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A Comparative Study on the Effects of Intelligent Diagnosis in Orthodontics and Conventional Orthodontic Treatment

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Abstract

Objective: To observe and investigate the therapeutic effects of intelligent diagnosis in orthodontics compared to conventional orthodontic treatment. **Methods**: A total of 96 patients undergoing orthodontic treatment in our hospital from September 2022 to July 2024 were selected as the study subjects and randomly divided into a conventional group and an intelligent group, with 48 patients in each group. The conventional group received conventional orthodontic treatment measures, while the intelligent group adopted intelligent diagnosis in addition to conventional orthodontic treatment. The clinical effects, aesthetic outcomes, and changes in canine width, molar width, and Little's index were compared between the two groups after orthodontic diagnosis. **Results**: The average error in two-dimensional cephalometric measurements in the intelligent group was significantly lower than that in the conventional group ($p<0.05$), while there was no significant difference in accuracy within the 2-4mm error range between the two groups ($p>0.05$). In terms of aesthetic outcomes, the nasolabial angle, mentolabial angle, and upper lip length in the intelligent group were significantly better than those in the conventional group ($p<0.05$). No significant differences were observed in facial angle, H angle, and lip thickness parameters between the two groups ($p>0.05$). The intelligent group significantly outperformed the conventional group in terms of changes in canine width, molar width, and Little's index ($p<0.05$). The orthodontic success rate in the intelligent group (93.75%) was significantly higher than that in the conventional group (79.17%) ($p<0.05$).**Conclusion**: Intelligent diagnosis in orthodontics contributes to enhance the precision of orthodontic diagnosis and treatment, reducing medical disparities, enabling less experienced practitioners to achieve professional standards comparable to those of experienced practitioners, and broadly improving the medical standards in the field of orthodontics.

Keywords: *Orthodontics; Intelligent diagnosis; Two-dimensional projection; Convolutional neural network*

1.0 Introduction

Orthodontic treatment is a crucial medical procedure in modern dental healthcare, aimed at correcting abnormal arrangements of teeth and jaws to improve patients' occlusion function and facial aesthetics. As people's awareness of oral health and facial aesthetics continues to rise, the demand for orthodontic treatment has shown an increasing trend year by year [1]. According to statistics from relevant departments, the market size of China's orthodontic industry grew from 51 billion yuan to 61 billion yuan between 2019 and 2023, with

an average annual compound growth rate of 4.58%. The number of individuals undergoing orthodontic treatment has exceeded 50 million, with adolescents accounting for the largest proportion of these patients [2]. The limitations of conventional orthodontic diagnostic methods lie in their time-consuming nature, precision, and personalization, and the effectiveness of such diagnoses can vary depending on the physician's experience level, leading to inconsistencies in the overall quality of orthodontic treatment and affecting patients' treatment experience. With the rapid development of digital technology and artificial intelligence in recent years, intelligent orthodontic diagnosis has gradually emerged as a research hotspot in modern orthodontics [3]. The intelligent orthodontic diagnosis system integrates advanced technologies such as three-dimensional imaging, deep learning algorithms, and big data analysis. Its clinical application not only enhances diagnostic accuracy but also provides a more scientific basis for the formulation of treatment plans. However, while the development of intelligent orthodontic diagnosis technology can bring many conveniences to clinical applications, its superiority in specific treatment effects still needs to be verified through rigorous clinical research. The purpose of this study is to compare the clinical effects of intelligent orthodontic diagnosis with conventional orthodontic treatment and delve into the application value of intelligent technology in orthodontic treatment. Through a randomized controlled trial involving 96 patients, this study analyzes the specific performance of intelligent orthodontic diagnosis in two-dimensional projection testing, aesthetic outcomes, tooth alignment improvement, and orthodontic success rate, thereby providing a scientific basis and theoretical foundation for the improvement and optimization of future orthodontic treatment techniques.

2.Materials and Methods

2.1Study Design

This study included 96 patients who underwent orthodontic treatment in the Department of Stomatology of the Second Affiliated Hospital of North Sichuan Medical Collegefrom September 2022 to July 2024. These patients were randomly divided into two groups using the cluster random sampling method; conventional group and intelligent groups, with 48 patients in each group. In the conventional group, there were 17 males and 31 females, aged between 18 and 49 years old, with an average age of (31.42±7.84) years. According to the Angle classification of malocclusion, there were 21 cases of Class I malocclusion, 16 cases of Class II malocclusion, and 11 cases of Class III malocclusion. In the intelligent group, there were 18 males and 30 females, aged between 18 and 46 years old, with an average age of (31.58±7.92) years. Based on the Angle classification, there were 23 cases of Class I malocclusion, 17 cases of Class II malocclusion, and 8 cases of Class III malocclusion. There was no statistically significant difference in general information between the two groups ($p>0.05$), and the study was approved by the Hospital Ethics Committee, ensuring comparability.

Inclusion Criteria:① Patients with a complete permanent dentition and fully erupted teeth;② Patients aged 18 years or older and under 75 years;③ Patients and their families are informed of the study and voluntarily sign the informed consent form.

Exclusion Criteria:① Patients with diseases such as angina pectoris, hypertension, heart failure, etc.;② Patients unable to provide complete imaging data;③ Patients with type 2 diabetes and whose condition is not yet under stable control;④ Patients with severe psychological or psychiatric disorders;⑤ Patients with progressive periodontal diseases;⑥ Female patients who are pregnant.

2.2 Methods

In this study, the conventional group adopted the conventional orthodontic diagnostic approach. This method commenced with a comprehensive oral examination at the patient's initial visit to document the baseline conditions of the maxillofacial structures and tooth alignment. The examination involved a detailed assessment of tooth arrangement, occlusion type, facial skeletal symmetry, and soft tissue conditions. Following this, dental impressions were taken from the patient and used to create plaster models for detailed occlusion analysis. This analysis aimed to identify issues such as malocclusion, diastema, tooth inclinations, and occlusal contact points.

Subsequently, the dentist performed quantitative measurements on the prepared models to obtain parameters such as arch width, tooth angles, and displacement degrees as diagnostic data. Additionally, imaging examinations were conducted for the patients, including panoramic radiographs to provide a comprehensive view of the teeth and jaws, and cephalometric radiographs to analyze jaw relationships, the relative positions of teeth and jaws, and the morphology of facial soft tissues. The cephalometric analysis involved manually marking anatomical landmarks. After integrating all diagnostic data, the dentist formulated a treatment plan based on the patient's needs and expectations. During the treatment process, regular follow-ups were conducted, and the appliances were adjusted accordingly based on tooth movements and biomechanical principles.

Patients in the intelligent group underwent an intelligent orthodontic diagnostic system that integrates digital imaging technology with artificial intelligence. The diagnostic process of this system is divided into the following three main stages, as illustrated in Figure 1.

(1)Data Acquisition and Processing:

During the patient's initial visit, high-resolution Cone Beam Computed Tomography (CBCT) and digital panoramic radiographs are utilized to acquire three-dimensional (3D) images of the patient's maxillofacial region. This process precisely constructs the 3D anatomical structure of the patient's jaws, along with complete information on their dentition and jaws. Concurrently, clinical data (including oral examination results, occlusion records, medical history, etc.) are collected from the patient. All imaging data undergo preprocessing steps such as noise removal, image standardization, and necessary are cropping. Subsequently, these data are input into the database of the intelligent diagnostic system.

(2)Intelligent Diagnostic Analysis:

The diagnostic analysis process primarily encompasses two aspects:

a. Two-dimensional Image Intelligent Analysis: Employing deep learning algorithms such as Convolutional Neural Networks (CNN), the system automatically locates key anatomical landmarks (e.g., Sella, Nasion, Pogonion) on cephalometric radiographs. The system then automatically calculates cephalometric data, including Sella-Nasion-A Point (SNA), Sella-Nasion-B Point (SNB), and A Point-Nasion-B Point (ANB) angles, among others, and assesses the relative positions of the maxilla and mandible as well as tooth alignment based on these data. Furthermore, it conducts automatic image calibration and superimposition analysis to evaluate structural changes at different time points, and providing precise diagnostic reports for doctors.

b. Cervical Vertebral Maturation Analysis: The system automatically analyzes the patient's lateral cervical spine radiographs to assess the stage of skeletal maturity. Through the quantitative analysis of morphological parameters of second to fourth cervical vertebrae, the system precisely determines the patient's growth potential and optimal treatment timing, and assisting doctors in identifying the most suitable period for orthodontic intervention.

(3)Treatment Plan Generation and Execution:

Based on the results of the intelligent analysis, the system automatically generates an orthodontic treatment plan. This plan encompasses the selection of appliances, specific tooth movement paths, and estimated treatment duration and steps. Concurrently, virtual treatment simulation is employed to visualize the outcomes of different treatment options, allowing for a comparison of the optimal therapeutic effects achievable with the selected plan. The generated treatment plan is then validated by clinicians, who make necessary adjustments based on the patient's specific conditions and their clinical experience. After verification and modification by the doctor, along with confirmation of the plan's feasibility and safety, the final treatment plan is determined.

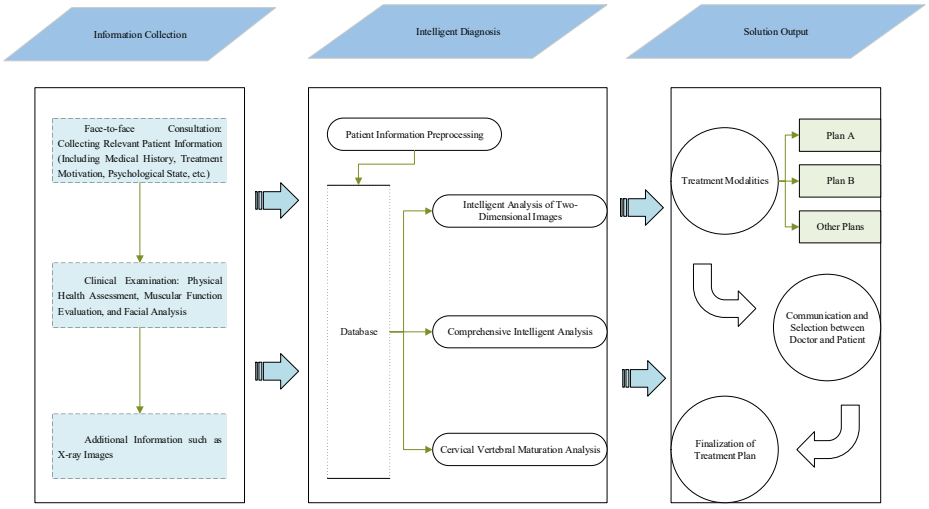

Figure 1: Diagnosis Process of the Intelligent Orthodontic Diagnosis System

2.3 Observation Indicators

Accuracy of Two-Dimensional Projection Testing: The accuracy of two-dimensional projection testing is evaluated by assessing the automatic localization error of 15 key anatomical landmarks on cephalometric radiographs [4]. These 15 landmarks include the Nasion (N), Sella (S), Porion (P), Bolton Point, Orbitale (Or), Anterior Nasal Spine (ANS), Posterior Nasal Spine (PNS), Upper Incisor (UI), Upper Alveolar Point (A), Lower Incisor (LI), Lower Alveolar Point (B), Pogonion (Pog), Gnathion (Gn), Menton (Me), and Gonion (Go), as illustrated in Figure 2. The localization error is calculated using the Euclidean distance formula[4-5], with the measurement error expressed in millimeters (mm). The following criteria are used in this study to calculate the accuracy:

(1)Accuracy within a 2-mm error range: Calculates the proportion of landmarks successfully localized by the system within a 2-mm error margin.

(2)Accuracy within a 3-mm error range: Calculates the proportion of landmarks successfully localized by the system within a 3-mm error margin.

(3)Accuracy within a 4-mm error range: Calculates the proportion of landmarks successfully localized by the system within a 4-mm error margin.

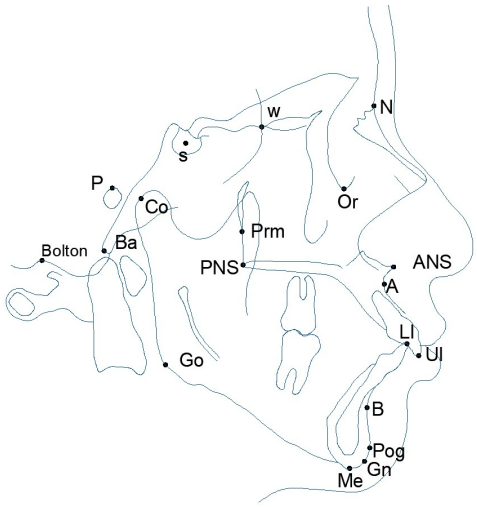

Figure 2: Schematic Diagram of Cephalometric Landmarks(文献)

Aesthetic Effect: The aesthetic effect is evaluated using Wineeph8.0 software, which conducts fixed-point measurements on X-ray lateral cephalograms. The computer-based geometric ruler is employed to directly measure the following critical angles and distance parameters to assess the facial aesthetic improvement post-orthodontic treatment:

(1)H-Angle: The angle formed between the line connecting the soft tissue pogonion (Pog) and the upper lip protrusion point and the NB line. It evaluates the facial convexity, with a larger value indicating a more pronounced anterior facial protrusion.

(2)Nasolabial Angle: The angle formed by the intersection of a line extending from the subnasal point to the columella and the anterior intersection point with the upper lip protrusion point on this line. It reflects the relative position and shape of the nose and upper lip, and the size of the nasolabial angle correlates with the overall facial aesthetics.

(3)Facial Angle: The posterior intersection angle formed by the line connecting the subnasal point and the anterior soft tissue point, and the line connecting the glabella point and the subnasal point. It assesses the facial protrusion or recession, reflecting the aesthetic balance of the facial contour.

(4)Sulcus Inclination Angle: The posterior inferior intersection angle formed by the intersection of the line connecting the labial sulcus point (B) and the soft tissue pogonion (Pog) with the FH plane. It evaluates the coordination between the lips and the maxillofacial region.

(5)Upper and Lower Lip Lengths: The distances from the perpendicular feet of the upper and lower lips, respectively, to the line connecting the subnasal point and the soft tissue pogonion, measured perpendicularly. These assess the proportional height of the lips.

(6)Upper and Lower Lip Thicknesses: Measured as the distances from the upper lip protrusion point to the labial surface of the upper central incisor and from the lower lip protrusion point to the labial surface of the lower central incisor, respectively. These reflect the fullness of the lips and the three-dimensional sense of the face.

Changes in Width of Canines, Width of Molars, and Little's Index:

(1)Canine Width: The distances between the maxillary and mandibular canines (transverse distance between the cusps of bilateral canines) are measured separately to assess the alignment of canines and changes in the width of the dental arch.

(2)Molar Width: The distance between the mesiobuccal cusps of the maxillary and mandibular first molars is measured to evaluate the lateral expansion of molars and the degree of improvement in the overall occlusion relationship.

(3)Overjet and Overbite: Under central occlusion, the horizontal distance between the incisal edges of the upper and lower anterior teeth (overjet) and the vertical distance by which the upper anterior teeth overlap the labial surfaces of the lower anterior teeth (overbite) are measured. This assesses the adjustment of the anterior teeth occlusion relationship.

(4)Little's Index: The sum of the distances between tooth contact points between bilateral canines in both the maxilla and mandible is measured to evaluate the alignment of the dentition. A higher Little's Index indicates a greater degree of malalignment.

Orthodontic Success Rate and Adverse Reactions:

(1)Criteria for Successful Orthodontic Treatment: The treatment outcomes are evaluated 30 days after treatment completion. The success criteria include significant relief of gingival pain symptoms, marked improvement in occlusion comfort (with chewing efficiency increased by over 80%), substantial improvement in periodontal health indicators (with a reduction of over 80%), and noticeable enhancement in tooth aesthetics and color.

(2)Monitoring of Adverse Reactions: During the treatment, adverse reactions experienced by patients, including oral infections, oral discomfort, and soft tissue edema, are recorded.

2.4 Statistical Analysis

In this study, statistical software (SPSS version 24.0) was employed to analyze the research-related data. For measurement data (t), which complied with normal distribution, the mean ± standard deviation "±s" was used for expression, and independent samples were analyzed using the "t"-test. Count data were expressed as percentages "[n/(%)]", and the "χ^2" test was applied for independent samples. A P-value of less than 0.05 indicated statistically significant differences between groups.

3.Results

3.1Accuracy of Two-Dimensional Cephalometric Measurements

After orthodontic treatment, there was no significant difference ($p > 0.05$) in the accuracy of two-dimensional cephalometric measurements within 2-4 mm between the intelligent group and conventional group. However, the average error of the intelligent group was lower than that of the conventional group ($p < 0.05$), as shown in Table 1.

Table 1 Comparison of Accuracy of Two-Dimensional Cephalometric Measurements between Two Groups [n(%) / ±s, mm]

Group / n (cases)	Accuracy within Fixed Error Range (%)			Mean Error (mm)
	2mm	3mm	4mm	
intelligent	81.98	92.14	96.03	1.28±0.96

Group / 48				
Conventional Group / 48	75.62	84.79	90.67	1.69±0.94
T/x^2	1.211	2.695	2.314	2.114
P	0.271	0.101	0.128	0.037

3.2Aesthetic Effects

After the orthodontic treatment, the nasolabial and mentolabial angle of patients in the intelligent group were significantly larger than those in the conventional group ($p < 0.05$). The upper lip length of patients in the intelligent group was also longer than that in the conventional group ($p < 0.05$). However, no significant differences were observed between the two groups in facial angle, H-angle, lower lip length, upper lip thickness, and lower lip thickness ($p > 0.05$), as shown in Table 2.

Table 2 Comparison of Orthodontic Aesthetic Effects between Two Groups [±s, mm/°]

Group / n (cases)	**Lip Length (mm)**		**Lip Thickness (mm)**		**Facial Angle (°)**			
	Upper Lip	**Lower Lip**	**Upper Lip**	**Lower Lip**	**Nasolabial Angle**	**Facial Angle**	**Mentolabial Angle**	**H-Angle**
Intelligent Group / 48	26.64±1.25	47.89±4.65	13.09±1.14	13.08±1.49	99.48±11.47	162.78±6.26	80.15±8.57	17.57±2.21
Conventional Group / 48	24.11±1.19	47.68±4.26	12.86±1.49	12.99±1.57	88.65±10.96	162.49±6.32	70.48±8.29	18.04±2.49
t	10.156	0.231	0.849	0.288	4.730	0.226	5.619	0.978
P	<0.001	0.818	0.398	0.774	<0.001	0.822	<0.001	0.331

3.3Changes in Maxillary and Mandibular Canine Width, Molar Width, and Little's Index

After orthodontic treatment, the intelligent group showed significantly greater changes in maxillary and mandibular canine width, maxillary and mandibular molar width, and Little's Index compared to the conventional group ($p < 0.05$), as presented in Table 3.

Table 3 Comparison of Changes in Maxillary and Mandibular Canine Width, Molar Width, and Little's Index between Two Groups [±s, mm]

Group / n	**Canine Width (mm)**	**Molar Width (mm)**	**Change in Little's Index**

(cases)					(mm)	
	Maxillary Canine	Mandibular Canine	Maxillary Molar	Mandibular Molar	Maxillary	Mandibular
intelligent Group / 48	0.68±0.19	0.59±0.22	0.59±0.21	0.59±0.25	0.77±0.18	1.22±0.31
Conventional Group / 48	0.52±0.22	0.42±0.13	0.38±0.19	0.44±0.17	0.52±0.17	0.96±0.18
t	3.813	4.609	5.138	3.437	6.996	5.025
P	<0.001	<0.001	<0.001	0.001	<0.001	<0.001

3.4Orthodontic Success Rate and Adverse Reactions

After orthodontic treatment, the success rate of intelligent group reached 93.75%, significantly higher than the conventional group at 79.17% ($p < 0.05$). Furthermore, the incidence of complications in the intelligent group was lower than that in the conventional group, although the difference was not statistically significant ($p > 0.05$). As shown in Table 4.

Table 4 Comparison of Complication Incidence between Two Groups [n(%)]

Group / n (cases)	Orthodontic Success Rate	Complication Status				
		Oral Infection	Oral Discomfort	Soft Tissue Edema	Others	Complication Incidence Rate
Intelligent Group / 48	46 (95.83)	1 (2.08)	1 (2.08)	0 (0.00)	1 (2.08)	3 (6.25)
Conventional Group / 48	40 (83.33)	4 (8.33)	3 (6.25)	2 (4.17)	1 (2.08)	10 (20.83)
x^2	4.019					4.360
P	0.045					0.037

4.Discussion

Orthodontics, as an essential branch of contemporary dental medicine, primarily focuses on the study of the growth and development patterns of teeth and jaws, as well as methods for correcting their abnormalities [6]. Orthodontic treatment involves the application of moderate biomechanical forces through appliances to gradually move teeth into their ideal positions, restoring normal dental arch morphology and occlusion function

[7]. As people's pursuit of facial aesthetics increases, modern orthodontic treatment not only emphasizes the restoration of tooth alignment and function but also places greater importance on enhancing facial aesthetics. Consequently, the precision of orthodontic diagnosis and the value of customized treatment planning have continually risen in significance [8]. Intelligent orthodontic diagnosis, a diagnostic technology widely applied in this field in recent years, integrates advanced digital technologies and artificial intelligence algorithms. This approach offers higher diagnostic accuracy, efficiency, and capability for personalized treatment planning compared to conventional orthodontic diagnostic methods [9-10]. Notably, the inclusion of convolutional neural networks (CNNs) within these systems enables automated recognition and precise localization of key anatomical landmarks in patients. It is not only reduces the manual operation errors but also enhances the consistency and objectivity of diagnoses, ensuring that the outcomes of orthodontic treatment are less influenced by variations in physician experience [11-12].

The results of this study indicated that while there was no significant difference in accuracy within the 2-4 mm error range between the intelligent group and the conventional group in two-dimensional cephalometric measurements ($p > 0.05$), the average error in the intelligent group was significantly lower than that in the conventional group ($p < 0.05$). This finding may be attributed to the advantages of the intelligent orthodontic diagnosis system in automatic recognition and localization of anatomical landmarks. Although the accuracy difference between the two groups was not significant within larger error ranges, the precision of the intelligent system was evident within smaller error ranges. This can be linked to the high-precision landmark localization achieved by the intelligent system using deep learning algorithms, which can identify and reduce uncertainties arising from factors such as image quality and individual patient differences, thus outperforming conventional manual measurement methods in overall measurement accuracy. This result is consistent with the findings of Chen Zhaoxiang [13], suggesting that intelligent orthodontic treatment for teeth can achieve higher detection accuracy and improve the quality of orthodontic treatment for patients. Furthermore, in the assessment of aesthetic effects, the nasolabial angle and mentolabial angle of the intelligent group were significantly larger than those of the conventional group ($p < 0.05$), and the upper lip length was also significantly better in the intelligent group ($p < 0.05$). However, no significant differences were observed between the two groups in facial angle, H-angle, and lip thickness ($p > 0.05$). These results demonstrate that the intelligent diagnosis system can better optimize specific aesthetic parameters and has advantages in improving facial contours and lip morphology. This advantage may stem from the system's automated detection and precise analysis of aesthetic indicators during initial diagnosis, enabling it to develop treatment plans that more effectively target these key aesthetic features for correction [14]. Additionally, the simulation of different treatment options by the intelligent system and the selection of those that enhance facial aesthetics contribute to the superior performance of the intelligent group in these aesthetic parameters. Moreover, the study revealed that the maxillary and mandibular canine widths, molar widths, and changes in Little's Index in the intelligent group were significantly better than those in the conventional group ($p < 0.05$). This is due to the advantages of the intelligent diagnosis system in planning tooth movement paths. The intelligent system can perform precise three-dimensional reconstruction and tooth arrangement analysis, accurately calculate the ideal position of each tooth, and plan the optimal movement path. This precision enables teeth to move more accurately to their intended positions during treatment, demonstrating the system's stronger corrective ability in complex malocclusions and occlusion adjustments. This finding is consistent with the results of Xue Xin et al. [15], indicating that combining orthodontic treatment with new technologies can effectively improve the outcome of orthodontic treatment and facial aesthetics. Additionally, the orthodontic success rate in the intelligent group (93.75%) was significantly higher than the conventional group (79.17%) ($p < 0.05$). The higher success rate in the intelligent group is primarily attributed to its high precision and personalization in diagnosis and treatment plan generation, as well as the dynamic adjustment capabilities of the intelligent system, which optimize correction strategies during treatment, thereby enhancing overall treatment outcomes. Although there was no significant difference in complication rates between the two groups ($p > 0.05$), this may be due to factors such as sample size and

individual differences, resulting in a lack of statistical significance. This suggests the need for further studies with larger sample sizes in the future.

In summary, intelligent orthodontic diagnosis possesses notable advantages in enhancing treatment accuracy, improving aesthetic outcomes, and raising the success rate of treatments. Nevertheless, further multicenter studies are necessary to expand the sample size and validate its applicability in diverse patient populations. With the continuous advancement of technology in the future, the algorithmic optimization and data analysis precision of intelligent orthodontic systems are expected to be further improved, laying a solid foundation for broader clinical applications.

[References]

[1] Pan Yihua, Zhao Zhihe, Liu Jun. CBCT Evaluation of Condylar Position and Its Changes Before and After Orthodontic Treatment in Patients with Malocclusion. [J]. Journal of Prevention and Treatment of Stomatological Diseases, 2024, 32(2): 149-154.

[2] Kim H J, Yu H J, Mangal U, et al. Author Correction: Evaluation of Dental Plaque Reduction Using Microcurrent-Emitting Toothbrushes in Orthodontic Patients: A Randomized, Double-Blind, Crossover Clinical Trial. [J]. Scientific Reports, 2024, 14(1): 18398.

[3] Shi Quan, Huo Na, Liu Hongchen. Application of Artificial Intelligence in Orthodontics. [J]. Chinese Journal of Orthodontics, 2023, 30(2): 97-100.

[4] Marcela G, Antonia M A, Fernando J A, et al. Automated Artificial Intelligence-Based Three-Dimensional Comparison of Orthodontic Treatment Outcomes with and without Piezocision Surgery. [J]. Orthodontics & Craniofacial Research, 2023, 27(2): 321-331.

[5] W B G, S C, F F Z, et al. [Automated Cephalometric Landmark Identification and Location Based on Convolutional Neural Network]. [J]. Chinese Journal of Stomatology, 2023, 58(12): 1249-1256.

[6] Wang Yong, Wang Lin. Analysis of Several Basic Concepts Related to Mechanics in Orthodontics. [J]. Stomatology, 2024, 44(1): 60-62.

[7] Fan Xiuru, Liu Jia. Application of Orthodontic Treatment in Combined Therapy for Periodontal Disease. [J]. Journal of Stomatological Research, 2023, 39(9): 780-784.

[8] Zhang Jinhua, Pan Jie, Sun Zhipeng, Wang Xiao. The Influence of Different Root Canal Contents on the Accuracy of Cone Beam Computed Tomography in Diagnosing Vertical Root Fractures. [J]. Journal of Peking University (Health Sciences), 2023, 55(2): 333-338.

[9] A.L. D, M.A. O, Y.I. N. Application of Digital Technologies in Biomechanical Simulation of Orthodontic Tooth Movement. [J]. Russian Journal of Biomechanics, 2019, 23(3): 305-318.

[10] Karen H, Vivian S, Budi K, et al. In-vivo Evaluation of Artificial Intelligence Driven Remote Monitoring Technology for Tracking Tooth Movement and Reconstruction of 3-Dimensional Digital Models During Orthodontic Treatment. [J]. American Journal of Orthodontics and Dentofacial Orthopedics, 2023, 164(5): 690-699.

[11] Nakornnoi T, Chanmanee P. Accuracy of Digital Imaging Software to Predict Soft Tissue Changes during Orthodontic Treatment. [J]. Journal of Imaging, 2024, 10(6): 134.

[12] Ma Q, Kobayashi E, Jin S, et al. 3D Evaluation Model of Facial Aesthetics Based on Multi-Input 3D Convolution Neural Networks for Orthognathic Surgery. [J]. The International Journal of Medical Robotics + Computer Assisted Surgery, 2024, 20(3): e2651.

[13] Chen Zhaoxiang. Research and Application of Intelligent Orthodontics Technology. [J]. Software, 2023, 44(11): 166-168.

[14] Han H S, Lim J, Kim S J, et al. Accuracy of Posteroanterior Cephalogram Landmarks and Measurements Identification Using a Cascaded Convolutional Neural Network Algorithm: A Multicenter Study. [J]. Korean Journal of Orthodontics, 2024, 54(1): 48-58.

[15] Xue Xin, Wang Jing, Huang Yinli, Zhang Cui. Application Effect of 3D Digital Orthodontics in Adult Orthodontic Treatment. [J]. Ning