commonly used measurement method in clinic is X-ray cephalometry, but the cephalometric measurement is based on the image basis of two-dimensional plane, and the maxillofacial region is a complex three-dimensional structure. therefore, there are some defects in X-ray cephalometric measurement, such as deformation, magnification, overlap and so on. With the application of multi-slice spiral CT and three-dimensional reconstruction technology, the three-dimensional imaging and measurement of teeth and maxillofacial region become possible, and the measurement of related parameters is more accurate and convenient. As X-ray head radiography, spiral CT and other examination methods have the harm of X-ray radiation, and the vast majority of patients undergoing orthodontic treatment are teenagers, more attention should be paid to the effects of X-ray radiation on the body [37]. MRI images the tissue through the principle of nuclear magnetic resonance, which can perform multi-plane and multi-sequence imaging, and stereoscopically display the structure of the oral and maxillofacial region [37]. It has the advantages of non-invasive, non-ionizing radiation, the ability to distinguish different soft tissues, and can well display the structures around the joint. It has been widely used in clinical examination [38].

Because MRI imaging technology has the characteristics of non-radiation and high soft tissue resolution, it is mainly used to display the temporomandibular joint in oral and maxillofacial orthodontics. MRI can not only observe the bone remodeling of condyle and articular fossa in maxillofacial orthodontic patients, but also evaluate the morphology of articular cartilage more accurately[39]. MRI can clearly display the soft tissue structure of maxillofacial skin, subcutaneous fat and muscle, and measure the related parameters conveniently, which has obvious advantages over spiral CT and X-ray cephalometry in maxillofacial soft tissue measurement [37].

2.Computer aided design technology

2.1 3D printing

In the field of orthodontics, 3D printing technology has been used to make plaster models, personalized brackets and invisible appliances, which can be customized according to different conditions of patients in the mouth. to meet the accuracy, comfort and personalized needs of orthodontic treatment [40]. Under the background of digital and accurate treatment, "3D digital orthodontics" combined with computer-aided three-dimensional diagnosis, personalized design and digital molding technology has the advantages of accuracy, natural effect, short correction time and so on[41].In recent years, with the development of 3D printing technology and the popularization of digital image acquisition and CAD technology, the development and application of "digital workflow"in the field of stomatology have been pushed forward, which mainly includes three steps.That is, through the intraoral scanner and cone beam computed tomography (CBCT) for digital data acquisition, the use of CAD software to complete data processing and model design, the construction of 3D printing products [42,43].

At present, three-dimensional (3D) printing is the most advanced technology in the manufacturing industry because it shortens the manufacturing lead time, reduces the required cost, and allows printing projects with complex structures. Therefore, it has been implemented in dentistry to create a clear orthodontic alignment machine and to implant surgical templates, orthognathic surgical chips and temporary crowns. However, physical models are needed to make orthodontic appliances. On the other hand, the 3D printing model can realize the digital reproduction of dentition, and the model is more robust, which avoids the possible clinical technical errors, impression deformation and model material shrinkage of the traditional plaster model [43].

Kim et al.[44] found that compared with the traditional plaster impression, the resin model based on in-mouth scanning digital model and photocuring 3D printing technology has higher accuracy and strength. Moreover, compared with the traditional hot-pressing film technology, the direct 3D printing invisible appliance has the advantages of smooth edges and a small number of accessories, but it also has some problems such as poor biosafety and unstable color[45]. Therefore, the research and development of 3D printing stealth appliance materials with excellent biocompatibility, which can be stable, safe and long-term used in oral environment is the current research hotspot [40].

2.2 Digital analysis and design of cephalometric measurement

In recent years, with the continuous development of three-dimensional measurement technology and computer software technology, scholars' attention and application of three-dimensional measurement technology are increasing. Three-dimensional measurement technology can provide more information than two-dimensional cephalometric measurement, especially in facial soft tissue imaging and measurement, quantitative analysis of asymmetric deformities and the establishment of digital occlusal model [46].

Three-dimensional cephalometry is to use CBCT or spiral tomography technology to obtain the three-dimensional data of the patient's cranio-maxillofacial region, simulate the three-dimensional anatomical structure of the patient's cranio-maxillofacial region, construct a virtual cranio-maxillofacial structure model, and use related software to measure and analyze the line distance, angle, proportion and other indexes on the computer. Compared with the traditional cephalometric film, three-dimensional cephalometric measurement can measure the left and right sides of the skull respectively, in addition to eliminating the overlap and unequal magnification artifacts of the left and right sides of the anatomical structure, thus improving the accuracy of line distance and angle measurement [47].

The content of three-dimensional cephalometry can be further enriched by combining CBCT images with images of other measurement forms, such as three-dimensional photographic images recording the surface morphology of the head and face, magnetic resonance images showing soft tissue, and intraoral scanning images showing dentition and surrounding tissues, to obtain an omni-directional individualized model of the patient [48].

2.3 Digital design of orthodontic appliance

With the wide application of digital technology in the field of stomatology, especially in the past few years, people have higher and higher requirements for orthodontic aesthetics, which leads to the traditional orthodontic methods can not meet the needs of people. The invisible correction technology without bracket is the embodiment of the combination of digitalization and precision treatment. Since Align launched the Invisalign bracket-free stealth appliance in 1997, with the continuous development of digital technology, the indications for bracket-less stealth correction range from mild to moderate crowding with low difficulty to cases with high difficulty in tooth extraction and severe deep covering, allowing more and more patients to enjoy the benefits brought by digital technology[49]. The domestic bracket-free invisible appliance officially entered the market in 2004. The product was jointly developed by the School of Stomatology of Capital Medical University, the Department of Mechanical Engineering of Tsinghua University and Beijing Times Angel Biotechnology Co., Ltd. The bracket-free stealth correction technology with independent intellectual property rights in China has been developed for the first time, and it has been popularized and applied in domestic orthodontic clinic [50].

The transparent appliance is made of polymer material by hot pressing film technology, which produces the corrective force to move the teeth through the elastic deformation of the material, and finally achieves the designed target position by constantly moving the teeth in a small range [51]. The manufacture of transparent appliance requires that the dental information of patients is scanned by intraoral scanner or collected by silicone rubber impression material to reconstruct the digital model. After the digital model is established, the treatment design is carried out by digital tooth arrangement. At this stage, orthodontists interact with technicians through computer software to complete the design of tooth movement. The digital models corresponding to each step of tooth movement design are processed into solid models, which are also called master molds, and then the hot pressing die forming technology is used to make all the appliances [52].

Compared with the traditional fixed treatment, the transparent appliance has the following advantages: high comfort, good aesthetics, easy to maintain oral hygiene, mild oral mucosal stimulation and less prone to orthodontic emergency[53]. The application advantages of digital technology in invisible correction are reflected in accurate positioning and efficient movement, visual scheme design, which can better complete orthodontic correction. However, the application of invisible correction still needs to evaluate patients in many aspects and formulate personalized diagnosis and treatment programs based on the situation of patients, so as to maximize the advantages of digital medicine.

CONCLUSION

Digital technology is indispensable for medicine. In the environment of promoting accurate medical treatment and minimally invasive medical treatment, doctors have to have higher requirements for themselves, and have higher requirements for the patient data obtained by examination, more accurate and perfect data is essential. At this time, digital technology just meets the needs of medical development in the general environment [54].

Nowadays, with the accelerated arrival of the information age, various medical disciplines are developing rapidly, and digital technology is more and more widely used in orthodontics, which will be an important trend and direction to change the future of stomatology. We need to pay atten tion to it,fully study it, and treat digital technology reasonably. Strive for its better application in orthodontic treatment, so that more people can benefit from it.

REFERENCES

1. Wang Yi, Li Xiaobing. (2023) Research progress and application prospect of digital dental arch diagnosis and treatment [J]. Beijing Stomatology, 31: 298-301.
2. Zhou Wei, Liu Yang, Xie Chun, Wei Bo, Tan Qingyun, Hu Min. (2018) Clinical application of 3 D digital dental model data base for oral patients [J]. Journal of Mathematical Medicine and Pharmacy, 31: 1378-1380.
3. Sun Lehai, Sun Qingguang. (2021) Application value of three-dimensional digital dental model in orthodontics [J]. Zhongguo practical Medicine, 139.DOI:10.14163/j.cnki.11 16: 137-Chinese-5547/r.2021.19.050.
4. Peng Jiamei, Yan Bin, Wang Lin, etc. (2008) Application of three-dimensional digital dental model in orthodontics [J]. Chinese Journal of practical Stomatology,02: 110111.
5. Hu Xinyi, Fa Chen, Pan Xiaogang. (2015) Evaluation of the accuracy and reliability of establishing three-dimensional digital dental model by laser scanning [J]. Journal of Stomatological Materials and Instruments, 24: 123-128.
6. Jiao Peifeng, Liu Yang, Bi Zhenyu. (2013) A three-dimensional digital dental model with tooth root was established based on laser scanning and CT [J]. Chinese Journal of Clinical Anatomy, 31: 389-392. DOI:10.13418/j.issn.1001-165x.2013.04.036.
7. Cousley RR, Turner MJ. (2014) Digital model planning and computerized fabrication of orthognathic surgery wafers[J]. J Orthod, 41: 38-45.
8. Kwon SY, Yong K, Ahn HW, et al. (2014) Computer-aided designing and manufacturing of lingual fixed orthodontic appliance using 2D/3D registration software and rapid prototyping[J]. Int J Dent, 11: 164164.
9. RENNE W, LUDLOW M, FRYML J, et al. (2017) Evaluation of the accuracy of 7 digital scanners: An in vitro analysis based on 3-dimensional comparisons[J]. J Prosthet Dent 118 : 36-42.
10. Ye Niansong, Fang Bing. (2022) Digitalized orthodontic appearance [J]. Journal of Oral Medicine, 38: 707-712.
11. Tian Hua, Wu Buling, Bi Zhenyu, etc. (2011) Application of maxillofacial soft tissue model established by laser three-dimensional scanning in orthodontics [J]. Journal of Southern Medical University,31: 864-866.
12. Qiu Yong, Song Yan. (2020) Application effect and aesthetic evaluation of 3D printing technology in adolescent orthodontic treatment under CBCT reconstruction [J]. Chinese Academy of Aesthetic Medicine, 29: 133-137. DOI:10. 15909/j.cnki.cn61-1347/r.003549.
13. Tan Hui, Hu Chun. (2020) 3 cases of impacted supernumerary teeth in different positions of maxilla were found and treated by CBCT before orthodontic treatment. Modern Medicine and Health, 36: 951-953.
14. Yang Quanquan, Li Zhiyong, Wang Jiao. (2019) Analysis of the value of CBCT in orthodontic treatment of adolescent oral malocclusion [J]. Monthly Journal of Psychology, 14: 201.
15. Mehmet Zahit Adisen, Aydan Keles, Serap Yorubulut, et al. (2020) Age estimation by measuring maxillary canine pulp /tooth volume ratio on cone beam CT images with two different voxel sizes [J]. Australian J Forensic Sci. 52: 71-82.
16. De Grauwe A, Ayaz I, Shujaat S, Dimitrov S, Gbadegbegnon L, Vande Vannet B, Jacobs R. (2019) CBCT in orthodontics: a systematic review on justification of CBCT in a paediatric population prior to orthodontic treatment. Eur J Orthod. 8: 381-389. doi: 10.1093/ejo/cjy066. PMID: 30351398; PMCID: PMC6686083.
17. Berkhout, W.E. (2015) [The ALARA-principle. Backgrounds and enforcement in dental practices]. Nederlands tijdschrift voor tandheelkunde, 122: 263–270.
18. Jacobs, R. (2011) Dental cone beam CT and its justified use in oral health care. JBR-BTR: organe de la Societe royale belge de radiologie(SRBR)=orgaan van de Koninklijke Belgische Vereniging voor Radiologie (KBVR), 94: 254–265.
19. Wu Guofeng. (2017) Clinical standardized operation of facial arch recording [J]. Journal of practical Stomatology, 33: 413,416.
20. Yao Jiangwu. (2016) Digital prosthodontics (1)-- introduction [J]. Journal of Clinical Stomatology, 32: 50-53.
21. Li Ruyi, Luo Feng, Wan Qianbing. (2022) The principle and application progress of real-time recording system of mandibular movement [J]. International Journal of Stomatology, 49: 182-188.
22. Aslanidou K, Xie R, Christou T, Lamani E, Kau CH. (2020) Evaluation of temporomandibular joint function after orthognathic surgery using a jaw tracker. J Orthod. 47:140-148. doi: 10.1177/1465312520908277. Epub 2020 Mar 1. PMID: 32114874.
23. He S, Kau CH, Liao L, Kinderknecht K, Ow A, Saleh TA. (2016) The use of a dynamic real-time jaw tracking device and cone beam computed tomography simulation. Ann Maxillofac Surg. 6: 113-9.
24. Zhou Chen, Wang Weicai, Deng Lidi, Deng Jianqing, Zhang Xueqin, Cai Bin, Wu Liping. (2018) Application of 3dMD ®stereoscopic photography in orthodontic teaching [J]. Chinese Journal of Stomatology Research (Electronic Edition), 12: 375-378.
25. Eidson L, Cevidanes LH, de Paula LK, et al. (2012) Three-dimensional evaluation of changes in lip position from before to after orthodontic appliance removal [J]. Am J Orthod Dentofacial Orthop. 142: 410- 418.
26. Schaaf H, Malik CY, Streckbein P, et al. (2010) Threedimensional photographic analysis of outcome after helmet treatment of a nonsynostotic cranial deformity[J]. J Craniofac Surg, 21:1677-1682.
27. Maal TJ, van Loon B, Plooij JM, et al.Registration of 3- dimension facial photographs for clinical use [J]. J Oral Maxillofac Surg, 2012, 68(10):2391-2401.
28. Shen Shunyao, Xin Pengfei, Dai Jiewen et al. (2012) Preliminary application of 3dMD photogrammetry system in the diagnosis of hemifacial shortness [J]. Journal of Oral and Maxillofacial surgery, 22: 261-264.
29. Xin Pengfei, Guangxi Navy, Chen Zhibiao, et al. A preliminary report on the reconstruction of craniofacial soft tissue deformities assisted by 3dMD photogrammetry system [J]. Chinese Journal of Oral and Maxillofacial surgery, 2011 Journal of Oral and Maxillofacial surgery: 307-311.
30. Gao Pengcheng, Zhao Zhengqi, Chen Yali, etc. (2019) Study on the accuracy of obtaining deformed facial images by three-dimensional photography system based on stereoscopic photography [J]. Huaxi Journal of Stomatology, 37: 174-179.
31. Xue Mingfei, Chen Ning, du Yifei. (2015) Application of digital three-dimensional photogrammetry in oral and maxillofacial soft tissue evaluation [J]. Stomatology, 35: 1072-1075.
32. Zhou Chen, Wang Weicai, Deng Lidi, Deng Jianqing, Zhang Xueqin, Cai Bin, Wu Liping. (2018) Application of 3dMD ®stereoscopic photography in orthodontic teaching [J]. Chinese Journal of Stomatology Research (Electronic Edition), 12: 375,-378.
33. Fan Yunyi. (2024) Research and Application of Intraoral scanning data processing Technology based on Image recognition [D]. University of Electronic Science and Technology. DOI:10.27005/d.cnki.gdzku.2023.000581.
34. Lee J H, Kim D H, Jeong S N, et al. (2018) Detection and diagnosis of dental caries using a deep learning-based convolutional neural network algorithm[J]. Journal of Dentistry, 77: 106-111.
35. Miki Y, Muramatsu C, Hayashi T, et al. (2017) Classification of teeth in cone-beam CT using deep convolutional neural network[J]. Computers in Biology and Medicine, 80: 24-29.
36. Tang Qing. (2021) Research on automatic Cephalometric Measure-

ment based on convolution Neural Network [D]. Tianjin University of Medical Sciences. DOI:10.27366/d.cnki.gtyku.2021.000757.
37. Zhao Zhenhua, Wang Boyin, Zhang Guoxing et al. (2011) Application of MRI in orthodontic treatment measurement [J]. Chinese Journal of Clinical Medical Imaging, 22: 215-217.
38. Chen Ping, Wang Peijun, Shi Fengqi, etc. (2020) MRI examination of temporomandibular joint in patients with Angle class III malocclusion [J]. Medical Information, 33: 51-54.
39. Xu Ming, Zhang Zuoquan. (2008)Clinical study of spiral CT three-dimensional reconstruction in orthodontic impacted teeth [J]. Guangdong Dental Disease Prevention and Cure.
40. Shan Jian Bo, he Xin, Wen Ning. (2022) Application of 3D printing technology in oral clinic [J]. Medical Science of the Armed Police, 733: 817-820.DOI:10.14010/j.cnki.wjyx.2022.09.023.
41. Shi Feifei, GE Wenhui, Xu Laijun. (2023) Progress in clinical application of digital 3 D printing technology in stomatology [J]. Shandong Medicine, 63: 104-108.
42. HE D, DU W, LI J, et al. (2018) Clinical feasibility and efficiency of a 3-dimensional printed surgical template for mandibular angle oste-otomy and mandibular angle splitting osteotomy[J]. Br J Oral Maxillofac Surg, 56: 594-599.
43. COUSLEY R R. (2020) Introducing 3D printing in your orthodontic prac-tice[J]. J Orthod, 47: 265-272.
44. [44]Kim S Y, Shin Y S, Jung H D, et al. (2018) Precision and trueness of dental models manufactured with different 3- dimensional printing techniques[J]. Am J Orthod Dentofacial Orthop.153: 144-153.
45. [45]Maspero C, Tartaglia G M. (2020) 3D Printing of clear orthodontic aligners: where we are and where we are going [J]. Materials (Basel). 13: 5204.
46. Ai Jiang, Mi Congbo. (2011) Application of three-dimensional measurement in orthodontics [J]. Tissue Engineering Research and Clinical Rehabilitation in China, 15: 4868-4871.
47. Yang Jinting, Han Xianglong, Bai Ding. (2015) Application of digital three-dimensional diagnosis and treatment in orthodontics [J]. International Journal of Stomatology, 446-449.
48. Zhang Zihan, Xiong Xin, Wang Jun. (2020) Research status and application development of three-dimensional cephalometry [J]. International Journal of Stomatology, 547: 739-744.
49. Reinhardt S. (2016) 10 Tips and tricks to finish your invisalign-cases with success[J]. Int J Orthod Milwaukee, 27: 69-79.
50. Bai Yuxing, Tian Jie, Zhou Jiemin, et al. (2008) A preliminary study on the clinical application of domestic bracket-free stealth correction technique [J]. Zhonghua Journal of Stomatology, 08: 464,467.
51. Gu Zexu. (2020) Anchorage control and clinical strategy of non-bracket stealth correction [J]. Chinese Journal of Stomatology, 08: 531,535.
52. Zhao Zhihe, Editor-in-Chief, Orthodontics (7th Edition). 2020. three hundred and one.
53. Buschang P H, Shaw S G, Ross M, et al. (2014) Comparative time efficiency of aligner therapy and conventional edgewise braces[J]. Angle Orthod, 84: 391-6.
54. Gao Xiaobo, Gao Sen, Guo Junjian, Zhang Wanru, Li Yanyan, Jia Guangran, Lei Bocheng. (2017) Study on digital measurement of mandible data in patients with skeletal class III malocclusion [J]. Journal of Chifeng University (Natural Science Edition), 33: 75-77.

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