Original Research

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The effect of the type of jaw growth caused by the change of baby teeth on the bioelectric activity of the chewing muscles

Vladimir V. Shkarin, Irina V. Didenko, Yuliya A. Makedonova ✉, Sergei V. Dmitrienko, Elena N. Iarygina, Anastasia G. Pavlova-Adamovich, Elena A. Ogonyan

Volgograd State Medical University, Volgograd, Russian Federation

✉ mihai-m@yandex.ru

Abstract

INTRODUCTION. The bioelectric activity of the masticatory muscles is influenced by many factors due to the parameters of the craniofacial complex – morphometric parameters of the head. However, there is no data in the literature on the effect of the type of jaw growth during periods of alternating bite on the functional activity of the muscles that lift the lower jaw.

AIM. To determine the impact of jaw growth type, associated with the transition from deciduous to permanent teeth, on the bioelectrical activity of the masticatory muscles.

MATERIALS AND METHODS. A survey of 150 children aged 5 to 14 years was conducted, randomized into 5 groups – group I – the final period of milk bite and preparation of the jaw for tooth replacement. Group II – the first permanent molars and incisors of the lower jaw erupted. Group III – there was a change of permanent milk incisors. Group IV – there was a complete change of all baby teeth. Group V – the second permanent molars have erupted. An analysis of the telerentgenogram and the functional activity of the masticatory muscles is presented by determining absolute and relative indicators.

RESULTS. In patients of groups I, II and III, low bioelectric activity was detected, which increases during the complete change of all baby teeth and the eruption of the second permanent molars, which is due to the formation of chewing activity of the muscles. Also, during this period, the symmetry and synchronicity of the work of the masticatory and temporal muscles proper was noted.

CONCLUSIONS. Minimal changes during jaw growth due to the change of baby teeth lead to a change in the functional activity of the masticatory muscles, which may subsequently be a predictor factor for the development of neuromuscular imbalance in the maxillofacial region.

Keywords: removable bite, telerentgenogram, electromyography, jaw growth

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Влияние типа роста челюстей, обусловленного сменой молочных зубов, на биоэлектрическую активность жевательных мышц

В.В. Шкарин, И.В. Диденко, Ю.А. Македонова ✉, С.В. Дмитриенко, Е.Н. Ярыгина, А.Г. Павлова-Адамович, Е.А. Огонян

Волгоградский государственный медицинский университет, г. Волгоград, Российская Федерация

✉ mihai-m@yandex.ru

Резюме

ВВЕДЕНИЕ. На биоэлектрическую активность жевательной мускулатуры влияет множество факторов, обусловленные параметрами кранио-фациального комплекса – морфометрические параметры головы. Однако, в литературе отсутствуют данные о влиянии типа роста челюстей в периоды сменного прикуса на функциональную активность мышц, поднимающих нижнюю челюсть.

ЦЕЛЬ ИССЛЕДОВАНИЯ. Определить влияние типа роста челюстей, обусловленного сменой молочных зубов, на биоэлектрическую активность жевательных мышц.

МАТЕРИАЛЫ И МЕТОДЫ. Проведено обследование 150 детей в возрасте от 5 до 14 лет, рандомизированные на 5 групп – I группа – завершающий период молочного прикуса и подготовка челюсти к смене зубов. II группа – прорезались первые постоянные моляры и резцы нижней челюсти. III группа – произошла смена молочных резцов постоянными. IV группа – произошла полная смена всех молочных зубов. V группа – прорезались вторые постоянные моляры. Представлен анализ телерентгенограммы и функциональной активности жевательной мускулатуры с помощью определения абсолютных и относительных показателей.
РЕЗУЛЬТАТЫ. У пациентов I, II и III групп выявлена низкая биоэлектрическая активность, которая в период полной смены всех молочных зубов и прорезывания вторых постоянных моляров увеличивается, что обусловлено формированием жевательной активности мускулатуры. Также в данный период отмечалась симметричность и синхронность работы собственно жевательной и височной мышц.
ВЫВОДЫ. Минимальные изменения в период роста челюстей, обусловленные сменой молочных зубов, приводят к изменению функциональной активности жевательных мышц, которая впоследствии может являться фактором-предиктором развития нейромышечного дисбаланса челюстно-лицевой области.

Ключевые слова: сменный прикус, телерентгенограмма, электромиография, рост челюсти

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INTRODUCTION

Morphometric parameters of the craniofacial complex determine the characteristics of the masticatory muscles, as demonstrated by previous studies [1]. However, during the mixed dentition period, structural transformations occur as a result of jaw growth associated with the eruption of primary and permanent teeth [2]. To date, the literature provides detailed data on changes in craniofacial parameters in children during the transition from primary to permanent dentition. Researchers have observed that the most significant dimensional changes occur in the facial region of the skull and are related to the phases of occlusal height increase following the eruption of key teeth [3].

At the same time, international literature reports that by the time of dental replacement, the dimensions of the neurocranium in children reach approximately 90% of adult values. It is therefore evident that the size of cranial bones contributes to the anatomical and functional features of the masticatory musculature [4]. Morphometric peculiarities of the facial skeleton in children during the early mixed dentition stage have also been documented in the presence of occlusal abnormalities, particularly in terms of vertical skeletal parameters. During this period, active growth of the mandibular ramus continues, accommodating the developing buds of permanent molars [5].

Furthermore, the type of facial skeletal growth is influenced by the gonial angle, which ranges from 118° to 122° in cases of neutral growth patterns. Consequently, the orientation of the muscle attachment site at this angle is presumed to affect the bioelectrical activity of the masticatory muscles [6]. However, no current literature provides data on the influence of jaw growth during the mixed dentition period on the functional activity of masticatory muscles.

Electromyography remains the principal method for assessing the bioelectrical activity of the masticatory muscles and is well documented in both textbook and scientific literature [7]. Surface electromyography (sEMG) is one of the primary auxiliary diagnostic tools, enabling objective assessment of the functional state of the masticatory muscles, including their bioelectrical activity [8]. While this method is described in both domestic and international publications, the majority of studies offer comparative analyses between patient groups and controls without clearly defined quantitative criteria [9; 10].

Several studies have reported asymmetry in the bioelectrical activity of the masticatory muscles in children with physiological occlusion, whereas in malocclusion cases, the temporal and masseter muscles exhibit synchronized function. However, these investigations have not addressed the typological changes in the functional state of the masticatory muscles during tooth replacement in relation to jaw growth. This gap in knowledge formed the rationale for the present study.

AIM

To examine the influence of jaw growth patterns associated with the transition from primary to permanent dentition on the bioelectrical activity of the masticatory muscles.

MATERIALS AND METHODS

The study was conducted at the Department of Dentistry and the Department of Prosthetic Dentistry and Orthodontics of the Institute of Continuing Medical and Pharmaceutical Education at Volgograd State Medical University. In accordance with the study standardization protocol, specific inclusion, non-inclusion, and exclusion criteria were developed.

Inclusion criteria

- Age 5–14 years
- Absence of chronic somatic diseases
- Absence of periodontal diseases
- Absence of temporomandibular joint dysfunction
- Informed voluntary consent of the parents

Exclusion criteria

- Presence of pain on percussion of the tooth
- Unwillingness to undergo procedures
- Simultaneous participation in another clinical trial
- Socially vulnerable population groups

Exclusion criteria

- Individuals under 5 years and over 14 years of age
- Low patient compliance
- Patient's withdrawal from further participation in the study
- Orthodontic treatment
- Administration of botulinum toxin type A

Fig. 1. Inclusion, Non-inclusion, and Exclusion Criteria for Study Participants

Рис. 1. Критерии включения / невключения / исключения пациентов в исследование

All participants were divided into five equal groups (30 individuals each), based on the eruption stage of specific tooth groups:

– Group I – final stage of primary dentition and preparation of the jaws for tooth transition.

– Group II – eruption of the first permanent molars and mandibular incisors.

– Group III – replacement of primary incisors with permanent ones.

– Group IV – complete replacement of all primary teeth.

– Group V – eruption of the second permanent molars.

Dental examinations were carried out using both basic and supplementary diagnostic methods. Clinical oral evaluation was performed using a dental mirror and probe. The dental status and presence of periodontal conditions were assessed. Lateral and posteroanterior cephalometric radiographs were obtained using the Evolution (Italy) imaging system.

Electromyographic (EMG) examination was conducted using the **Synapsis** system in accordance with standard protocols. Surface electrodes were placed on the masseter and temporalis muscles, with an interelectrode distance of at least 1 cm. Patients were seated in a dental chair in a relaxed, resting state.

During the "rest" trial, the following parameters were recorded:

– maximum and mean amplitudes of the masseter and temporalis muscles on both sides;

– Temporalis Muscle Symmetry Index (TMSI);

– Masseter Muscle Symmetry Index (MMSI);

– Center of Muscle Coordination (CMC);

– Torsion Index (TORS).

Mean amplitude values were considered absolute parameters, measured in microvolts (µV). Relative parameters – TMSI, MMSI, CMC, and TORS – were automatically calculated by the software and expressed as percentages.

Statistical analysis was performed using Statistica 10.0 Enterprise. Descriptive and inferential statistics were applied, including the calculation of the mean (M), standard error ($\pm m$), standard deviation (σ), and intergroup comparisons using Student's t-test to assess statistical significance.

RESULTS

Analysis of the mean amplitude of the temporalis and masseter muscles revealed group-dependent differences in bioelectrical activity. It is evident that the functional activity of the examined muscles depends on the type of jaw growth and the number of erupted teeth. In Group I, the mean amplitude of the temporalis muscle was statistically significantly lower compared to other groups: 21.4% lower than Group II, 25% lower than Group III, 33.9% lower than Group IV, and 66.8% lower than Group V. No statistically significant differences were observed between Groups II, III, and IV ($p > 0.05$). However, in Group Vchildren with erupted second permanent molarsthe mean amplitude was 36.7% higher than in Group II, 32.9% higher than in Group III, and 24% higher than in Group IV (children with complete primary tooth replacement).

The values of mean masseter muscle amplitude followed a similar trend to the temporalis muscle. The lowest value was recorded in Group I (81.4±2.1 µV), which was 16% lower than in Group II, 22.2% lower than in Group III, 24.6% lower than in Group IV, and 45.7% lower than in Group V ($p < 0.05$). No significant differences were noted among Groups II, III, and IV ($p > 0.05$), which is likely due to the presence of first permanent molars in all three groups. The replacement of incisors alone does not appear to affect the functional state of the masticatory muscles, as these teeth are primarily involved in incising rather than chewing. In contrast, the eruption of second permanent molars significantly enhances the bioelectrical activity of both the temporalis and masseter muscles, as confirmed by the statistical analysis ($p < 0.05$).

Table 1. Absolute values of bioelectrical activity, µV

Таблица 1. Абсолютные значения биоэлектрической активности, мкВ

Indicators	Group	Mean amplitude
Temporalis muscle	I	56.3±2.4
	II	68.1±3.2
	III	70.2±3.1
	IV	75.1±2.7
	V	93.4±3.1
Masseter muscle	I	81.4±2.1
	II	93.9±2.4
	III	98.7±2.6
	IV	101.3±2.7
	V	118.4 ± 3.3

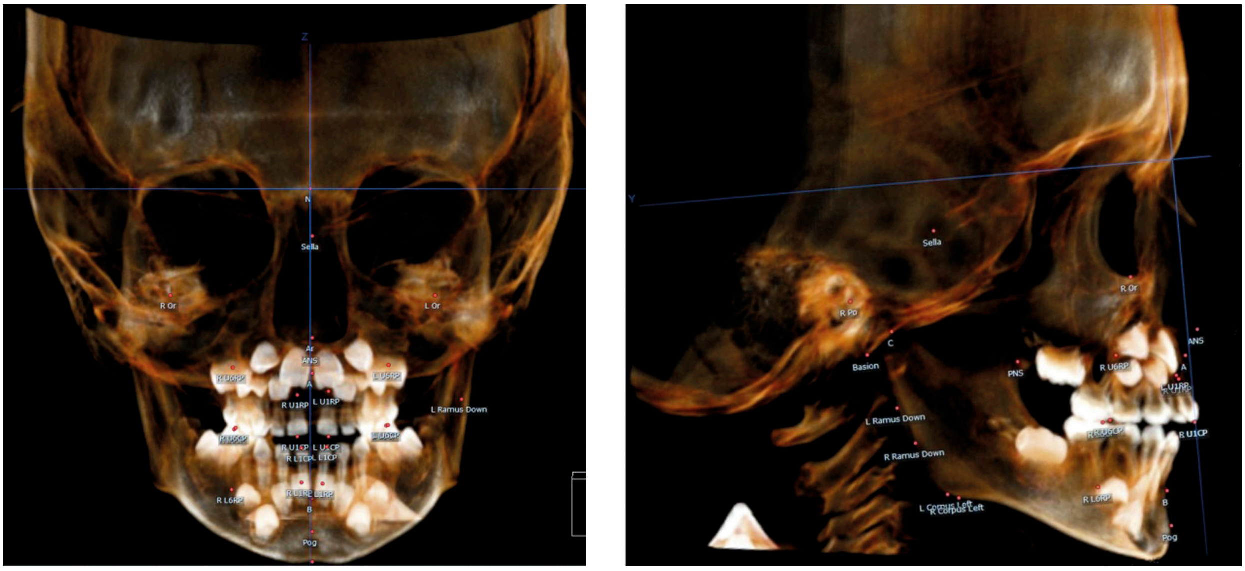
Table 2. Relative indicators of bioelectrical activity, %

Таблица 2. Относительные показатели биоэлектрической активности, в %

Group	TMSI	MMSI	TORS	CMC
I	19.7±4.6	20.3±3.1	22.4±3.6	23.1±3.5
II	15.2±3.6	16.9±2.0	15.9±1.8	14.7±2.1
III	15.6±1.4	16.7±1.7	15.2±1.9	15.6±1.5
IV	16.1±1.5	15.6±2.4	15.1±1.6	14.9±2.0
V	11.9±1.8	18.7±2.1	14.8±1.7	15.3±1.4

Relative electromyographic parameters reflecting the dynamics of neuromuscular changes are presented in Table 2.

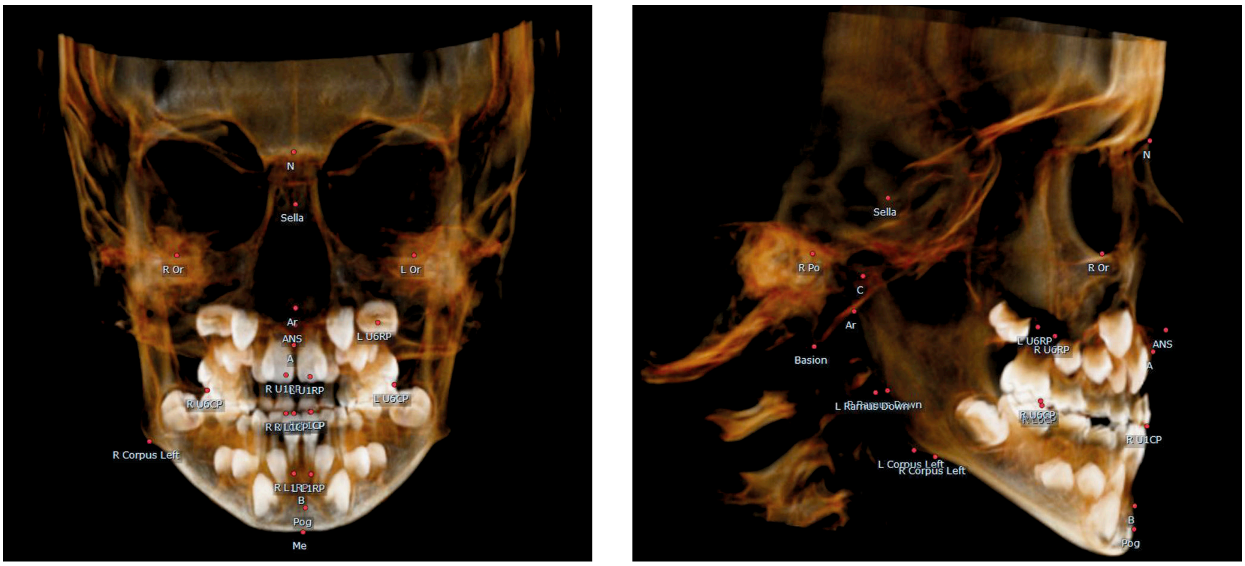
The analysis of the relative indicators of masticatory muscle activity revealed no statistically significant differences between the comparison groups ($p>0.05$). In children at the stage of primary dentition and in the preparatory phase for tooth transition, higher symmetry indices were observed. These values tended to decrease with age and over time. Greater symmetry and stability of muscle activity were noted during the eruption of the



A B

Fig. 2. Patient M., cephalometric radiograph: *A* – frontal view, *B* – lateral view

Рис. 2. Пациент М., телерентгенограмма: *А* – в прямой проекции, *В* – в боковой проекции



A B

Fig. 3. Patient M., cephalometric radiograph in frontal (*A*) and lateral (*B*) views of a child following the eruption of the first permanent molars and mandibular incisors

Рис. 3. Пациент М., телерентгенограмма в прямой (*А*) и боковой (В) проекциях ребенка после прорезывания первых постоянных моляров и нижних резцов second permanent molars, with the corresponding parameters demonstrating high reproducibility.

An increased torsion index in Group I children indicates an unbalanced activity of the masticatory muscles. In Groups II, III, and IV, the values were averaged, showing no predominance of either muscle group.

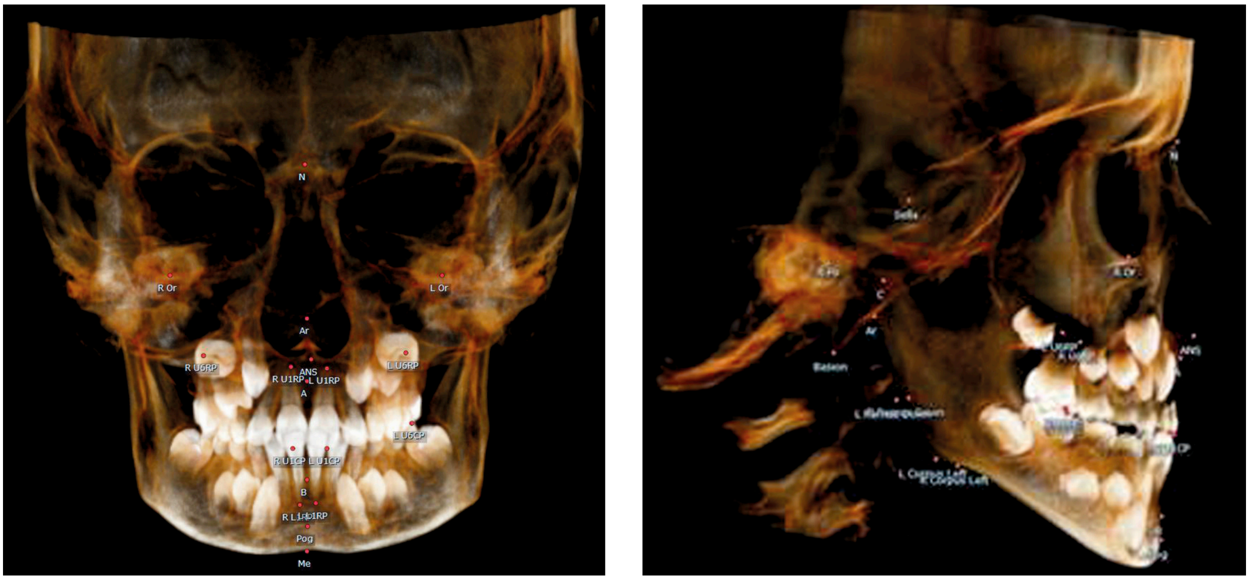
A cephalometric radiograph of patient M. from Group I, in both frontal and lateral views, is presented in Fig. 2.

Cephalometric radiograph of Patient P. from Group II, shown in both frontal and lateral projections, is presented in Fig. 3.

Cephalometric radiograph of Patient O. from Group III is presented in Fig. 4.

Cephalometric radiograph of Patient K. from Group IV is presented in Fig. 5.

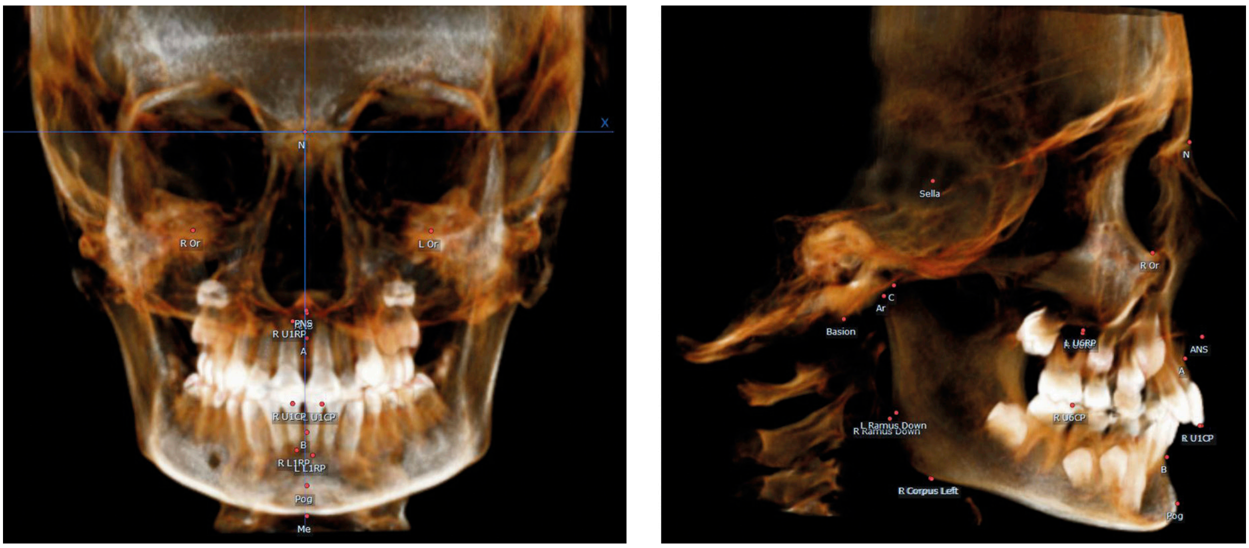
Cephalometric radiograph of Patient V. from Group V is presented in Fig. 6.



A **B**

Fig. 4. Patient M., cephalometric radiograph in frontal (*A*) and lateral (*B*) views after the replacement of primary incisors (Fig. 5)

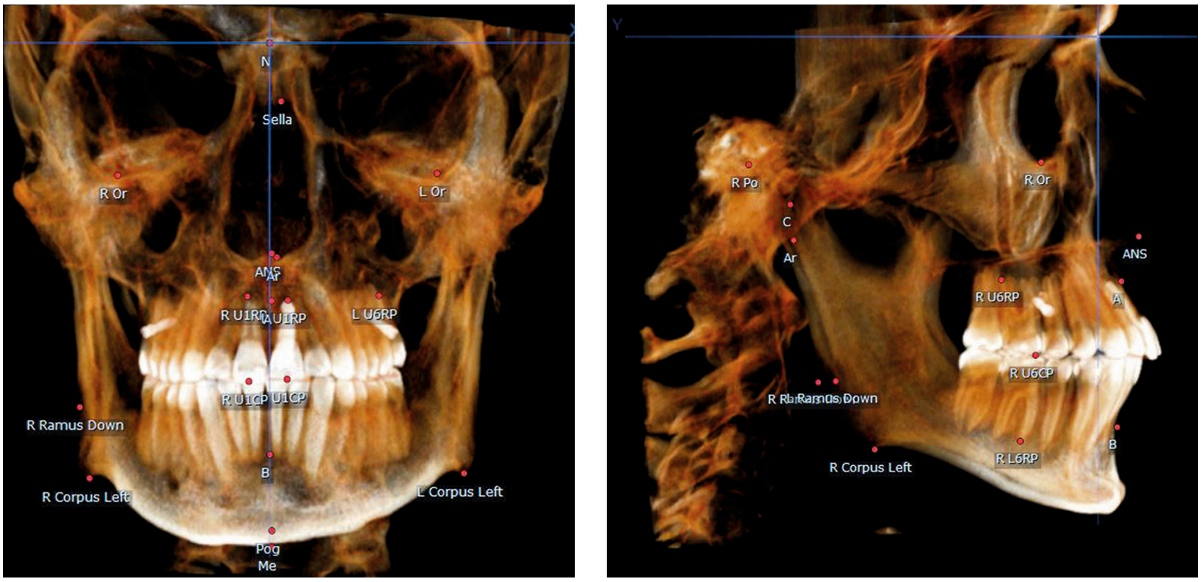
Рис. 4. Пациент М., телерентгенограмма в прямой (*А*) и боковой (*В*) проекциях после смены молочных резцов (рис. 5)



A **B**

Fig. 5. Cephalometric radiograph in frontal (*A*) and lateral (*B*) views of a child after the complete replacement of all primary teeth

Рис. 5. Телерентгенограмма в прямой (*А*) и боковой (*Б*) проекциях ребенка после смены всех молочных зубов



A **B**

Fig. 6. Cephalometric radiograph in frontal (*A*) and lateral (*B*) views of a child after the eruption of the second permanent molars

Рис. 6. Телерентгенограмма в прямой (*A*) и боковой (*B*) проекциях ребенка после прорезывания вторых постоянных моляров

CONCLUSION

Thus, the present study demonstrated a direct correlation between jaw growth patterns during the transition from primary to permanent dentition and the bioelectrical activity of the mandibular elevator muscles. It was established that children in the final stage of primary dentition exhibited reduced functional activity of the masticatory muscles. During the eruption of the first permanent molars and mandibular incisors, as well as during the replacement of primary incisors with permanent ones, the bioelectrical activity remained slightly diminished. However, during the complete replacement of all primary teeth and the eruption of the second permanent molars, a clear symmetry and synchrony in the function of the masseter and temporalis muscles was observed, along with an increase in their functional activity.

It is noteworthy that even minor changes in occlusion during the mixed dentition period can alter the functional state of the masticatory muscles, potentially leading to neuromuscular imbalance. The more pronounced the changes in the dentoalveolar system and jaw structure, the more significant their impact on the neuromuscular system.

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INFORMATION ABOUT THE AUTHORS

Vladimir V. Shkarin – Dr. Sci. (Med.), Professor, Head of the Department of Public Health and Public Health, Institute of Continuing Medical and Pharmaceutical Education, Volgograd State Medical University, 1 Pavshikh Bortsov Sq., Volgograd 400131, Russian Federation; https://orcid.org/0000-0002-7520-7781

Irina V. Didenko – Postgraduate Student at the Department of Dentistry, Institute of Continuing Medical and Pharmaceutical Education, Volgograd State Medical University, 1 Pavshikh Bortsov Sq., Volgograd 400131, Russian Federation; https://orcid.org/0009-0002-0756-4186

Yuliya A. Makedonova – Dr. Sci. (Med.), Professor, Head of the Department of Dentistry, Institute of Continuing Medical and Pharmaceutical Education, Volgograd State Medical University, 1 Pavshikh Bortsov Sq., Volgograd 400131, Russian Federation; https://orcid.org/0000-0002-5546-8570

Sergei V. Dmitrienko – Dr. Sci. (Med.), Professor, Head of the Department of Orthopedic Dentistry and Orthodontics, Institute of Continuing Medical and Pharmaceutical Education, Volgograd State Medical University, 1 Pavshikh Bortsov Sq., Volgograd 400131, Russian Federation; https://orcid.org/0000-0001-6955-2872

Elena N. Iarygina – Cand. Sci (Med.), Associate Professor, Head of the Department of Surgical Dentistry and Maxillofacial Surgery, Volgograd State Medical University, 1 Pavshikh Bortsov Sq., Volgograd 400131, Russian Federation; https://orcid.org/0000-0002-8478-9648

Anastasia G. Pavlova-Adamovich – Cand. Sci. (Med.), Associate Professor of the Department of Dentistry, Institute of Continuing Medical and Pharmaceutical Education, Volgograd State Medical University, 1 Pavshikh Bortsov Sq., Volgograd 400131, Russian Federation; https://orcid.org/0000-0002-0643-6863

Elena A. Ogonyan – Cand. Sci. (Med.), Associate Professor, Associate Professor of the Department of Dentistry, Institute of Continuing Medical and Pharmaceutical Education, Volgograd State Medical University, 1 Pavshikh Bortsov Sq., Volgograd 400131, Russian Federation; https://orcid.org/0009-0007-0493-3763

ИНФОРМАЦИЯ ОБ АВТОРАХ

Шкарин Владимир Вячеславович – д.м.н., профессор, заведующий кафедрой общественного здоровья и здравоохранения Института непрерывного медицинского и фармацевтического образования, ФГБОУ ВО «Волгоградский государственный медицинский университет», 400131, Российская Федерация, г. Волгоград, площадь Павших Борцов, д. 1; https://orcid.org/0000-0002-7520-7781

Диденко Ирина Васильевна – аспирант кафедры стоматологии Института непрерывного медицинского и фармацевтического образования, ФГБОУ ВО «Волгоградский государственный медицинский университет», 400131, Российская Федерация, г. Волгоград, площадь Павших Борцов, д. 1; https://orcid.org/0009-0002-0756-4186

Македонова Юлия Алексеевна – д.м.н., профессор, заведующий кафедрой стоматологии Института непрерывного медицинского и фармацевтического образования, ФГБОУ ВО «Волгоградский государственный медицинский университет», 400131, Российская Федерация, г. Волгоград, площадь Павших Борцов, д. 1; https://orcid.org/0000-0002-5546-8570

Дмитриенко Сергей Владимирович – д.м.н., профессор, заведующий кафедрой ортопедической стоматологии и ортодонтии Института непрерывного медицинского и фармацевтического образования, ФГБОУ ВО «Волгоградский государственный медицинский университет», 400131, Российская Федерация, г. Волгоград, площадь Павших Борцов, д. 1; https://orcid.org/0000-0001-6955-2872

Ярыгина Елена Николаевна – к.м.н., доцент, заведующий кафедрой хирургической стоматологии и челюстно-лицевой хирургии, ФГБОУ ВО «Волгоградский государственный медицинский университет», 400131, Российская Федерация, г. Волгоград, площадь Павших Борцов, д. 1; https://orcid.org/0000-0002-8478-9648

Павлова-Адамович Анастасия Геннадьевна – к.м.н., доцент кафедры стоматологии Института непрерывного медицинского и фармацевтического образования, ФГБОУ ВО «Волгоградский государственный медицинский университет», 400131, Российская Федерация, г. Волгоград, площадь Павших Борцов, д. 1; https://orcid.org/0000-0002-0643-6863

Огонян Елена Александровна – к.м.н., доцент, доцент кафедры стоматологии Института непрерывного медицинского и фармацевтического образования, ФГБОУ ВО «Волгоградский государственный медицинский университет», 400131, Российская Федерация, г. Волгоград, площадь Павших Борцов, д. 1; https://orcid.org/0009-0007-0493-3763

AUTHOR'S CONTRIBUTION

Vladimir V. Shkarin – general supervision, final approval for publication of the manuscript.

Irina V. Didenko – writing the text, checking critical intellectual conten.

Yuliya A. Makedonova – concept development and text editing.

Sergei V. Dmitrienko – concept development and text editing.

Elena N. Iarygina – data collection, analysis and interpretation of the obtained results.

Anastasia G. Pavlova-Adamovich – collection and processing of material.

Elena A. Ogonyan – writing the text; content correction.

ВКЛАД АВТОРОВ

В.В. Шкарин – общее руководство, окончательное утверждение для публикации рукописи.

И.В. Диденко – написание текста, проверка критически важного интеллектуального содержания.

Ю.А. Македонова – разработка концепции и редактирование текста.

С. . Дмитриенко – разработка концепции и редактирование текста.

Е.Н. Ярыгина – сбор данных, анализ и интерпретация полученных результатов.

А.Г. Павлова-Адамович – сбор и обработка материала.

Е.А. Огонян – написание текста; корректировка содержания.