Original Research

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Features of the X-ray anatomy of the gnathic part of the face in children in the period of removable occlusion

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Abstract

INTRODUCTION. The variability of the gnathic part of the human face during the period of removable occlusion is determined by the order of replacement of milk teeth with permanent teeth.

AIM. Purpose of the study was to determine the features of the X-ray anatomy of the gnathic part of the face in children in the period of removable occlusion.

MATERIALS AND METHODS. Teleradiographs and orthopantomograms obtained from 56 children of different ages were analyzed. On orthopantomograms, an articular horizontal was drawn connecting the upper points of the articular heads. From the middle point of the articular horizontal and perpendicular to it, an aesthetic vertical was drawn, which passed between the incisors to the chin point. The ratio of the distance from the midpoint to the articular head to the coefficient of 1.5 determined the position of the retro molar point, from which the retro molar vertical was drawn downwards, which was used as the stress axis for the distal upper teeth. On the lower jaw, the bisector of the mandibular angle served as the stress axis for the lower molars.

RESULTS. The results of the analysis of radiographs of children in the period of occlusion of milk teeth showed that on the radiographs the rudiment of the first upper permanent molar was located in front of the retro molar vertical, and the lower first molar in front of the bisector of the mandibular angle. As the jaws grew, the position of the stress axes changed, but with the optimal size of the jaws, the distal teeth did not extend beyond its limits.

CONCLUSIONS. The X-ray anatomical features of the gnathic part of the face were determined by the replacement of milk teeth with permanent ones. A special place is occupied by the retro molar space, in which distally located permanent molars are formed. The location of permanent teeth or parts of them behind the retro molar verticals creates tension in the gnathic part of the face and can determine the tactics of extraction and non-extraction methods of orthodontic treatment.

Keywords: orthopantomography, teleradiography, reversible occlusion, physiological occlusion

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Особенности рентгенологической анатомии гнатического отдела лица у детей в период сменного прикуса

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Резюме

ВВЕДЕНИЕ. Вариабельность гнатической части лица человека в периоде сменного прикуса определяется очередностью смены молочных зубов постоянными.

ЦЕЛЬ. Определение особенностей рентгенологической анатомии гнатической части лица у детей в периоде сменного прикуса.

МАТЕРИАЛЫ И МЕТОДЫ. Проанализированы телерентгенограммы и ортопантомограммы, полученные у 56 детей различного возраста. На ортопантомограммах проводили суставную горизонталь, соединяющие верхние точки суставных головок. От средней точки суставной горизонтали и перпендикулярно к ней, проводили эстетическую вертикаль, которая проходила между резцами до подбородочной точки. Отношение расстояния от средней точки до суставной головки к коэффициенту 1,5, определяло положение ретро молярной точки, от которой вниз проводили ретро молярную вертикаль, которая использовалась в качестве стресс-оси для дистально расположенных верхних зубов. На нижней челюсти стресс-осью для нижних моляров служила биссектриса нижнечелюстного угла.

РЕЗУЛЬТАТЫ. Результаты анализа рентгенограмм детей в периоде прикуса молочных зубов, показали то, что на рентгенограммах зачаток первого верхнего постоянного моляра располагался впереди ретро молярной вертикали, а нижнего первого моляра впереди биссектрисы нижнечелюстного угла. По мере роста челюстей менялось положение стресс-осей, но при оптимальных размерах челюстей дистальные зубы не выходили за ее пределы.
ВЫВОДЫ. Рентгеноанатомические особенности гнатической части лица определялись сменой молочных зубов постоянными. Особое место занимает ретро молярное пространство, в котором формируются дистально расположенные постоянные моляры. Расположение постоянных зубов или их частей позади ретро молярных вертикалей создает напряжение в гнатической части лица и может определить тактику экстракционных и без экстракционных методов ортодонтического лечения.

Ключевые слова: ортопантомография, телерентгенография, сменный прикус, физиологическая окклюзия

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INTRODUCTION

The period of tooth replacement in humans is typically accompanied by changes in the craniofacial complex, particularly within its gnathic component [1]. The present study identifies individual characteristics of the principal parameters of the dental arches under conditions of optimal occlusal equilibrium. Attention has been drawn to the group eruption of teeth and to changes in occlusal vertical dimension associated with the eruption of additional permanent molars in the posterior segments of the dental arches [2]. This process contributes to a subsequent increase in occlusal height and dental arch depth, which is reflected in the dimensions of the gnathic portion of the face.

Standard diagnostic protocols in clinical practice include radiological methods that allow, in vivo, assessment of the proportional relationships between individual facial components and the parameters of major stable cranial landmarks [3; 4]. These methods are also employed in morphological studies to evaluate anatomical variability across all regions of the craniofacial complex, including the gnathic part of the face.

The radiographic anatomical features of the gnathic region are determined by the replacement of primary teeth with permanent dentition. The principal radiological diagnostic methods include orthopantomography, lateral cephalography, and cone-beam computed tomography [5]. In the cited studies, researchers provided detailed information on the construction of the occlusal plane, the positional characteristics of occlusal reference points, and conducted comparative analyses of various diagnostic techniques. For the analysis of orthopantomograms, a tetrasectional method has been proposed, in which the distance between points located along the inferior contour of the articular eminence slope is divided into segments (four on each side). However, these data were obtained in individuals with complete dentition and did not reflect dynamic changes in the retromolar space, a recognized zone of jaw growth.

Methods of cephalometric analysis are aimed at determining the size and spatial relationships of the jaws within the cranial structure as a whole and allow evaluation of the positional relationships of the osseous components of the temporomandibular joint [6].

Relative stability of the vertical dimensions of the nasal region has been noted, except in cases influenced by genetically determined conditions, including variants of connective tissue dysplasia [7; 8]. In these studies, the authors identified phenotypic manifestations of undifferentiated connective tissue dysplasia in children and adolescents and reported associated alterations in vertical facial parameters.

Changes in facial parameters and dentoalveolar arches are assessed using numerous biometric methods, including photostatic facial analysis, with particular emphasis on the nasal and mandibular regions [2; 9]. The studies highlight the importance of identifying typological features of the face and dental arches that determine the variability of gnathic anatomy. Observations have been reported regarding the relationships between dental arch dimensions across different arch forms and dental types [10; 11]. Index-based metrics have been proposed to evaluate the proportionality of sagittal, diagonal, and transverse parameters.

Despite the fact that permanent molars are generally regarded as the key determinants of occlusal equilibrium, there is a paucity of data regarding methods for determining the position of these key teeth. Only limited studies emphasize the importance of considering distal occlusal reference points when assessing jaw position. Evidence has been presented on the influence of asymmetry on the shape of dental arches and the positioning of distal occlusal landmarks [12]. However, these investigations were conducted in individuals with fully established permanent dentition.

It should be noted that such studies have both applied and scientific as well as educational significance. Specific features of parameter utilization in dental arch modeling, taking into account the anatomical variability of the gnathic region, have been described [13; 14].

The effectiveness of radiological diagnostic methods has been demonstrated in the assessment of patient cohorts under dispensary observation and in evaluating the quality of diagnostic and therapeutic interventions [15; 16].

Thus, the characterization of the radiographic anatomy of the gnathic region in children during the mixed dentition period remains a relevant issue. This developmental stage is marked by changes in the retromolar space associated with the formation and eruption of distally positioned teeth, which determined the objective of the present study.

AIM

To determine the specific features of the radiographic anatomy of the gnathic region of the face in children during the mixed dentition period based on lateral cephalography and orthopantomography.

MATERIALS AND METHODS

The study was retrospective in design and involved the evaluation of archived lateral cephalograms and orthopantomograms of 48 patients with optimal functional occlusion. Radiographs were stratified according to age groups based on the physiological sequence of tooth replacement.

Inclusion criteria: children with physiological occlusal relationships of the dental arches and a neutral jaw position, determined by the relationship of the first permanent molars.

Exclusion criteria: children with incomplete dentition, as well as those presenting with occlusal anomalies in the vertical, sagittal, or transverse planes, were excluded from the study. Patients with congenital or acquired pathologies of the maxillofacial region were also not included.

The initial group comprised children following the completion of primary dentition function. These data were considered as the baseline, reflecting the dimensions of the dentoalveolar arches and the position of distal teeth under conditions of occlusal equilibrium in the primary dentition.

During the mixed dentition period (main group), subgroups were formed according to the stages of group eruption of permanent teeth. The first subgroup included children with erupted first permanent molars and mandibular central incisors. The second subgroup consisted of children in whom all primary incisors had been replaced. In the third subgroup, the first primary molars had been replaced by first premolars, along with the eruption of mandibular canines. The fourth subgroup included children in whom the remaining primary teeth had been replaced by second premolars and maxillary permanent canines. The final stage, characterized by the eruption of second permanent molars, defined the fifth subgroup.

On orthopantomograms, specific points and reference lines were established to assess the dimensions of the dentoalveolar arches and the optimal position of distally located teeth in occlusion. For this purpose, the condylion point (Cond) was identified bilaterally at the most superior point of the mandibular condyle heads and connected by the articular horizontal line. From the midpoint of this horizontal line, a median vertical line was constructed, typically connecting the central point (Cp) with the menton (Me).

The constructed gonion point (Go) was determined conventionally as the intersection of a tangent to the mandibular ramus and a line connecting the gonion region with the menton (Me), located at the inferior aspect of the chin along the midline. From the angular point Go, a perpendicular was drawn to the articular horizontal line. The intersection of these lines defined point Go′. This construction was proposed because, on orthopantomograms – unlike lateral cephalograms – the mandibular angle may be subject to distortion.

The distance between point Go′ and the central point (Cp) was divided by a coefficient of 1.5. The resulting value was projected from the central point onto the articular horizontal line to define point RM. From RM, a perpendicular line was drawn, located within the retromolar region and typically passing near the distal surfaces of the posterior teeth delimiting the dentoalveolar arches. Additionally, half of the distance between Cp and RM determined the position of the molar vertical, with the corresponding point on the articular horizontal line designated as M1 (Fig. 1).

The optimal position of the mandibular distal teeth was defined by their location anterior to the stress axis, corresponding to the bisector of the gonial-mental angle (Go′–Go–Me).

The cephalometric analysis was based on the condylar-spinal line connecting the most superior point of the mandibular condyle to the anterior nasal spine (Cond–SNA). A reference point (RM) was established at the midpoint of this line, from which a perpendicular line was drawn inferiorly. As in orthopantomographic analysis, this perpendicular delineated the retromolar region (Fig. 2).

The stress axis used to assess the position of the mandibular distal tooth (or tooth germ) was defined as the bisector of the condylar-gonial-mental angle (Cond–Go–Me), in contrast to the corresponding axis applied in orthopantomographic analysis.

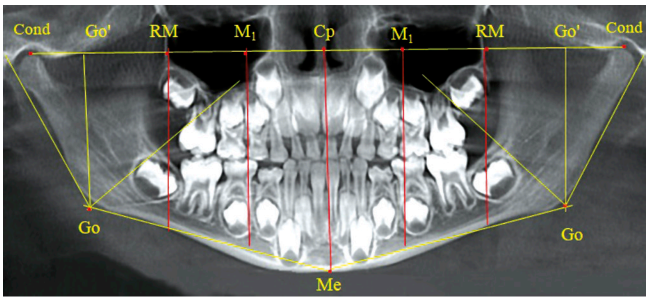
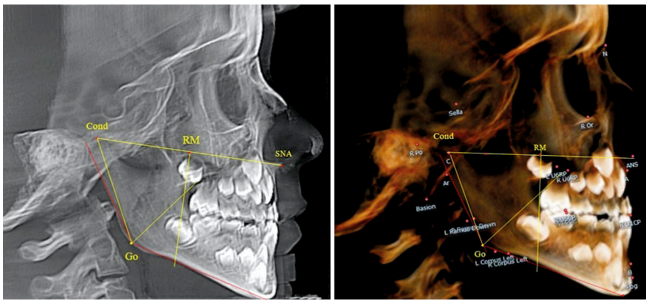


Fig. 1. Orthopantomographic analysis of a child in the mixed dentition period for determining the position of distally located teeth

Рис. 1. Анализ ортопантомограммы ребенка в период сменного прикуса при определении положения дистально расположенных зубов



A B

Fig. 2. Analysis of a lateral cephalogram (*A*) and a 3D model (*B*) during the mixed dentition period

Рис. 2. Анализ боковой телерентгенограммы (*A*) и 3D модели (*B*) в период сменного прикуса

On the analyzed, standardized radiographs, linear and angular measurements were obtained, followed by the construction of reference lines. Given the wide variability in jaw dimensions in children at different stages of ontogenesis, the assessment of radiographic anatomical features was based not on absolute values expressed in millimeters or degrees, but rather on the positional relationships of teeth relative to the constructed reference lines.

RESULTS

The analysis of orthopantomograms in children with fully established primary dentition revealed specific features in the positioning of developing permanent successor tooth germs relative to the roots of primary teeth, as well as the formation of additional tooth germs, including distally located permanent molars.

The esthetic centerline was defined as a perpendicular drawn from the midpoint of the intercondylar horizontal line (Cond–Cond). This reference line passed between the maxillary and mandibular central incisors and extended to the inferior border of the chin (point Me).

The ratio of the segment of the articular horizontal line from the central point (Cp) to the projection of the gonion point (Go′), divided by a coefficient of 1.5, determined the position of the initial reference point (RM) used for constructing the retromolar vertical perpendicular to the articular horizontal. A characteristic feature of this developmental stage was that the germ of the maxillary first permanent molar, under conditions of optimal occlusal relationships, was located anterior to the retromolar vertical. This finding indicated a favorable spatial position of the tooth germ, which would subsequently facilitate proper eruption during root development.

In addition, the distance (Cp–RM) defined the dentoalveolar dimension of the maxilla on both the right and left sides. The molar vertical, originating from the molar point (M1), passed through the distal surfaces of the first primary molars in both dental arches (Fig. 3).

The developing germs of the first permanent mandibular molars were located anterior to the bisector of the Go′–Go–Me angle. This finding, consistent with observations in the maxilla, indicated a favorable spatial orientation for the subsequent formation and eruption of the first permanent molar of the mandible. Antimeric teeth in both jaws were positioned symmetrically relative to the diagnostic reference lines.

Analysis of lateral cephalograms and the three-dimensional model demonstrated that the spatial relationships of teeth and jaws relative to the reference lines were comparable to those obtained from orthopantomographic assessment.

A reference point (RM) was established at the midpoint of the Cond–SNA articular horizontal line, from which a perpendicular was drawn inferiorly. As in orthopantomographic analysis, this perpendicular delineated the retromolar region. The germ of the maxillary first permanent molar was typically located anterior to the retromolar vertical.

The bisector of the Cond–Go–Me angle (stress axis), similarly to orthopantomographic findings, was positioned posterior to the developing germs of the first permanent mandibular molars (Fig. 4).

Thus, in clinical practice, both orthopantomography and lateral cephalography are considered suitable for the analysis of tooth position and assessment of proportional relationships of the jaws.

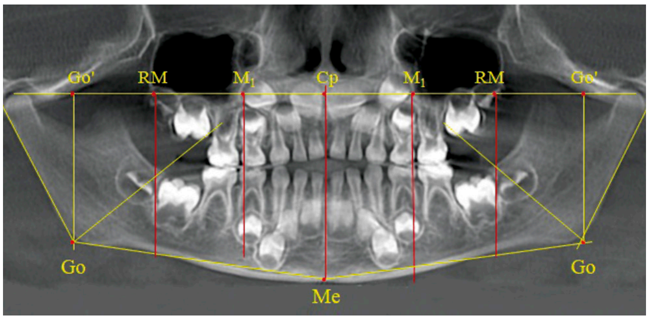
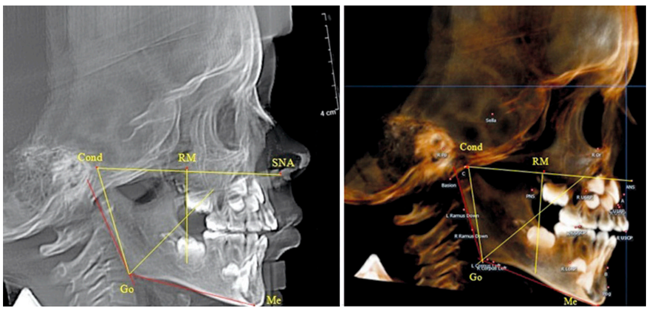


Fig. 3. Orthopantomogram of a 4-year-old child in the primary dentition period

Рис. 3. Ортопантомограмма ребенка 4 года в период прикуса молочных зубов



A B

Fig. 4. Lateral cephalogram (*A*) and a 3D model (*B*) of a 4-year-old child in the primary dentition period

Рис. 4. Боковая телерентгенограмма (*A*) и 3D модель (*B*) ребенка 4 года в период прикуса молочных зубов

In the analysis of radiographs from children in the first subgroup (with erupted first permanent molars and mandibular central incisors), changes in tooth positioning relative to the established reference lines were observed. The first permanent molars consistently maintained occlusal stability, while the second permanent molars demonstrated crown mineralization, and the mineralization of successor teeth of the permanent dentition continued.

A characteristic feature of this developmental stage was that the germs of the second maxillary permanent molars were located anterior to the retromolar vertical line. This spatial configuration indicated a favorable position of the tooth germs, ensuring their subsequent eruption during root formation. Furthermore, the Cp–RM distance defined the dentoalveolar dimension of the maxilla on both the right and left sides.

The molar vertical originating from the molar point (M1), in contrast to the primary dentition period, shifted toward the middle third of the mesial surface of the second primary molars in both dental arches. This shift was associated with an increase in the retromolar space (Fig. 5).

The germs of the second permanent mandibular molars were located anterior to the bisector of the Go′–Go–Me angle. This spatial arrangement, similar to that observed in the maxilla, had a favorable influence on the formation and eruption of the mandibular first permanent molars.

Analysis of lateral cephalograms and the three-dimensional model demonstrated that the spatial relationships of teeth and jaws relative to the reference lines were consistent with those obtained from orthopantomographic assessment. The bisector of the Cond–Go–Me angle, similarly to the orthopantomographic findings, was positioned posterior to the developing germs of the second permanent mandibular molars (Fig. 6).

In the analysis of radiographs from children with erupted permanent incisors (second eruption subgroup), it was observed that the germs of the second maxillary permanent molars, similarly to the previous subgroup, were positioned anterior to the retromolar vertical line. This finding indicated a favorable spatial orientation of the tooth germs. The molar vertical originating from the molar point (M1) passed in close proximity to the middle third of the crowns of the second primary molars in both dental arches (Fig. 7).

Analysis of lateral cephalograms and the three-dimensional model demonstrated that the spatial relationships of teeth and jaws relative to the reference lines were consistent with the values obtained from orthopantomographic evaluation. The bisector of the Cond–Go–Me angle, similarly to the findings on orthopantomograms, was positioned posterior to the developing germs of the second permanent mandibular molars (Fig. 8).

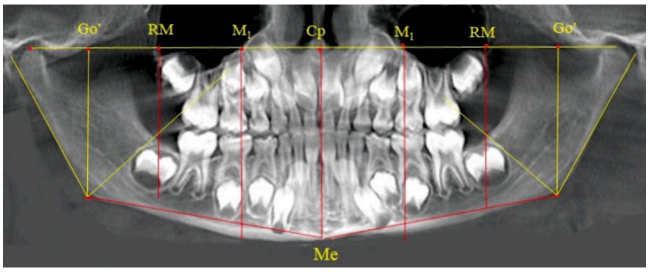


Fig. 5. Orthopantomogram of a 7-year-old child after eruption of the first group of permanent teeth

Рис. 5. Ортопантомограмма ребенка 7 лет после прорезывания первой группы постоянных зубов

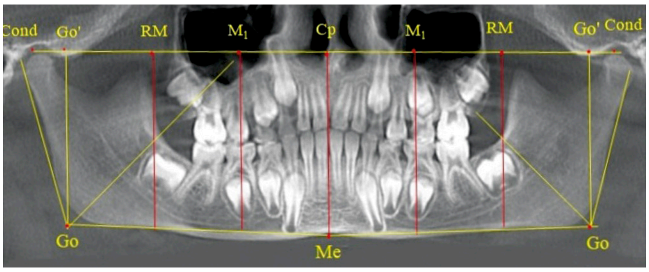
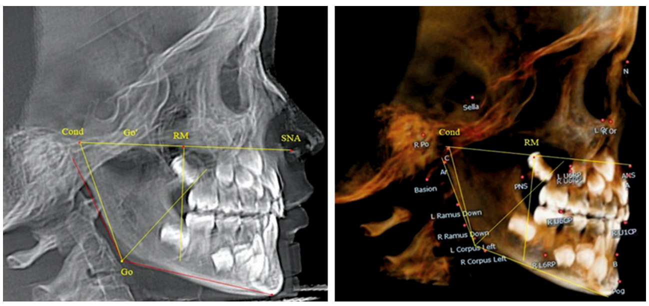


Fig. 7. Orthopantomogram of an 8-year-old child following eruption of the permanent incisors

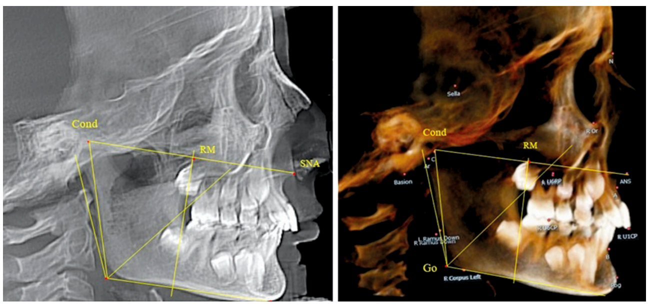
Рис. 7. Ортопантомограмма ребенка 8 лет после прорезывания постоянных резцов



A B

Fig. 6. Lateral cephalogram (*A*) and a 3D model (*B*) of a 7-year-old child following eruption of the first group of permanent teeth

Рис. 6. Боковая телерентгенограмма (*A*) и 3D модель (*B*) ребенка 7 лет после прорезывания первой группы постоянных зубов



A B

Fig. 8. Lateral cephalogram (*A*) and a 3D model (*B*) of an 8-year-old child following eruption of the permanent incisors

Рис. 8. Боковая телерентгенограмма (*A*) и 3D модель (*B*) ребенка 8 лет после прорезывания постоянных резцов

After complete replacement of primary dentition by permanent teeth, continued mineralization and root formation of permanent premolars, canines, and second molars was observed. The germs of the developing second maxillary permanent molars, similarly to the previous subgroup, were positioned anterior to the retromolar vertical line (Fig. 9).

The bisector of the Cond–Go–Me angle was positioned posterior to the developing germs of the second permanent mandibular molars. Following the eruption of the second permanent molars, complete formation of the permanent occlusion was achieved. At this stage, radiographic anatomical characteristics were primarily determined by the presence or absence of third molars (or their tooth germs) within the maxillary and mandibular bones. The most favorable condition was considered to be the presence of 14 teeth in both the maxillary and mandibular dental arches (Fig. 10).

On the lateral radiograph, similarly to the orthopantomogram, the distally located teeth were positioned anterior to the stress axes of both the maxilla and the mandible (Fig. 11). In such cases, an adequate amount of free space in the retromolar region was identified in both the maxilla and the mandible. The molar vertical line delineated the molar segment of the dental arch.

In the presence of third molars, orthopantomographic evaluation focused on the position of the maxillary third molars relative to the retromolar line, and of the mandibular third molars relative to the bisector of the mandibular angle (Fig. 12).

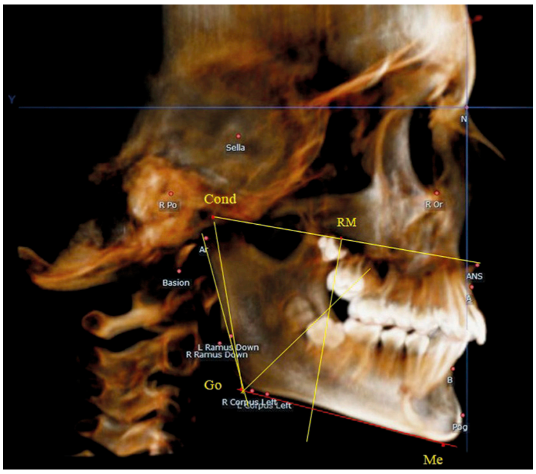


Fig. 9. Radiograph of a 12-year-old child after replacement of primary teeth with permanent dentition

Рис. 9. Рентгенограмма ребенка 12 лет после замещения молочных зубов постоянными

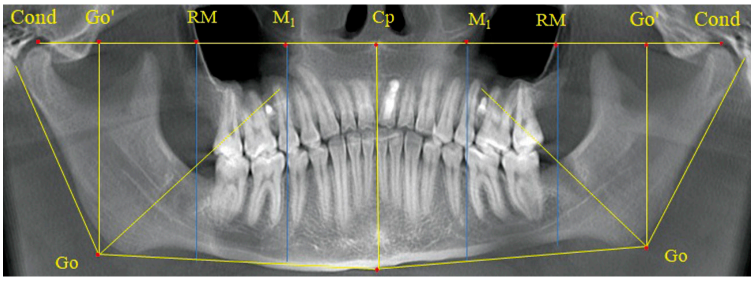


Fig. 10. Orthopantomogram of a 16-year-old patient with a complete set of permanent teeth

Рис. 10. Ортопантомограмма пациента 16 лет с полным комплектом постоянных зубов

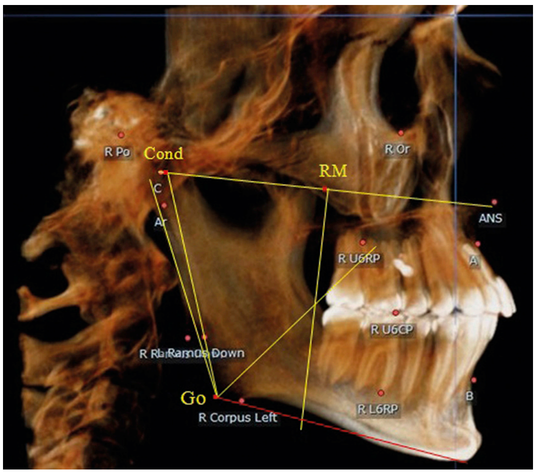


Fig. 11. Radiograph of a 16-year-old patient with a complete set of permanent teeth and physiological occlusion

Рис. 11. Рентгенограмма пациента 16 лет с полным комплектом постоянных зубов при физиологической окклюзии

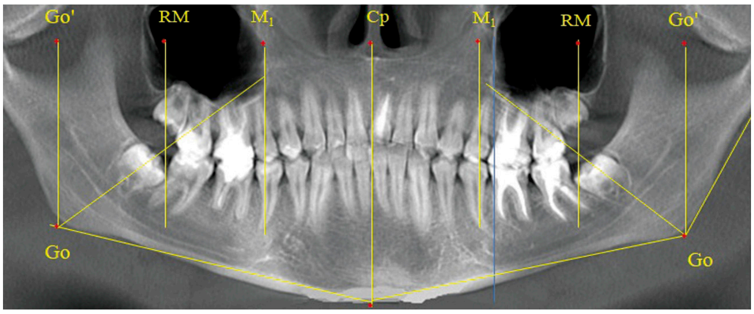


Fig. 12. Orthopantomogram of a 17-year-old patient with the presence of third molar tooth germs

Рис. 12. Ортопантомограмма пациента 17 лет при наличии зачатков зубов мудрости

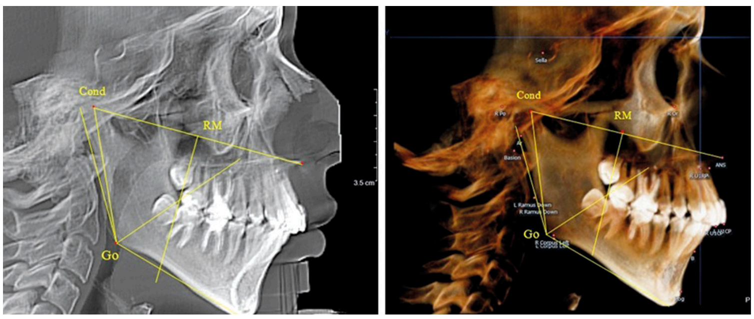


Fig. 13. Radiograph of a 17-year-old patient with the presence of third molar tooth germs

Рис. 13. Рентгенограмма пациента 17 лет при наличии зачатков зубов мудрости

On the lateral radiograph, similarly to the orthopantomogram, distally positioned teeth in cases of optimal jaw dimensions were located anterior to the stress axes of both the maxilla and the mandible. When teeth or their components were positioned beyond the diagnostic reference lines, this was considered an indicator for the potential indication of alternative extraction of third molars (Fig. 13).

Protrusion of third molars beyond the stress axes created biomechanical tension within the jaws and served as a determinant for the selection of extraction-based therapeutic strategies.

Thus, the assessment of the spatial relationship of erupted distal teeth or their developing germs relative to the diagnostic lines of the retromolar space represents a diagnostic criterion for evaluating the concordance or discordance between tooth size and dentoalveolar arch dimensions, and it further guides the choice of orthodontic treatment modalities in patients.

DISCUSSION

The results of the present study demonstrated that during the mixed dentition period in children with physiological occlusal relationships of the dental arches and a neutral jaw position within the craniofacial complex, the position of distally located molars plays a key role.

The morphological characteristics of the gnathic region in children are determined by changes in key parameters associated with the replacement of primary teeth by permanent successors, as well as the eruption of accessory teeth in the distal segments of the dental arches. The majority of scientific studies addressing the gnathic region during the mixed dentition period focus on morphometric changes related to increased occlusal vertical dimension and dental arch depth due to growth of distal segments [1; 3].

The proposed analytical method for both orthopantomograms and lateral cephalograms enabled the determination of the optimal spatial positioning of distally located teeth for harmonious development of the maxillofacial region. The retromolar vertical line typically delineates the retromolar space and allows assessment of available space for the eruption of permanent molars. This method is of particular relevance in evaluating the position of third molars. Existing literature provides data regarding indications for extraction-based therapy [9; 11], including asymmetric dental arch forms requiring removal of antimers, as well as indications for extraction of impacted or semi-impacted third molars with atypical positioning confirmed by cone-beam computed tomography.

The proposed approach enables the determination of organ-preserving orthodontic treatment strategies, taking into account individual anatomical features of the gnathic region and the principles of patient-centered healthcare.

The study results indicate that, regardless of the ontogenetic stage, the retromolar vertical can be used as a stress axis for predicting the optimal eruption of molars in the distal segments of the dental arches. A promising direction for future research is the evaluation of the retromolar space in children with sagittal occlusal anomalies.

CONCLUSION

Radiographic anatomical features of the gnathic region are determined by the transition from primary to permanent dentition. Particular attention is given to the retromolar space, where distally located permanent molars develop.

The proposed method of constructing stress axes enables the assessment of optimal parameters of the retromolar space, in which the tooth germs of permanent molars, including third molars, are formed. The positioning of permanent teeth or their components posterior to the retromolar vertical lines generates functional stress within the gnathic region and may guide the selection of either extraction or non-extraction orthodontic treatment strategies.

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