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ЕЖЕМЕСЯЧНЫЙ НАУЧНЫЙ ЖУРНАЛ

Медицинские новости Грузии

საქართველოს სამედიცინო სიახლენი

GEORGIAN MEDICAL NEWS

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GMN: Georgian Medical News is peer-reviewed, published monthly journal committed to promoting the science and art of medicine and the betterment of public health, published by the GMN Editorial Board since 1994. GMN carries original scientific articles on medicine, biology and pharmacy, which are of experimental, theoretical and practical character; publishes original research, reviews, commentaries, editorials, essays, medical news, and correspondence in English and Russian.
GMN is indexed in MEDLINE, SCOPUS, PubMed and VINITI Russian Academy of Sciences. The full text content is available through EBSCO databases.

GMN: Медицинские новости Грузии - ежемесячный рецензируемый научный журнал, издаётся Редакционной коллегией с 1994 года на русском и английском языках в целях поддержки медицинской науки и улучшения здравоохранения. В журнале публикуются оригинальные научные статьи в области медицины, биологии и фармации, статьи обзорного характера, научные сообщения, новости медицины и здравоохранения. Журнал индексируется в MEDLINE, отражён в базе данных SCOPUS, PubMed и ВИНИТИ РАН. Полнотекстовые статьи журнала доступны через БД EBSCO.

GMN: Georgian Medical News – საქართველოს სამედიცინო სიახლენი – არის ყოველთვიური სამეცნიერო სამედიცინო რეცენზირებადი ჟურნალი, გამოიცემა 1994 წლიდან, წარმოადგენს სარედაქციო კოლეგიისა და აშშ-ის მეცნიერების, განათლების, ინდუსტრიის, ხელოვნებისა და ბუნებისმეტყველების საერთაშორისო აკადემიის ერთობლივ გამოცემას. GMN-ში რუსულ და ინგლისურ ენებზე ქვეყნდება ექსპერიმენტული, თეორიული და პრაქტიკული ხასიათის ორიგინალური სამეცნიერო სტატიები მედიცინის, ბიოლოგიისა და ფარმაციის სფეროში, მიმოხილვითი ხასიათის სტატიები.
ჟურნალი ინდექსირებულია MEDLINE-ის საერთაშორისო სისტემაში, ასახულია SCOPUS-ის, PubMed-ის და ВИНИТИ РАН-ის მონაცემთა ბაზებში. სტატიების სრული ტექსტი ხელმისაწვდომია EBSCO-ს მონაცემთა ბაზებიდან.

WEBSITE

www.geomednews.com

К СВЕДЕНИЮ АВТОРОВ!

При направлении статьи в редакцию необходимо соблюдать следующие правила:

1. Статья должна быть представлена в двух экземплярах, на русском или английском языках, напечатанная через **полтора интервала на одной стороне стандартного листа с шириной левого поля в три сантиметра**. Используемый компьютерный шрифт для текста на русском и английском языках - **Times New Roman** (**Кириллица**), для текста на грузинском языке следует использовать **AcadNusx.** Размер шрифта - **12**. К рукописи, напечатанной на компьютере, должен быть приложен CD со статьей.

2. Размер статьи должен быть не менее десяти и не более двадцати страниц машинописи, включая указатель литературы и резюме на английском, русском и грузинском языках.

3. В статье должны быть освещены актуальность данного материала, методы и результаты исследования и их обсуждение.

При представлении в печать научных экспериментальных работ авторы должны указывать вид и количество экспериментальных животных, применявшиеся методы обезболивания и усыпления (в ходе острых опытов).

4. К статье должны быть приложены краткое (на полстраницы) резюме на английском, русском и грузинском языках (включающее следующие разделы: цель исследования, материал и методы, результаты и заключение) и список ключевых слов (key words).

5. Таблицы необходимо представлять в печатной форме. Фотокопии не принимаются. **Все цифровые, итоговые и процентные данные в таблицах должны соответствовать таковым в тексте статьи**. Таблицы и графики должны быть озаглавлены.

6. Фотографии должны быть контрастными, фотокопии с рентгенограмм - в позитивном изображении. Рисунки, чертежи и диаграммы следует озаглавить, пронумеровать и вставить в соответствующее место текста **в tiff формате**.

В подписях к микрофотографиям следует указывать степень увеличения через окуляр или объектив и метод окраски или импрегнации срезов.

7. Фамилии отечественных авторов приводятся в оригинальной транскрипции.

8. При оформлении и направлении статей в журнал МНГ просим авторов соблюдать правила, изложенные в «Единых требованиях к рукописям, представляемым в биомедицинские журналы», принятых Международным комитетом редакторов медицинских журналов - http://www.spinesurgery.ru/files/publish.pdf и http://www.nlm.nih.gov/bsd/uniform_requirements.html
В конце каждой оригинальной статьи приводится библиографический список. В список литературы включаются все материалы, на которые имеются ссылки в тексте. Список составляется в алфавитном порядке и нумеруется. Литературный источник приводится на языке оригинала. В списке литературы сначала приводятся работы, написанные знаками грузинского алфавита, затем кириллицей и латиницей. Ссылки на цитируемые работы в тексте статьи даются в квадратных скобках в виде номера, соответствующего номеру данной работы в списке литературы. Большинство цитированных источников должны быть за последние 5-7 лет.

9. Для получения права на публикацию статья должна иметь от руководителя работы или учреждения визу и сопроводительное отношение, написанные или напечатанные на бланке и заверенные подписью и печатью.

10. В конце статьи должны быть подписи всех авторов, полностью приведены их фамилии, имена и отчества, указаны служебный и домашний номера телефонов и адреса или иные координаты. Количество авторов (соавторов) не должно превышать пяти человек.

11. Редакция оставляет за собой право сокращать и исправлять статьи. Корректура авторам не высылается, вся работа и сверка проводится по авторскому оригиналу.

12. Недопустимо направление в редакцию работ, представленных к печати в иных издательствах или опубликованных в других изданиях.

При нарушении указанных правил статьи не рассматриваются.

REQUIREMENTS

Please note, materials submitted to the Editorial Office Staff are supposed to meet the following requirements:

1. Articles must be provided with a double copy, in English or Russian languages and typed or compu-ter-printed on a single side of standard typing paper, with the left margin of **3** centimeters width, and **1.5** spacing between the lines, typeface - **Times New Roman** (**Cyrillic**), print size - **12** (referring to Georgian and Russian materials). With computer-printed texts please enclose a CD carrying the same file titled with Latin symbols.

2. Size of the article, including index and resume in English, Russian and Georgian languages must be at least 10 pages and not exceed the limit of 20 pages of typed or computer-printed text.

3. Submitted material must include a coverage of a topical subject, research methods, results, and review.

Authors of the scientific-research works must indicate the number of experimental biological species drawn in, list the employed methods of anesthetization and soporific means used during acute tests.

4. Articles must have a short (half page) abstract in English, Russian and Georgian (including the following sections: aim of study, material and methods, results and conclusions) and a list of key words.

5. Tables must be presented in an original typed or computer-printed form, instead of a photocopied version. **Numbers, totals, percentile data on the tables must coincide with those in the texts of the articles.** Tables and graphs must be headed.

6. Photographs are required to be contrasted and must be submitted with doubles. Please number each photograph with a pencil on its back, indicate author's name, title of the article (short version), and mark out its top and bottom parts. Drawings must be accurate, drafts and diagrams drawn in Indian ink (or black ink). Photocopies of the X-ray photographs must be presented in a positive image in **tiff format**.

Accurately numbered subtitles for each illustration must be listed on a separate sheet of paper. In the subtitles for the microphotographs please indicate the ocular and objective lens magnification power, method of coloring or impregnation of the microscopic sections (preparations).

7. Please indicate last names, first and middle initials of the native authors, present names and initials of the foreign authors in the transcription of the original language, enclose in parenthesis corresponding number under which the author is listed in the reference materials.

8. Please follow guidance offered to authors by The International Committee of Medical Journal Editors guidance in its Uniform Requirements for Manuscripts Submitted to Biomedical Journals publication available online at: http://www.nlm.nih.gov/bsd/uniform_requirements.html
http://www.icmje.org/urm_full.pdf
In GMN style for each work cited in the text, a bibliographic reference is given, and this is located at the end of the article under the title "References". All references cited in the text must be listed. The list of references should be arranged alphabetically and then numbered. References are numbered in the text [numbers in square brackets] and in the reference list and numbers are repeated throughout the text as needed. The bibliographic description is given in the language of publication (citations in Georgian script are followed by Cyrillic and Latin).

9. To obtain the rights of publication articles must be accompanied by a visa from the project instructor or the establishment, where the work has been performed, and a reference letter, both written or typed on a special signed form, certified by a stamp or a seal.

10. Articles must be signed by all of the authors at the end, and they must be provided with a list of full names, office and home phone numbers and addresses or other non-office locations where the authors could be reached. The number of the authors (co-authors) must not exceed the limit of 5 people.

11. Editorial Staff reserves the rights to cut down in size and correct the articles. Proof-sheets are not sent out to the authors. The entire editorial and collation work is performed according to the author's original text.

12. Sending in the works that have already been assigned to the press by other Editorial Staffs or have been printed by other publishers is not permissible.

**Articles that Fail to Meet the Aforementioned
Requirements are not Assigned to be Reviewed.**

ავტორთა საყურადღებოდ!

რედაქციაში სტატიის წარმოდგენისას საჭიროა დავიცვათ შემდეგი წესები:

1. სტატია უნდა წარმოადგინოთ 2 ცალად, რუსულ ან ინგლისურ ენებზე,დაბეჭდილი სტანდარტული ფურცლის 1 გვერდზე, 3 სმ სიგანის მარცხენა ველისა და სტრიქონებს შორის 1,5 ინტერვალის დაცვით. გამოყენებული კომპიუტერული შრიფტი რუსულ და ინგლისურენოვან ტექსტებში - **Times New Roman** (**Кириллица**), ხოლო ქართულენოვან ტექსტში საჭიროა გამოვიყენოთ **AcadNusx.** შრიფტის ზომა – 12. სტატიას თან უნდა ახლდეს CD სტატიით.

2. სტატიის მოცულობა არ უნდა შეადგენდეს 10 გვერდზე ნაკლებს და 20 გვერდზე მეტს ლიტერატურის სიის და რეზიუმეების (ინგლისურ,რუსულ და ქართულ ენებზე) ჩათვლით.

3. სტატიაში საჭიროა გაშუქდეს: საკითხის აქტუალობა; კვლევის მიზანი; საკვლევი მასალა და გამოყენებული მეთოდები; მიღებული შედეგები და მათი განსჯა. ექსპერიმენტული ხასიათის სტატიების წარმოდგენისას ავტორებმა უნდა მიუთითონ საექსპერიმენტო ცხოველების სახეობა და რაოდენობა; გაუტკივარებისა და დაძინების მეთოდები (მწვავე ცდების პირობებში).

4. სტატიას თან უნდა ახლდეს რეზიუმე ინგლისურ, რუსულ და ქართულ ენებზე არანაკლებ ნახევარი გვერდის მოცულობისა (სათაურის, ავტორების, დაწესებულების მითითებით და უნდა შეიცავდეს შემდეგ განყოფილებებს: მიზანი, მასალა და მეთოდები, შედეგები და დასკვნები; ტექსტუალური ნაწილი არ უნდა იყოს 15 სტრიქონზე ნაკლები) და საკვანძო სიტყვების ჩამონათვალი (key words).

5. ცხრილები საჭიროა წარმოადგინოთ ნაბეჭდი სახით. ყველა ციფრული, შემაჯამებელი და პროცენტული მონაცემები უნდა შეესაბამებოდეს ტექსტში მოყვანილს.

6. ფოტოსურათები უნდა იყოს კონტრასტული; სურათები, ნახაზები, დიაგრამები - დასათაურებული, დანომრილი და სათანადო ადგილას ჩასმული. რენტგენოგრამების ფოტოასლები წარმოადგინეთ პოზიტიური გამოსახულებით **tiff** ფორმატში. მიკროფოტოსურათების წარწერებში საჭიროა მიუთითოთ ოკულარის ან ობიექტივის საშუალებით გადიდების ხარისხი, ანათალების შეღებვის ან იმპრეგნაციის მეთოდი და აღნიშნოთ სურათის ზედა და ქვედა ნაწილები.

7. სამამულო ავტორების გვარები სტატიაში აღინიშნება ინიციალების თანდართვით, უცხოურისა – უცხოური ტრანსკრიპციით.

8. სტატიას თან უნდა ახლდეს ავტორის მიერ გამოყენებული სამამულო და უცხოური შრომების ბიბლიოგრაფიული სია (ბოლო 5-8 წლის სიღრმით). ანბანური წყობით წარმოდგენილ ბიბლიოგრაფიულ სიაში მიუთითეთ ჯერ სამამულო, შემდეგ უცხოელი ავტორები (გვარი, ინიციალები, სტატიის სათაური, ჟურნალის დასახელება, გამოცემის ადგილი, წელი, ჟურნალის №, პირველი და ბოლო გვერდები). მონოგრაფიის შემთხვევაში მიუთითეთ გამოცემის წელი, ადგილი და გვერდების საერთო რაოდენობა. ტექსტში კვადრატულ ფჩხილებში უნდა მიუთითოთ ავტორის შესაბამისი N ლიტერატურის სიის მიხედვით. მიზანშეწონილია, რომ ციტირებული წყაროების უმეტესი ნაწილი იყოს 5-6 წლის სიღრმის.

9. სტატიას თან უნდა ახლდეს: ა) დაწესებულების ან სამეცნიერო ხელმძღვანელის წარდგინება, დამოწმებული ხელმოწერითა და ბეჭდით; ბ) დარგის სპეციალისტის დამოწმებული რეცენზია, რომელშიც მითითებული იქნება საკითხის აქტუალობა, მასალის საკმაობა, მეთოდის სანდოობა, შედეგების სამეცნიერო-პრაქტიკული მნიშვნელობა.

10. სტატიის ბოლოს საჭიროა ყველა ავტორის ხელმოწერა, რომელთა რაოდენობა არ უნდა აღემატებოდეს 5-ს.

11. რედაქცია იტოვებს უფლებას შეასწოროს სტატია. ტექსტზე მუშაობა და შეჯერება ხდება საავტორო ორიგინალის მიხედვით.

12. დაუშვებელია რედაქციაში ისეთი სტატიის წარდგენა, რომელიც დასაბეჭდად წარდგენილი იყო სხვა რედაქციაში ან გამოქვეყნებული იყო სხვა გამოცემებში.

აღნიშნული წესების დარღვევის შემთხვევაში სტატიები არ განიხილება.

Содержание:

EFFECTIVENESS OF STANDARD AND INDIVIDUALIZED MARPE DEVICES IN ADULT PATIENTS BASED ON CONE BEAM COMPUTED TOMOGRAPHY DATA

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Abstract.

Maxillary transverse deficiency (MTD) in adults is difficult to treat due to partial or complete fusion of the midpalatal suture and the limited effectiveness of conventional orthodontic expansion techniques. Traditional methods often lead mainly to dentoalveolar changes and may cause tooth inclination, periodontal complications, and instability of treatment outcomes. The purpose of this study was to analyze morphometric changes of the maxillary complex in adult patients after treatment with standard and individualized MARPE appliances using cone beam computed tomography (CBCT) and to compare their effectiveness in achieving skeletal expansion. Adult patients with diagnosed maxillary transverse deficiency were treated with either a standard MSE-type Microimplant-Assisted Rapid Palatal Expander (MARPE) or a customized MARPE appliance developed using digital planning. CBCT examinations were performed before treatment and after the expansion phase as part of clinically indicated diagnostic and treatment monitoring protocols. Morphometric analysis included measurements of transverse parameters of the maxillary complex. Statistical analysis was conducted using paired t-tests, the Mann-Whitney U-test, and analysis of variance (ANOVA) with a significance level of $p < 0.05$. Both appliances provided effective maxillary expansion and significant increases in transverse parameters of the upper jaw. However, the individualized MARPE demonstrated greater effectiveness compared to the standard MSE-type appliance in terms of intermolar width gain (4.8 ± 1.5 mm versus 3.4 ± 1.2 mm) and the frequency of midpalatal suture opening (85% versus 60%). CBCT enabled accurate three-dimensional visualization of skeletal changes and objective monitoring of treatment outcomes. The study provides a comparative evaluation of standard and customized MARPE appliances in adult patients based on CBCT morphometric data, emphasizing the advantages of individualized appliance design. Both MARPE systems are effective for treating maxillary transverse deficiency in adults. However, customized MARPE appliances provide more precise positioning, better anatomical adaptation, and potentially greater long-term stability of expansion results.

Key words. Maxillary skeletal expansion, MARPE, MARPE (MSE type), maxillary complex, facial skeleton sutures, adult orthodontics.

Introduction.

The number of adult patients seeking orthodontic care has increased over the past decades, in particular to correct transverse maxillary hypoplasia. The effectiveness of orthodontic treatment in this age group (25–44 years) largely depends on the ability to accurately assess the morphological changes in the maxillofacial area that accompany the intervention. Consequently, high-precision imaging methods are being actively introduced into clinical practice, primarily CBCT, which provides a three-dimensional picture of bone and tissue structures. MTD in adult patients is caused by partial or complete fusion of the midpalatal suture (MPS), which leads to crossbite, respiratory disorders, as well as aesthetic and periodontal complications that significantly impair the quality of life [1].

Conservative expansion methods in adults usually cause predominantly alveolar changes with possible complications such as tooth root inclination, gingival recession and instability of the obtained result, thereby reducing their clinical effectiveness [2,3]. In response to these limitations, innovative MARPE appliances have been recently developed, with MSE as one of the varieties. They enable orthopaedic microimplant-assisted maxillary expansion, avoiding surgical intervention [4]. The term MARPE is used as a general name for orthopaedic microimplant-assisted maxillary expansion. These include: standard MSE-type MARPE appliances manufactured according to a typical template and equipped with four microimplants with fixation in the midpalatal area; and customized MARPE appliances, which are planned using digital protocols and manufactured taking into account the anatomical features of each patient.

The key method for assessing morphological changes during expansion is CBCT, which provides high-resolution three-dimensional imaging and allows for precise measurement of jaw width, palatal depth, and MPS opening [5-7]. Despite clinical studies comparing MARPE with Surgically Assisted Rapid Palatal Expansion (SARPE) in adult patients using CBCT, data comparing the effectiveness of different types of MARPE, in particular MSE, remain limited, and standardized assessment methods have not yet been developed [8]. In adult patients, classic orthopaedic expansion is often limited by anatomical features MPS fusion, which significantly reduces the skeletal effect of the therapy and leads to tooth inclination and reduced stability of the results [9]. The introduction of technologies based on temporary microimplants has significantly improved the effectiveness and prognosis of treatment, as confirmed by numerous clinical observations [10]. At the same time, MARPE demonstrates satisfactory expansion under moderate suture resistance, but is more often associated with dental changes in the front part of the jaw, while MSE has a pronounced skeletal effect with fewer side effects [11].

Objective assessment of treatment outcomes should be based on detailed analysis of horizontal parameters and MPS morphology using CBCT [6,12]. However, most available studies are limited in sample size or do not make a clear comparison between standard and individualized MARPE, which makes it difficult to provide evidence-based clinical recommendations [8,13].

The aim of this study is to quantitatively assess the morphometric changes in the maxillary complex in adult patients after orthodontic treatment using standard and individualized MARPE appliances based on CBCT data. The study included a comparative analysis of the morphology of the maxilla before and after treatment, an assessment of the effectiveness of inter-suture expansion for each type of appliance, and an analysis of the diagnostic capabilities of CBCT as a tool for monitoring structural changes in the maxillofacial area of adult patients under orthodontic treatment.

MTD is still one of the most controversial issues in orthodontics in adult patients, which is explained by the complexity of morphological changes and the variability of clinical approaches. The issue of skeletal expansion using microimplants is particularly relevant, which has been actively studied in recent years. However, the lack of consensus indicates the inconsistency of the obtained results. In particular, Nguyen et al. used CBCT and showed that the MARPE can be effective in younger adult patients (up to 25 years old), although the researchers emphasized the dominance of dental inclinations, especially in the frontal area [14].

At the same time, MARPE is considered as a general term that covers different designs, including the MSE type. Alawady et al. explored the effectiveness of using the same MSE in combination with microosteoperforations (MOP) in different anatomical areas [15]. The authors did not contrast MSE with other types of MARPE, but used these terms as synonyms denoting the same appliance. The study demonstrated positive changes in jaw morphology and the effectiveness of MSE in combination with MOP, however, the authors did not consider MSE as an alternative to MARPE, as MSE is a variant of it.

MSE is a subtype of the MARPE that generates vectors of superior and posterior forces. It is a bicortical engagement determined by CBCT, hence reduces dentoalveolar tilting and achieves orthopaedic expansion by using temporary anchorage devices as bone anchors [12-16]. MSE can improve the airway in young adults, providing excellent and comparable results with surgically assisted RPE (SARPE) [17,18]. At the same time, many factors affecting success rate of MARPE have been mentioned and should be considered [19]. MARPE enabled more predictable and greater skeletal expansion, as well as less buccal tipping and alveolar height loss on anchorage teeth. So, MARPE is a better alternative for patients with MTD during the post-pubertal growth spurt stage [20]. However, when it comes to treating adults with MTD, MARPE has demonstrated a clinically feasible and stable approach with an 86.9% success rate for those between the ages of 18 and 28 [21,22]. Microosteoperforations (MOPs), a type of minimally invasive surgical method linked to MARPE, have been shown to enhance or facilitate the skeletal effect of expansion in adults [23,24]. A prospective randomized clinical trial was designed to compare MSE with midpalatal MOP and MSE with midpalatal and buccal MOP in a young adult study sample. The idea behind the null hypothesis was that there would be no appreciable benefit to using the MOP technique over the alternative.

Nie et al. identified key factors that influence the efficacy of standard MARPE in adolescents and adults, including patient age, midpalatal suture maturity (MPSM), and palatal bone thickness [16]. CBCT analysis of 50 patients demonstrated that the efficacy of MARPE decreased with increasing age and suture maturity. However, greater bone thickness at the microimplant sites correlated with better expansion. The authors emphasized the need for careful assessment of the palatal anatomy before choosing MARPE as a treatment modality. In this context, Coloccia et al. revealed the heterogeneity of results and possible limitations regarding the long-term stability of skeletal expansion in adult patients [17]. They also emphasized the need for further studies, in particular to control for asymmetries and optimize treatment outcomes. Bazargani et al. reached similar conclusions, who recorded a gradual narrowing of the intermolar width in non-retained patients in a five-year prospective study, emphasizing the importance of long-term orthodontic stabilization to maintain the expansion results [18].

Imaging techniques play a special role in modern studies. Almaqrami et al. and Santiago et al. independently demonstrated that only 3D tomography can reliably distinguish between dental and skeletal components of expansion, while 2D radiography often gives false positives [19,20]. At the same time, Li et al. revealed a significant variability in the measurement protocols of CBCT images between different clinics, which complicates inter-study comparisons [21]. In contrast to some skeptical findings, the study by Almaqrami et al. performed using CBCT compared a standard MSE-type MARPE and an individualized MARPE [19]. It showed that a customized MARPE provides a wider and more uniform skeletal expansion, especially in patients with a narrow or high palate, compared to a standard MSE-type MARPE. Shih et al. demonstrated the efficacy of MARPE in late adolescent patients with MTD [22]. In this case, the use of the MSE as a type of standard MARPE type 2 achieved significant orthopaedic maxillary expansion accompanied by correction of anterior overbite, as well as improvement of the facial profile due to maximum maxillary advancement and posterior mandibular rotation. The authors also noted increased volume of the velopharyngeal respiratory cavity according to CBCT data after expansion.

A study by Lee et al. analysed the three-dimensional changes of the nasal septum and surrounding facial structures after maxillary orthopaedic expansion using a standard MSE-type MARPE, assessed with CBCT [23]. The results showed significant improvement in nasal septum deviation (NSD) and positive changes in midface position in both short- and long-term follow-up periods. This confirms the additional benefits of using standard MSE-type MARPE not only for palatal expansion but also for the correction of certain facial deformities.

At the same time, the authors emphasized the importance of accurate positioning of the appliance, which remains an open question. A systematic review and meta-analysis by Zeng et al. confirmed the high efficacy of the standard MARPE in the treatment of MTD in adolescents and adults (success rate of about 94%) [1]. The analysis showed significant skeletal and dental expansion with partial recurrence later on. However, the use of standard MARPE is associated with certain dental and periodontal side effects and influence on other cranial structures and facial soft tissues. However, the researchers emphasized that the choice of appliance should be based on the individual morphology of the suture, its maturity, and the patient's age.

An innovative area of research has been the integration of digital planning into treatment. In particular, Cantarella et al. described a digital planning protocol for a standard MSE-type MARPE, which includes CBCT, 3D scanning, and template fabrication for precise microimplant positioning [4]. This approach provides high accuracy of placement, symmetrical expansion, and reduced stress on palatal structures. However, the authors acknowledge that, despite the promise of this approach, it requires further verification in larger samples with a long-term follow-up period. So, the analysis of the current literature demonstrates both a growing interest in the issue of skeletal expansion in adults and the lack of a single agreed treatment strategy. Despite the significant potential of the standard MSE-type MARPE, the issues of its universality, long-term effects, indications, and visual control methods remain unresolved. In this regard, there is a need for standardization of studies, the use of unified CBCT protocols, and the inclusion of functional assessment criteria.

Materials and Methods.

Research design:

The study was conducted as a prospective cohort clinical observation with a parallel comparison of three groups of patients aged 25-44 years with MTD. Group 1 included patients who underwent treatment with a standard MSE-type MARPE appliance; Group 2 included patients treated with a customized improved MARPE appliance manufactured using digital planning and navigation templates; Group 3 served as a non-treated diagnostic comparison group. Allocation was not randomized. Patients were assigned to the treatment groups according to predefined clinical and anatomical indications, palatal morphology, the feasibility of standard MSE-type installation, the need for individualized digital planning, and the treating orthodontist's decision. The control group included patients with comparable maxillary morphology whose CBCT scans had been obtained for clinically indicated orthodontic diagnostics and whose expansion treatment was deferred or not performed during the observation period.

Ethics and radiation safety. The study protocol was reviewed and approved by the local institutional ethics committee before data analysis. The corresponding approval number and date are provided in the submission documentation. Written informed consent was obtained from all participants. CBCT examinations were not performed solely for research purposes. All scans were clinically justified for orthodontic diagnosis, treatment planning, or post-treatment monitoring. The ALARA principle was followed by using the smallest appropriate field of view and the lowest exposure settings compatible with diagnostic quality.

Methods:

Several methods were used for the assessment. CBCT was used for high-resolution three-dimensional imaging of the anatomical structures of the maxilla before treatment and 3 months after the active phase of orthodontic expansion in the two treatment groups. In the control group, baseline CBCT images were analyzed only when these images had already been obtained for clinically indicated orthodontic diagnostic purposes; no additional radiation exposure was introduced for research. The examination was performed according to a standardized protocol that covered the maxillary complex, with a focus on the MPS. This allowed visualization of both skeletal and dental components, as well as the presence and type of suture opening. The method provided an objective assessment of structural changes and avoided the errors characteristic of 2D radiography. Morphometric analysis was performed using Planmeca Romexis Viewer 6.2 software. Point measurement tools were used to determine the intermolar, interpremolar, and interzygomatic widths, palatal depth, and the degree and type of MPS opening.

The Carlson and Moon method was used to classify the suture, which involves dividing it into parallel, fan-shaped, and partial opening. These morphometric parameters were compared between all three groups in order to assess the effectiveness of the different appliance designs. In interpreting the results, special attention was paid to the second group of patients treated with the customized MARPE, because the individualized design was hypothesized to provide higher clinical effectiveness, particularly greater expansion values and improved stability of the result. Statistical processing of the results was carried out in the IBM SPSS Statistics 26.0 program. A paired t-test was used to identify intragroup changes before and after treatment. The Mann-Whitney U-test was used for intergroup comparison of standard MSE-type MARPE and customized MARPE efficiency, which allowed taking into account the possible lack of normal distribution of the data. ANOVA was also performed to assess the influence of the type of appliance, age, and gender on the final results. The results were considered statistically significant at $p < 0.05$. The obtained data are presented in the form of mean values and standard deviations.

Sample:

The study involved 120 patients (age 25-44 years, mean - 34.2 ± 5.3) selected from patients who applied in 2022-2024. Inclusion criteria were diagnosed MTD, completed growth, high-quality clinically indicated CBCT images, and no previous orthodontic or surgical intervention in the upper jaw area. Patients with syndromic anomalies, previous orthodontic treatment, contraindications to implantation, or insufficient CBCT quality were excluded. Patients were divided into three groups of 40 people: Group 1 - treatment with a standard MSE-type MARPE appliance; Group 2 - treatment with an individually manufactured MARPE using navigation templates; Group 3 (diagnostic comparison group) - patients with comparable anatomical characteristics who did not undergo expansion during the observation period but had clinically indicated baseline CBCT images available. Because allocation was clinically determined rather than randomized, possible selection bias was considered when interpreting the findings. The sample size was confirmed by a preliminary statistical power analysis (alpha=0.05; beta=0.2), which supports the reliability of the findings.

Instruments:

Planmeca Romexis Viewer 6.2 – morphometric analysis, IBM SPSS Statistics 26.0 – statistical processing, Excel 365 – table processing, Adobe Illustrator 2024 – creation of graphs and diagrams.

Visualization and measurement. The standard MARPE appliance used in Group 1 was defined as an MSE-type prefabricated maxillary skeletal expander with four palatal microimplants positioned in the posterior paramedian palate. Bicortical engagement of the palatal and nasal cortical plates was planned for all 40 patients in Group 1 using pretreatment CBCT. Because individual palatal bone thickness and anatomical morphology may affect the actual depth of microimplant engagement, fixation was verified radiographically or clinically whenever anatomically feasible and interpreted as complete or functionally sufficient bicortical engagement, with possible partial bicortical engagement in anatomically thinner areas. The available clinical documentation did not allow a fully reproducible retrospective numerical subdivision of all Group 1 cases into complete bicortical, partially bicortical, and monocortical categories; therefore, fixation depth was not analyzed as a separate quantitative outcome. No clinically relevant monocortical fixation causing appliance instability, insufficient anchorage, or exclusion from the treatment protocol was recorded. These fixation characteristics were considered during interpretation of biomechanical outcomes. In contrast, the customized MARPE used in Group 2 was digitally planned and adapted to individual palatal morphology. Compared with the standard MSE-type design, the customized MARPE allowed more accurate selection of implant fixation sites according to bone density and thickness, variability in the number of microimplants (4 or 6), and the use of navigation templates for precise expander positioning. These design characteristics were expected to improve force direction toward the center of resistance, increase the likelihood of parallel MPS opening, and allow treatment of patients with narrow or anatomically complex palates where a standard device may be less predictable.

Patients in Group 1 were fitted with a standard MSE-type MARPE with four microimplants. In Group 2, a customized MARPE with variable placement of microimplants (4 or 6) based on morphometric analysis of bone density and palatal anatomy was used. In Group 3, no expansion treatment was performed during the observation period, and only previously clinically indicated diagnostic CBCT images were analyzed. Screw activation was performed according to an individual plan, on average 0.25 mm twice a day, until the desired expansion was achieved or MPS opening was confirmed by CBCT. Patients in the treatment groups underwent CBCT examination before treatment and 3 months after the active expansion phase when clinically indicated for treatment monitoring. Measurements were performed in three planes using specialized software (Planmeca Romexis Viewer 6.2). The main parameters were intermolar width, interpremolar width, interzygomatic distance, palatal depth, and the width and type of MPS opening.

Statistical analysis:

The patients' demographic characteristics were described by using univariate analysis to determine the frequency distribution and means with standard deviations. Bivariate analysis was performed using a paired t-test to compare parameters before and after treatment within each of the three groups. For intergroup comparisons, the Kruskal-Wallis test (H-test) and the Mann-Whitney test with Bonferroni correction for pairwise comparisons between groups (standard MSE-type MARPE vs. customized MARPE, each treatment group vs. control, etc.) were used. Multivariate ANOVA was used to identify the effects of device type, age, and gender on treatment outcomes. The level of statistical significance was set at $p < 0.05$. Data processing was performed using IBM SPSS Statistics 26.0.

Data collection:

Primary data were obtained from clinically indicated maxillary CBCT scans in 120 adult patients before orthodontic expansion or baseline diagnostic assessment and, in the treatment groups, after treatment with standard MSE-type MARPE or customized MARPE when follow-up imaging was clinically justified. Secondary data included clinical histories, age, gender, clinical diagnosis, and the type of appliance used. All data were collected in compliance with ethical standards, with patient consent, and according to the ALARA principle.

Results.

Digital tomography provided high-precision measurements of linear parameters, which allowed for objective assessment of changes in maxillary width, palate depth, and MPS condition. The obtained images were processed using specialized software that provides standardized morphometric analysis.

Univariate analysis.

The study analysed the patients' demographic characteristics listed in Table 1. The mean age of the participants was 34.2 ± 5.3 years. In the group of patients treated with the standard MSE-type MARPE, 60% were aged 25 to 44 years, while 65% in the group with the customized MARPE fell into the same age category. The gender distribution was approximately equal in all three groups: standard MSE-type MARPE - 45% men and 55% women, customized MARPE 50% each, and the control group (CG) 50% each.

The analysis of morphometric parameters presented in Table 2 showed a statistically significant increase in intermolar and interpremolar widths, as well as interzygomatic distances in both treatment groups after treatment ($p < 0.001$). Patients in Group 2 demonstrated a more pronounced intermolar width gain - 4.8 ± 1.5 mm compared with 3.4 ± 1.2 mm in Group 1 ($p = 0.012$), which indicates a higher effectiveness of the customized MARPE in expanding the upper jaw.

MPS opening was found in 85% of patients in the individualized MARPE group, significantly higher than in the standard MSE-type MARPE group (60%, p=0.034). The customized MARPE group had a more uniform and parallel suture divergence, whereas the standard MSE-type MARPE group had a more anterocentric widening with predominating alveolar changes.

Table 1. *The patients' demographic characteristics.*

Number (n=120)	Standard MSE-type MARPE (n=40)	Customized MARPE (n=40)	CG (n=40)
Age, years (mean ± SD)	34.3 ± 5.2	34.1 ± 5.4	34.2± 5.3
Sex, n (%)			
Male	18 (45%)	20 (50%)	20 (50%)
Female	22 (55%)	20 (50%)	20 (50%)

Note: the CG includes patients with similar anatomical characteristics of the maxillary complex who did not undergo orthodontic intervention at the time of examination.
Source: Developed by the author.

Table 2. *Morphometric parameters of the upper jaw before and after expansion (mm).*

Maxillary parameters before and after treatment (mean ± SD)	Standard MSE-type MARPE (n=40)	Customized MARPE (n=40)	CG (n=40)	p-value*
Interzygomatic distance, mm	Before: 98.5 ± 4.3	Before: 99.2 ± 4.1	99.1 ± 4.0	
	After: 102.7 ± 4.7	After: 106.4 ± 4.5	Baseline diagnostic values only	<0.001
Interpremolar distance, mm	Before: 34.8 ± 2.5	Before: 35.2 ± 2.3	35.0 ± 2.2	
	After: 38.1 ± 2.7	After: 40.3 ± 2.6	Baseline diagnostic values only	<0.001
Intermolar distance, mm	Before: 41.3 ± 3.1	Before: 42.0 ± 2.9	41.9 ± 2.8	
	After: 44.7 ± 3.4	After: 46.8 ± 3.3	Baseline diagnostic values only	<0.001
Palatal depth, mm	Before: 15.2 ± 1.6	Before: 15.0 ± 1.7	15.1 ± 1.5	
	After: 14.8 ± 1.5	**After: 14.5 ± 1.4**	Baseline diagnostic values only	**0.045**

Note: The CG served as a non-treated diagnostic comparison group. Only baseline CBCT values obtained for clinically indicated orthodontic diagnostic purposes were analyzed in this group. No additional follow-up CBCT examination was performed solely for research purposes in the CG; therefore, post-treatment changes were not assessed for this group. The p-values refer to within-group pre- and post-treatment comparisons in the two treatment groups.
Source: Developed by the author.

Table 3. *Comparison of the effectiveness of the standard MSE-type MARPE and the customized MARPE.*

Indicator	Standard MSE-type MARPE (n=40)	Customized MARPE (n=40)	p-value (Mann-Whitney U-test)
Increased intermolar width, mm	3.4 ± 1.2	4.8 ± 1.5	0.012
Frequency of MPS opening, %	60	85	0.034

Source: Developed by the author.

Table 4. *Subgroup analysis of intermolar width gain depending on the degree of initial deficiency in patients treated with the standard MSE-type MARPE and customized MARPE.*

Group	Degree of deficiency	Share of patients (%)	Average intermolar width gain (mm)
Standard MSE-type MARPE	Pronounced (≥40 mm)	40	4.0 ± 0.9
Standard MSE-type MARPE	Moderate (<40 mm)	60	3.0 ± 0.8
Customized MARPE	Pronounced (≥40 mm)	35	5.6 ± 1.0
Customized MARPE	Moderate (<40 mm)	65	4.4 ± 0.9

Source: Developed by the author.

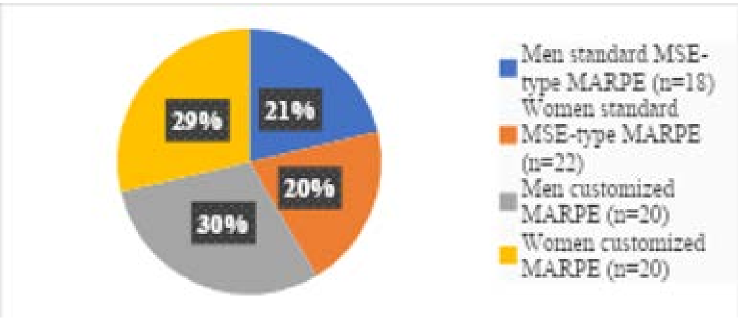

Figure 1. *Intermolar width gain (mm) by gender and their percentage ratio.*
Source: Developed by the author.

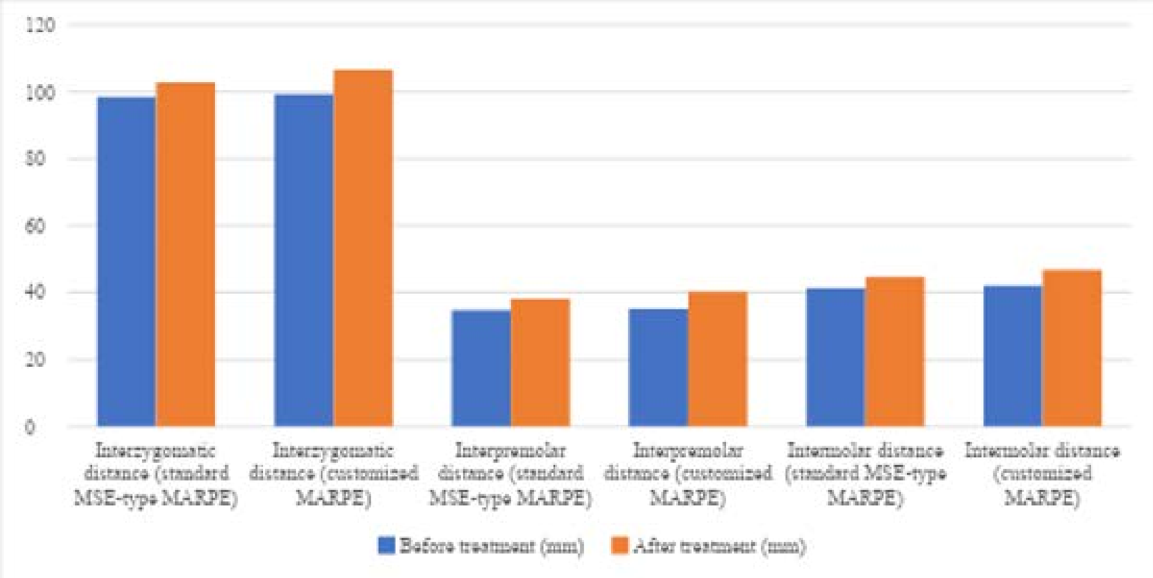

Figure 2. *Comparison of the mean values of morphometric parameters of the maxilla before and after treatment in the groups of standard MSE-type MARPE and customized MARPE appliance.*
Source: Developed by the author.

Bivariate analysis. Intergroup comparison of the effectiveness of the standard MSE-type MARPE and the customized MARPE was conducted using the Mann-Whitney U-test. The analysis showed statistically significant differences in intermolar width gain ($p=0.012$) and the frequency of MPS opening ($p=0.034$). The influence of additional factors, including appliance type, age, and gender, was assessed using ANOVA. Its results showed that appliance type was the only statistically significant factor affecting morphometric changes ($p<0.05$), whereas patients' age and gender did not show a significant effect on treatment results ($p>0.05$) (Table 3).

Table 3 shows that the intermolar width gain is significantly higher in the group with the customized MARPE than in the group with the standard MSE-type MARPE. This result, together with the higher frequency of MPS opening, indicates the higher effectiveness of the customized MARPE as an appliance for skeletal maxillary expansion. The probable reason is the difference in appliance design and force distribution during activation. In addition to greater width gain, the customized MARPE demonstrates better functional adaptation to the patients' anatomical features, which may contribute to greater long-term stability and reduced relapse risk.

The comparison of the effectiveness of the two MARPE variants was performed using the Mann-Whitney U-test (Table 3). The results confirmed statistically significant differences in intermolar width gain ($p = 0.012$) and the incidence of MPS opening ($p = 0.034$). ANOVA showed that appliance type was a significant factor affecting treatment outcome ($p < 0.05$), while patients' age and gender had no statistically significant effect ($p > 0.05$). Analysis of morphometric parameters showed a statistically significant increase in intermolar and interpremolar widths, as well as interzygomatic distances in both treatment groups after treatment ($p < 0.001$). Patients in the group with the customized MARPE showed a more pronounced intermolar width gain - 4.8 ± 1.5 mm, compared with 3.4 ± 1.2 mm in the group with the standard MSE-type MARPE ($p = 0.012$) (Figure 1).

Figure 1 shows that the mean intermolar width gain in men and women within each group did not differ significantly, indicating no statistically significant effect of gender on the effectiveness of treatment with both the standard MSE-type MARPE and the customized MARPE.

Subgroup analysis depending on the degree of initial intermolar width deficiency showed that patients with a pronounced deficiency (>=40 mm) in the customized MARPE group had the greatest increase in jaw width (5.6 ± 1.0 mm), followed by patients with a moderate deficiency (<40 mm; 4.4 ± 0.9 mm). In the standard MSE-type MARPE group, the corresponding values were 4.0 ± 0.9 mm and 3.0 ± 0.8 mm. The mean treatment time was significantly shorter in the group with the customized MARPE - 3.8 ± 0.6 months, compared with 4.5 ± 0.7 months in the group with the standard MSE-type MARPE ($p = 0.03$), indicating a faster and more predictable therapeutic effect of the individualized design (Table 4).

It is important to note that the customized MARPE showed both a greater intermolar width gain and better functional adaptation to the patients' anatomical features. Accurate positioning and adaptation of the appliance are key factors for improving skeletal response, functional stability, and reduction of complication risk, especially in patients with complex palatal morphology.

The changes in morphometric parameters before and after treatment in both groups were clearly illustrated in a bar chart, showing the mean values of interpremolar, intermolar, and interzygomatic widths before and after expansion (Figure 2).

Figure 2 demonstrates that all three morphometric measures (interpremolar, intermolar, and interzygomatic widths) significantly increased after both standard and customized MARPE. However, the gain was more pronounced in the customized MARPE group, which is consistent with previous analysis results ($p < 0.05$)

Six months after treatment, 40 patients underwent a repeat CBCT scan to assess the stability of the results. This follow-up subgroup included 20 patients from the standard MSE-type MARPE group and 20 patients from the customized MARPE group. Patients were included in the follow-up analysis if they had completed active expansion and retention, had no complications requiring protocol modification, and had clinically indicated follow-up CBCT images of sufficient quality. The expansion retention was 92% in the group with the customized MARPE and 85% in the group with the standard MSE-type MARPE, indicating greater long-term stability of the effect when using customized appliances. It should be emphasized that the customized MARPE provides a more uniform load on bone structures and better functional adaptation due to its precise positioning and adaptation to patient morphology. This has a positive effect on long-term stability, especially in cases of complex anatomy.

Therefore, the results of the study indicate the clinical advantages of the customized MARPE compared to the standard MSE-type MARPE in terms of expansion volume, quality of adaptation, and stability of the results. This is likely due to the design features, the individual placement of microimplants according to the patient's anatomy, and more precise control of the direction of force, which promotes symmetrical expansion and reduces the risk of complications. In addition, the use of CBCT has proven to be an effective method for monitoring morphometric changes throughout the treatment process, providing an accurate quantitative assessment of the results.

Discussion.

Maxillary expansion in adult patients has traditionally been considered a difficult task because of partial or complete MPS fusion, which leads to increased resistance of bone structures to mechanical stress. As Labunet et al. noted, classical methods of orthodontic expansion are often limited to mainly dental or alveolar changes without significant skeletal effect, which increases the risk of relapse and reduces long-term stability of results [12]. In this regard, the use of MARPE microscrew devices has become a significant breakthrough in the treatment of MTD in adults. A variation of this technology is the standard MSE-type MARPE, which involves the use of four microimplants placed closer to the centre of resistance, which contributes to a more uniform suture opening.

One of the main advantages of modern MARPE designs is the possibility of digital planning and the use of individualized navigation templates that ensure accurate positioning of the appliance in accordance with the patients' anatomical features. This reduces the risk of asymmetric expansion and increases the overall effectiveness of the treatment. The customized MARPE demonstrates higher adaptability to the clinical situation, which allows for effective treatment of patients with complex jaw morphology. The precise positioning of the device elements ensures the correct direction of force, promotes parallel MPS opening, and increases the functional stability of the results. So, customized MARPE designs have a potentially better long-term prognosis than standard models, due to a more accurate match to the patient's morphology, optimal load distribution and the possibility of digital planning.

Our data confirm that MARPE devices, including standard and customized designs, are capable of producing skeletal maxillary expansion, but with different clinical features depending on the design and fabrication method. For example, Cantarella et al. described a protocol for digital planning and fabrication of a MSE-type MARPE for patients with thin palatal bone [4]. The use of CAD/CAM technologies allowed for precise placement of six microimplants even with a palatal thickness of less than 2.5 mm, which ensures high accuracy and safety of placement. These results are consistent with the data of a number of recent studies, in particular with the work of Liao et al., who note that the use of a MARPE device (MSE type) provides a significant skeletal effect in maxillary expansion with minimal dental changes [25]. In particular, 71.1% of the width gain was due to skeletal changes, and the expansion process itself was almost parallel in the anterior-posterior direction (83.2% from ANS to PNS), which confirms the effectiveness of MSE-type devices as a highly accurate customized version of MARPE, especially in conditions of need for non-surgical skeletal expansion in adult patients.

At the same time, Almaqrami et al. indicate that the customized MARPE device provides wider and more uniform skeletal expansion in young adult patients compared with the standard MARPE type MSE device [26]. A retrospective study of 50 patients analysed on the basis of pre- and post-treatment CBCT images found that in the axial plane, the width gain in the individualized MARPE group was significantly greater in both the anterolateral maxillary wall area (4.68 ± 1.35 mm vs. 3.37 ± 1.53 mm) and the greater palatine foramen area (3.99 ± 1.35 mm vs. 3.28 ± 1.19 mm; $P < 0.01$). In the frontal plane, the customized MARPE demonstrated significantly greater transverse expansion at the midnasal, basal, alveolar, and dental levels.

These results are explained by the design features of the customized MARPE, in particular, more precise positioning of the microimplants according to the patient's anatomy, which provides a wider area of contact with the bone and a reduction in the dental component of the expansion. This is especially important in cases with a high level of anterior resistance or the need for a predominantly skeletal effect. It should be emphasized that the MSE, despite its separate name, is a variant of MARPE a standard non-customized design that uses a fixed position of the microimplants. In contrast, customized MARPE devices, which are manufactured using CAD/CAM technologies and navigation templates, provide more precise positioning of the implants according to the anatomical conditions of each patient. This contributes to a better skeletal effect and higher long-term stability of results, especially in complex clinical cases.

An important aspect is the observation of the MPS opening. As Shmyndiuk et al. noted, the success rate of MARPE varies from 82.8% to 100%, and the intermolar width gain ranges from 4.79 to 6.55 mm [27]. These results confirm that MARPE is a reliable method that allows to achieve a significant increase in both skeletal and dental width of the maxilla in patients with MTD. Furthermore, MARPE demonstrates better clinical results compared to traditional rapid expansion methods, while causing fewer periodontal complications compared to surgically assisted approaches. However, despite the positive data, the quality of the available evidence needs to be further improved.

Our analysis of morphometric parameters using CBCT, similar to the studies of Georgiadis et al., assessed not only quantitative changes in jaw width, but also spatial characteristics of expansion, such as suture opening angle, changes in palatal depth, and symmetry of expansion [28]. This approach enables individualized treatment plan by selecting the optimal appliance and activation technique with a view to the patient's anatomical features.

The use of 3D imaging and quantitative analysis, as Hoque et al. emphasized, not only improves the understanding of the biomechanics of MARPE, including its individualized and standard modifications, but also reduced the risk of complications such as incomplete or asymmetric expansion, excessive dental changes, and periodontal disorders [29]. Taking these factors into account is especially relevant in adult patients in whom the use of surgical expansion techniques may be undesirable or contraindicated.

The obtained results confirm that digital CBCT is a highly accurate and effective method for assessing morphometric changes in the maxilla in adult patients with MTD. The use of specialized software allowed standardizing the measurement procedure and ensuring objectivity in the analysis of changes in intermolar and interpremolar width, interzygomatic distances, palatal depth, and the degree of MPS opening.

The demographic characteristics of the study participants (mean age 34.2 ± 5.3 years, balanced male-female ratio), as described in the works of Mei et al., confirm the representativeness of the sample for the adult population with MTD [30]. The absence of a statistically significant effect of gender and age on the final treatment results (ANOVA, $p > 0.05$) is consistent with the data of Ates et al., who indicate that the main factors affecting the effectiveness of expansion are the type of apparatus and the degree of initial deficit [31].

A statistically significant intermolar width gains in the group of patients treated with the customized MARPE (4.8 ± 1.5 mm) compared with the standard MSE-type MARPE (3.4 ± 1.2 mm) indicates higher effectiveness of the individualized constructs in maxillary expansion. This is also confirmed by the higher frequency and uniformity of MPS opening (85% vs. 60%, $p = 0.034$), which is consistent with the results of studies by Hoque and Yang et al., who noted the design advantages of MARPE with rigid individual implant fixation, particularly better control of the expansion direction [9,32].

In their systematic review and meta-analysis, Kapetanović et al. found that the MARPE has a high treatment success rate of approximately 92.5% [33]. The use of MARPE leads to a statistically significant increase in both the skeletal width of the maxilla (on average by 2.33 mm) and the dental intermolar width (on average by 6.55 mm). However, patients experienced side effects, including increased tooth inclination, decreased cheekbone thickness and alveolar height, and changes in the soft tissues of the nose. In turn, Zeng et al. [1] confirmed an overall treatment success rate of approximately 93.9% and recorded a significant increase in the transverse width of the maxilla due to both skeletal and dental structures: approximately 49% of the expansion was due to the basal bone, 7.5% to the alveolar bone, and 43.6% to the dental component.

In addition, the average treatment time was significantly shorter in the group with the customized MARPE (3.8 ± 0.6 months) compared with the group with the standard MSE-type MARPE (4.5 ± 0.7 months, $p = 0.03$), which is an important factor for clinical practice and patient comfort. After 6 months of follow-up, the stability of the results was higher in the group with the customized MARPE (92% expansion retention) compared with the group with the standard MSE-type MARPE (85%), indicating better long-term efficacy of the customized MARPE and a lower risk of relapse.

According to a number of authors, promising areas of further research are the comparison of results with the use of surgical expansion methods, as well as the assessment of the impact of different device activation parameters on the clinical outcome. Therefore, the use of standard MSE-type and customized MARPE devices, assessed by CBCT, is a modern and effective method for solving the problem of MTD in adults, combining minimal invasiveness and high clinical effectiveness.

Study Limitations.

The dose of ionizing radiation during CBCT, although within acceptable limits, restrains the possibility of repeated use of the method for dynamic monitoring of changes during treatment.

The study did not take into account individual variations in bone density, cortical thickness, and degree of suture fusion, which may affect the expansion effectiveness.

Lack of control for lifestyle factors and comorbidities, which may affect the effectiveness of orthodontic treatment.

The fixation characteristics of the standard MSE-type MARPE were interpreted clinically and radiographically; however, fixation depth was not analyzed as a separate quantitative outcome because the available documentation did not support a fully reproducible retrospective subdivision into exact complete bicortical, partially bicortical, and monocortical categories. Therefore, possible variation in cortical engagement should be considered when interpreting biomechanical outcomes. Because patients were allocated according to clinical and anatomical indications rather than randomization, selection bias cannot be fully excluded in addition, the 6-month stability analysis was performed only in patients with clinically indicated follow-up CBCT images; therefore, the follow-up findings should be interpreted as supportive rather than definitive evidence of long-term stability.

Conclusion.

The study found that digital CBCT is a highly effective and indispensable tool for comprehensive assessment of the results of orthodontic maxillary expansion in adult patients. The use of CBCT allows for accurate three-dimensional images of bone structures, which significantly increases diagnostic value and allows for the assessment of morphological changes in real time with high accuracy and objectivity. A comparative analysis of the standard and individualized MARPE device showed that both methods provide a statistically significant intermolar width gain. Customized MARPE was more effective due to its precise positioning, better compliance with anatomy, and potentially higher long-term stability. Customized MARPE also demonstrates higher adaptability, allows the treatment of patients with complex anatomy, and provides higher precision in force direction, which contributes to parallel suture opening.

It was established that morphological changes in the maxillary complex after the use of expansion appliances are accompanied by both skeletal and dental adaptations, which confirms the multifactorial nature of orthodontic correction. Individual positioning of the device provides higher accuracy of force application and its direction, which contributes to parallel MPS opening, especially in patients with complex anatomy. The use of CBCT provides the opportunity to assess these changes not only in the frontal plane, but also in three-dimensional space, which allows for a comprehensive analysis of the quality of the therapeutic effect.

The obtained data confirm that early and accurate diagnostics of the anatomical and functional features of the upper jaw using digital tomography is the basis for choosing the optimal tactics of orthodontic treatment. In particular, determining the state and degree of MPS ossification allows predicting the possibility and effectiveness of expansion, as well as minimizing the risk of complications. The customized MARPE demonstrates potentially higher adaptability and allows for effective treatment of patients with complex anatomy, due to the possibility of precise positioning and coordination with the morphology of the jaw complex. In addition, the study emphasizes the importance of an individualized approach when choosing an orthodontic device, taking into account anatomical parameters, age, clinical situation, and expected results. This allows achieving maximum therapeutic effect and reducing treatment time, as well as improving the overall clinical prognosis.

Taking into account three-dimensional parameters and features of the bone structure obtained using CBCT contributes to increasing the safety and effectiveness of orthodontic interventions. This enables reducing the number of repeated procedures and complications, which has a positive effect on the patients' quality of life. So, the results of the study indicate the high potential of digital tomography as a standard in modern clinical orthodontics for assessing and planning the expansion of the upper jaw in adults. Further academic research should be aimed at improving CBCT techniques, as well as at developing adapted treatment protocols that take into account the individual anatomical and functional characteristics of each patient. It is also recommended to study long-term morphological and functional changes that occur after the use of different types of appliances, as well as the impact of these changes on the general health of the oral cavity and the structure of the facial skeleton.

REFERENCES

1. Zeng W, Yan S, Yi Y, et al. Long-term efficacy and stability of miniscrew-assisted rapid palatal expansion in mid to late adolescents and adults: a systematic review and meta-analysis. BMC Oral Health. 2023;23:829.
2. Vidalón JA, Loú-Gómez I, Quiñe A, et al. Periodontal effects of maxillary expansion in adults using non-surgical expanders with skeletal anchorage vs. surgically assisted maxillary expansion: a systematic review. Head Face Med. 2021;17:47.
3. Li K, Guilleminault C. Surgical and non-surgical maxillary expansion: expansion patterns, complications and failures. Orthod Fr. 2022;93:35-46.
4. Cantarella D, Karanxha L, Zanata P, et al. Digital planning and manufacturing of maxillary skeletal expander for patients with thin palatal bone. Med Devices (Auckl). 2021;14:299-311.
5. Chae J-M, Rogowski L, Mandair S, et al. A CBCT Evaluation of midpalatal bone density in various skeletal patterns. Sensors. 2021;21:7812.
6. Meyns J, Thanatchaporn J, Shujaat S, et al. Long-term three-dimensional skeletal effects of hybrid hyrax with facemask versus mentoplate in growing Class III patients: a randomized controlled trial. Prog Orthod. 2025;26:14.
7. Colak O, Paredes NA, Elkenawy I, et al. Tomographic assessment of palatal suture opening pattern and pterygopalatine suture disarticulation in the axial plane after midfacial skeletal expansion. Prog Orthod. 2020;21:21.
8. de Oliveira CB, Ayub P, Ledra IM, et al. Microimplant assisted rapid palatal expansion vs surgically assisted rapid palatal expansion for maxillary transverse discrepancy treatment. Am J Orthod Dentofacial Orthop. 2021;159:733-742.
9. Hoque T. Microimplant-assisted rapid palatal expansion (MARPE) - A comprehensive review. Int J Dent Oral Sci. 2021.
10. Walter A, Winsauer H, Crespo E, et al. Adult maxillary expansion: CBCT evaluation of skeletal changes and determining an efficiency factor between force-controlled polycyclic slow activation and continuous rapid activation for mini-screw-assisted palatal expansion - MASPE vs MARPE. 2024.
11. Oslavsky AM, Oslavska TM. Experience of using the apparatus "M.S.E." with transversal deficiency of the maxillary complex. Actual Dent. 2020;5:74.
12. Labunet A, Iosif C, Kui A, et al. Miniscrew-assisted rapid palatal expansion: A scoping review of influencing factors, side effects, and soft tissue alterations. Biomedicines. 2024;12:2438.
13. Winsauer H, Walter A, Katsaros C, et al. Success and complication rate of miniscrew assisted non-surgical palatal expansion in adults - A consecutive study using a novel force-controlled polycyclic activation protocol. Head Face Med. 2021;17:50.
14. Nguyen H, Shin JW, Giap HV, et al. Midfacial soft tissue changes after maxillary expansion using micro-implant-supported maxillary skeletal expanders in young adults: A retrospective study. Korean J Orthod. 2021;51:145-156.
15. Alawady A, Alfatah A, Mohamed RE, et al. Evaluation of maxillary skeletal expander (MSE) assisted by two techniques of microosteoperforations in young adults using CBCT: A randomised controlled trial. Adv Front Biosci. 2024;6:4191-4206.
16. Nie X, Zhang X, Liu Y, et al. Evaluation of palate-related factors of the effectiveness of microimplant-assisted rapid palatal expansion in late adolescents and adults. Clin Oral Investig. 2023;27:5239-5250.
17. Coloccia G, Inchingolo AD, Inchingolo AM, et al. Effectiveness of dental and maxillary transverse changes in tooth-borne, bone-borne, and hybrid palatal expansion through cone-beam tomography: A systematic review of the literature. Medicina (Kaunas). 2021;57:288.
18. Bazargani F, Knode V, Plaksin A, et al. Three-dimensional comparison of tooth-borne and tooth-bone-borne RME appliances: A randomized controlled trial with 5-year follow-up. Eur J Orthod. 2023;45:690-702.

19. Almaqrami BS, Saireke H, Wang X, et al. Custom fabrication of cast splint microimplant-assisted rapid palatal expansion appliances for treatment of maxillary deficiency in young adults. APOS Trends Orthod. 2022;11:247-253.
20. Santiago R, Werneck CS, Faria FR, et al. Quantitative evaluation of palatal bone thickness to guide miniscrews insertion: A CBCT assessment. HU Rev. 2020;46:1-9.
21. Li L, Zhai M, Wang M, et al. Three-dimensional evaluation effects of microimplant-assisted rapid palatal expansion on the upper airway volume: A systematic review and meta-analysis. J Clin Med. 2023;12:1790.
22. Shih SN, Ho KH, Wang CW, et al. Management of class III malocclusion and maxillary transverse deficiency with microimplant-assisted rapid palatal expansion (MARPE): A case report. Medicina (Kaunas). 2022;58:1052.
23. Lee HJ, Park JH, Seo HY, et al. A CBCT evaluation of nasal septal deviation and related nasofacial structures after maxillary skeletal expansion. Appl Sci. 2022;12:9949.
24. Sandhu G, Chaudhary DC, Thakur VK, et al. Correlation between facial pattern and midpalatal suture maturation in orthodontic patients − A CBCT-based radiographic study. J Indian Orthod Soc. 2025;0.
25. Liao YC, Ho KH, Wang CW, et al. Skeletal and dental changes after microimplant-assisted rapid palatal expansion (MARPE) – A cephalometric and cone-beam computed tomography (CBCT) study. Clin Investig Orthod. 2022;81:1-9.
26. Almaqrami BS, Al-Somairi MA, Al-Gumaei WS, et al. Degree and pattern of expansion of commercially available and custom-fabricated miniscrew-assisted rapid palatal expansion systems in young adult patients: A retrospective comparative analysis. Orthod Fr. 2024;95:100931.
27. Shmyndiuk M, Gevkaliuk N, Pynda M, et al. Evidences from systematic reviews regarding miniscrew-assisted rapid palatal expansion (MARPE) approach in orthodontics. Ukr Dent J. 2023;2:131-137.
28. Georgiadis T, Angelopoulos C, Papadopoulos MA, et al. Three-dimensional cone-beam computed tomography evaluation of changes in naso-maxillary complex associated with rapid palatal expansion. Diagnostics. 2023;13:1322.
29. Hoque T, Srinivasan D, Gnaneswar S, et al. Microimplant assisted rapid palatal expansion: A comprehensive review. J Clin Diagn Res. 2021;15:ZE01-ZE06.
30. Mei YS, Syed Mohamed AMF, Marizan Nor M, et al. Gender and age effects on dental and palatal arch dimensions among full siblings. J Oral Sci. 2023;65:237-242.
31. Ateş EM, Pamukçu H, Koç O, et al. Effects of different expansion appliances and surgical incisions on maxillary expansion: A finite element analysis. J Oral Maxillofac Surg Med Pathol. 2024.
32. Yang J, Tang Z, Shan Z, et al. Maxillary deficiency: treatments and applications for adolescents. Appl Sci. 2025;15:3256.
33. Kapetanović A, Theodorou CI, Bergé SJ, et al. Efficacy of miniscrew-assisted rapid palatal expansion (MARPE) in late adolescents and adults: A systematic review and meta-analysis. Eur J Orthod. 2021;43:313-323.