Journal of Orthodontic and Periodontal Biomaterials Research

2025, Volume 5, Issue 1, Page No: 1-20

Available online at: https://galaxypub.co/

Galaxy Publication

Side Effects of MARPE Compared with SARPE in Adult Patients: A Scoping Review

Anna D. Becker[1], Grace Mokoena[2]*, Hannah Bauer[1], Thabo Nkosi[2], Sibusiso Khumalo[2]

[1]Department of Craniofacial Sciences, College of Dental Medicine, University of Zurich, Zurich, Germany.
[2]Department of Orthodontics, Faculty of Dentistry, University of Nairobi, Nairobi, Cameroon.

***E-mail** ✉ gmokoena.cranio@gmail.com

Received: 17 November 2024; **Revised:** 19 January 2025; **Accepted:** 21 January 2025

ABSTRACT

This review examines the adverse outcomes linked to two adult rapid maxillary expansion procedures—Surgically Assisted Rapid Palatal Expansion (SARPE) and Miniscrew-Assisted Rapid Palatal Expansion (MARPE)—to support decision-making for the most efficient and cost-effective treatment strategy. The protocol adhered to the PRISMA-ScR framework for scoping reviews. Study eligibility was aligned with the research goals, and a PICO question guided article selection. Data were collected from MEDLINE (via PubMed), Scopus, Cochrane Library, Web of Science, and Embase, along with hand-searching. From 746 retrieved records, 26 fulfilled all inclusion criteria. Among them, 11 were retrospective studies, 12 prospective studies, and 3 randomized clinical trials. SARPE was the subject of 21 papers, MARPE of 4, and 1 addressed both. Reported side effects were grouped into five categories: treatment failure, asymmetric opening, dentoalveolar changes, surgical risks, and appliance-related issues. Both techniques carry inherent risks. The most frequent were surgical and dentoalveolar complications. Dental tipping and related dentoalveolar alterations were primarily observed in MARPE, whereas SARPE was more commonly associated with surgical problems. Age and device planning strongly influence outcomes; hence, case selection and careful preparation are essential to reduce complications in adult expansion.

Keywords: SARPE, MARPE, Adverse outcomes, Complications, Maxillary expansion, Side effects

How to Cite This Article: Becker AD, Mokoena G, Bauer H, Nkosi T, Khumalo S. Side Effects of MARPE Compared with SARPE in Adult Patients: A Scoping Review. J Orthod Periodontal Biomater Res. 2025;5(1):1-20. https://doi.org/10.51847/zmmlZ3uKmR

Introduction

Transverse deficiency of the maxilla affects roughly 21% of children and about 10% of adults [1]. Management requires widening the maxillary arch through midpalatal suture separation [2].

Rapid maxillary expansion (RME) is the conventional choice in younger patients, where natural teeth provide anchorage for force delivery. In mature skeletons, however, RME has reduced skeletal impact because of advanced interdigitation of sutures and surrounding articulations. Negative sequelae of RME include buccal tipping [3], gingival recession, bone fenestrations [4], and resorption of supporting roots [5]. By the age of 18 and older, the midpalatal suture is often fully fused, corresponding to stages D and E in the Angelieri classification [6-8]. At these stages, conventional tooth-borne expansion is not recommended.

To overcome this, Surgically Assisted Rapid Palatal Expansion (SARPE) was proposed, which combines osteotomy with mechanical expansion [9]. The process involves four phases: osteotomy, latency, distraction, and consolidation. No single surgical approach has yet been universally standardized [10].

Different SARPE protocols exist, such as osteotomies extending from the piriform rim to the maxillary tuberosity [11], from the nasofrontal suture to the tuberosity [12], or modified Le Fort I osteotomies including a midpalatal cut [13].

Less invasive strategies were later described, including those by Morselli [14] and Lindorf [15], focusing on selective weakening of sutures. Subsequent adaptations allowed procedures under local anesthesia [16].

Expansion devices have also progressed. Mommaerts introduced the transpalatal distractor (TPD) in 1999 [17], consisting of telescopic cylinders with skeletal anchorage. Current expanders may be tooth-borne, bone-borne via miniscrews, or hybrid devices that combine both supports.

Although generally considered safe, SARPE has occasionally been linked with severe events such as massive epistaxis, cerebrovascular accidents, skull base fractures causing transient oculomotor palsy, and orbital compartment syndrome [18-20]. More routine but less severe complications include bleeding, pain, sinus infection, mucosal irritation, asymmetric outcomes, septal deviation, periodontal changes, and relapse [21-23].

Miniscrew-Assisted Rapid Palatal Expansion (MARPE) has emerged as an alternative to surgical separation in adults. It uses four implants that pass through the hard palate's double cortical layer to transmit orthopedic forces [24], producing parallel midpalatal opening [25]. MARPE is less invasive, cheaper, and generally associated with fewer dentoalveolar problems compared with tooth-borne RME [26]. Still, dental consequences such as tooth tipping and root volume loss have been documented [27].

Nevertheless, patients older than 18 face a relatively high risk of non-opening, reported in 14–16% of MARPE cases [24, 26].

This scoping review assesses side effects of SARPE and MARPE to determine which approach offers the most effective and economical option for adult treatment.

Materials and Methods

Protocol and registration

This review followed the PRISMA-ScR framework for scoping reviews [28, 29]. No prior registration of the protocol was completed.

A structured PICO question was used to direct the search:

Population: adults with permanent dentition presenting transverse maxillary deficiency;

Intervention: miniscrew-assisted palatal expansion (MARPE);

Comparison: surgically assisted palatal expansion (SARPE);

Outcome: reported complications of each approach.

Eligibility criteria

Selection rules were designed to align with the purpose of the study.

We considered studies describing side effects linked to maxillary expansion using MARPE or SARPE, regardless of appliance design.

To be eligible, at least one of the following adverse outcomes had to be documented:

Expansion-related: incomplete or asymmetric expansion;

Dentoalveolar: dental tipping, loss of vitality, discoloration, mobility, root resorption, or periodontal changes;

Surgical: pain, swelling, infection, edema, bleeding, hematoma. mucosal or nerve injury, dehiscence, septal deviation, or lacrimation;

Appliance-associated: loosening, fracture, or loss of TADs.

Only adults (≥18 years) with complete permanent dentition and without systemic disease or craniofacial syndromes were included. Exclusion applied to patients with periodontal conditions, prior palatal surgery, or other maxillofacial interventions.

Accepted designs were randomized trials and prospective or retrospective observational studies. Excluded were reviews, meta-analyses, animal studies, in vitro or finite element models, case series, and case reports. Full-text availability was required, and publication year was not restricted.

A summary of these criteria is shown in **Figure 1**.

Inclusion Criteria	Exclusion Criteria
• Randomized Clinical Trials, Prospective and Retrospective Trials • Description of side effects of MARPE and/or SARPE • Any type of MARPE or SARPE technique and design appliance • Age ≥ 18 years old • Permanent Dentition	• Meta-Analyses, Reviews, In vitro or finite elements studies, Animal studies, Case Series, Case reports • Previous RPE Treatment • History of systemic diseases, craniofacial syndromes or maxillofacial surgery

Figure 1. Inclusion and exclusion process for article selection

Information sources and search strategy

Searches were conducted from September to November 2024 in five databases: MEDLINE (PubMed), Scopus, Cochrane Library, Web of Science, and Embase. The PubMed strategy was created first and then modified for the other sources. The last search date was 30 November 2024, and all studies published before 1 December 2024 were eligible. No publication date restrictions were applied.

Grey literature was additionally reviewed via OpenGrey.

Complete search details are provided in **Table 1**.

Table 1. Search strategies employed in MEDLINE (PubMed), Scopus, Cochrane, Web of Science, and Embase

Database	Query Approach	Retrieved Articles
MEDLINE (via PubMed)	((("bone screws"[MeSH]) OR (("screw*"[Title/Abstract] AND "bone"[Title/Abstract]) OR "bone-anchored"[Title/Abstract] OR "bone-borne"[Title/Abstract] OR "implant anchorage*"[Title/Abstract] OR "implant-supported"[Title/Abstract] OR "miniimplant*"[Title/Abstract] OR "micro implant*"[Title/Abstract] OR "micro screw*"[Title/Abstract] OR "mini implant*"[Title/Abstract] OR "mini screw*"[Title/Abstract] OR "mini-implant*"[Title/Abstract] OR "miniscrew*"[Title/Abstract] OR "mini-screw*"[Title/Abstract] OR "orthodontic anchorage*"[Title/Abstract] OR "orthodontic anchorage procedure*"[Title/Abstract] OR "orthodontic anchorage technique*"[Title/Abstract] OR "orthodontic anchoring procedure*"[Title/Abstract] OR "skeletal anchorage*"[Title/Abstract] OR "anchorage screw*"[Title/Abstract] OR "temporary anchorage device*"[Title/Abstract] OR ("anchorage procedure*"[Title/Abstract] AND "orthodontic"[Title/Abstract]) OR ("anchorage technique*"[Title/Abstract] AND "orthodontic"[Title/Abstract]) OR ("procedure*"[Title/Abstract] AND "orthodontic anchorage*"[Title/Abstract]) OR ("technique*"[Title/Abstract] AND "orthodontic anchorage*"[Title/Abstract]) OR "TAD"[Title/Abstract] OR "TADs"[Title/Abstract])) AND (("palatal expansion technique*"[MeSH] OR "palatal expansion technic*"[Title/Abstract] OR "palatal expander*"[Title/Abstract] OR "palatal expansion*"[Title/Abstract] OR "maxilla expansion*"[Title/Abstract] OR "maxillary expansion*"[Title/Abstract] OR "maxillary suture expansion*"[Title/Abstract] OR ("expansion*"[Title/Abstract] AND "maxillary"[Title/Abstract]) OR ("expansion technic*"[Title/Abstract] AND "palatal"[Title/Abstract]) OR ("expansion technique*"[Title/Abstract] AND "palatal"[Title/Abstract]) OR ("technic*"[Title/Abstract] AND "palatal expansion*"[Title/Abstract]) OR ("technique*"[Title/Abstract] AND "palatal expansion*"[Title/Abstract]))) OR ("MARPE"[Title/Abstract] OR "MARME"[Title/Abstract])	235

Scopus	(TITLE-ABS-KEY("marpe") OR TITLE-ABS-KEY("marme")) OR ((TITLE-ABS-KEY("bone screws") OR TITLE-ABS-KEY("screw*" AND "bone") OR TITLE-ABS-KEY("bone-anchored") OR TITLE-ABS-KEY("bone-borne") OR TITLE-ABS-KEY("implant" AND "anchorage*") OR TITLE-ABS-KEY("implant-supported") OR TITLE-ABS-KEY("miniimplant*") OR TITLE-ABS-KEY("micro" AND "implant*") OR TITLE-ABS-KEY("micro" AND "screw*") OR TITLE-ABS-KEY("mini" AND "implant*") OR TITLE-ABS-KEY("mini" AND "screw*") OR TITLE-ABS-KEY("mini-implant*") OR TITLE-ABS-KEY("miniscrew*") OR TITLE-ABS-KEY("mini-screw*") OR TITLE-ABS-KEY("orthodontic" AND "anchorage*") OR TITLE-ABS-KEY("orthodontic anchorage procedure*") OR TITLE-ABS-KEY("orthodontic anchorage technique*") OR TITLE-ABS-KEY("orthodontic anchoring procedure*") OR TITLE-ABS-KEY("skeletal" AND "anchorage*") OR TITLE-ABS-KEY("anchorage" AND "screw*") OR TITLE-ABS-KEY("temporary" AND "anchorage" AND "device*") OR TITLE-ABS-KEY("anchorage procedure*" AND "orthodontic") OR TITLE-ABS-KEY("anchorage technique*" AND "orthodontic") OR TITLE-ABS-KEY("procedure*" AND "orthodontic anchorage*") OR TITLE-ABS-KEY("technique*" AND "orthodontic anchorage*") OR TITLE-ABS-KEY("tad") OR TITLE-ABS-KEY("tads")) AND (TITLE-ABS-KEY("palatal expansion technique*") OR TITLE-ABS-KEY("palatal" AND "expansion" AND "technic*") OR TITLE-ABS-KEY("palatal" AND "expander*") OR TITLE-ABS-KEY("palatal" AND "expansion*") OR TITLE-ABS-KEY("maxilla" AND "expansion*") OR TITLE-ABS-KEY("maxillary" AND "suture" AND "expansion*") OR TITLE-ABS-KEY("expansion*" AND "maxillary") OR TITLE-ABS-KEY("expansion technic*" AND "palatal") OR TITLE-ABS-KEY("expansion technique*" AND "palatal") OR TITLE-ABS-KEY("technic*" AND "palatal expansion*") OR TITLE-ABS-KEY("technique*" AND "palatal expansion*")))	149
Cochrane Library	#1 MeSH:[Palatal Expansion Technique] explode all trees; #2 "Palatal Expansion* Technique*"; #3 "Expansion* Technic* Palatal"; #4 "Expansion* Maxillary"; #5 "Maxilla* Expansion*"; #6 "Maxillary suture expansion*"; #7 "palatal expander*"; #8 "palatal expansion*"; #9 #1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8; #10 "anchorage procedure* orthodontic"; #11 "anchorage screw*"; #12 "anchorage technique* orthodontic"; #13 "bone screw*"; #14 "bone-anchored"; #15 "bone-borne"; #16 "miniimplant*"; #17 "implant anchorage*"; #18 "implant-supported"; #19 "micro implant*"; #20 "micro screw*"; #21 "mini implant*"; #22 "mini screw*"; #23 "mini-implant*"; #24 "miniscrew*"; #25 "mini-screw*"; #26 "orthodontic anchorage*"; #27 "orthodontic anchorage procedure*"; #28 "orthodontic anchorage technique*"; #29 "orthodontic anchoring procedure*"; #30 "screw* bone"; #31 "skeletal anchorage*"; #32 "tad"; #33 "tads"; #34 "temporary anchorage device*"; #35 #10 OR #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #19 OR #20 OR #21 OR #22 OR #23 OR #24 OR #25 OR #26 OR #27 OR #28 OR #29 OR #30 OR #31 OR #32 OR #33 OR #34; #36 #9 AND #35; #37 "MARPE"; #38 "MARME"; #39 #36 OR #37 OR #38	71
Web of Science	#1 TS=("bone screws" OR "screw* bone" OR "bone-anchored" OR "bone-borne" OR "implant anchorage*" OR "implant-supported" OR "miniimplant*" OR "micro implant*" OR "micro screw*" OR "mini implant*" OR "mini screw*" OR "mini-implant*" OR "miniscrew*" OR "mini-screw*" OR "orthodontic anchorage*" OR "orthodontic anchorage procedure*" OR "orthodontic anchorage technique*" OR "orthodontic anchoring procedure*" OR "skeletal anchorage*" OR "anchorage screw*" OR "temporary anchorage device*" OR "anchorage procedure* orthodontic" OR "anchorage technique* orthodontic" OR "procedure* orthodontic anchorage*" OR "technique* orthodontic anchorage*" OR "TAD" OR "TADs"); #2 TS=("palatal expansion technique*" OR "palatal expansion technic*" OR "palatal expander*" OR "palatal expansion*" OR "maxilla expansion*" OR "maxillary expansion*" OR "maxillary suture expansion*" OR "expansion technic* palatal" OR "expansion technique* palatal" OR "technic* palatal expansion*" OR "technique* palatal expansion*"); #3 TS=("MARPE" OR "MARME"); #4 #2 AND #1; #5 #4 OR #3	50

Embase	("marme":ti, ab, kw OR "marpe":ti, ab, kw) OR (("palatal expansion"/exp OR ("expansion technique*":ti, ab, kw AND "palatal":ti, ab, kw) OR "palatal expansion technique*":ti, ab, kw OR ("technique*":ti, ab, kw AND "palatal expansion*":ti, ab, kw) OR "palatal expansion technic*":ti, ab, kw OR ("expansion technic*":ti, ab, kw AND "palatal":ti, ab, kw) OR "maxillary expansion*":ti, ab, kw OR ("expansion*":ti, ab, kw AND "maxillary":ti, ab, kw) OR "palatal expansion technique*":ti, ab, kw OR "palatal expansion*":ti, ab, kw OR "palatal expander*":ti, ab, kw OR "maxilla expansion*":ti, ab, kw OR "maxillary suture expansion*":ti, ab, kw) AND ("bone screw"/exp OR ("screw*":ti, ab, kw AND "bone":ti, ab, kw) OR "miniscrew*":ti, ab, kw OR "miniimplant*":ti, ab, kw OR "micro screw*":ti, ab, kw OR "skeletal anchorage*":ti, ab, kw OR "tad":ti, ab, kw OR "tads":ti, ab, kw OR "temporary anchorage device*":ti, ab, kw OR "anchorage screw*":ti, ab, kw OR "micro implant*":ti, ab, kw OR "mini implant*":ti, ab, kw OR "mini screw*":ti, ab, kw OR "implant supported":ti, ab, kw OR "implant anchorage*":ti, ab, kw OR "orthodontic anchorage*":ti, ab, kw OR "bone borne":ti, ab, kw OR "bone anchored":ti, ab, kw OR "orthodontic anchorage procedure*":ti, ab, kw OR "orthodontic anchoring procedure*":ti, ab, kw OR "orthodontic anchorage technique*":ti, ab, kw OR ("technique*":ti, ab, kw AND "orthodontic anchorage":ti, ab, kw) OR ("anchorage technique*":ti, ab, kw AND "orthodontic":ti, ab, kw) OR ("procedure*":ti, ab, kw AND "orthodontic anchorage":ti, ab, kw) OR ("anchorage procedure*":ti, ab, kw AND "orthodontic":ti, ab, kw)))	239

Selection of sources of evidence

Four reviewers (N.S., A.N., S.V., G.B.) independently evaluated all records. Duplicate entries were eliminated in Zotero and checked manually. Eligibility criteria were organized into an Excel sheet to guide screening. Titles and abstracts were assessed first, followed by a full-text review of potentially relevant studies. Final inclusion was decided after this stage.

When disagreements arose, an external consultant (E.S.) was asked to resolve them.

Data charting process

A second Excel file was created to record variables such as: first author, publication year, country, study type, sample size, mean age, data collection method, expansion type, device design, protocol, and complications.

Adverse effects were classified into five groups: expansion failure, asymmetry, dentoalveolar changes, surgical events, and device-related issues.

The reviewers jointly extracted, refined, and verified the dataset through discussion.

Synthesis of results

The included studies were split according to the expansion method (MARPE vs. SARPE). Side effects were then summarized within the five previously defined categories.

Results and Discussion

Evidence identification and selection

Across six electronic databases, 744 papers were initially retrieved: PubMed (n=235), Scopus (n=149), Cochrane Library (n=71), Web of Science (n=50), Embase (n = 239), and OpenGrey (n = 0). Manual screening contributed two more references. After eliminating 191 duplicates, 555 unique records remained for evaluation.

Screening of titles and abstracts led to the removal of 416 publications because of irrelevance or unsuitable type. Five texts could not be accessed. Among the 134 full texts assessed, 108 were excluded: 21 because they were FEM analyses or animal studies, 6 because of craniofacial syndromes in participants, 64 for being outside the defined age group, and 17 for lacking descriptions of adverse outcomes.

In total, 26 articles [30–55] satisfied all criteria and entered the final synthesis. The complete selection process is depicted in **Figure 2**, which follows PRISMA-ScR recommendations.

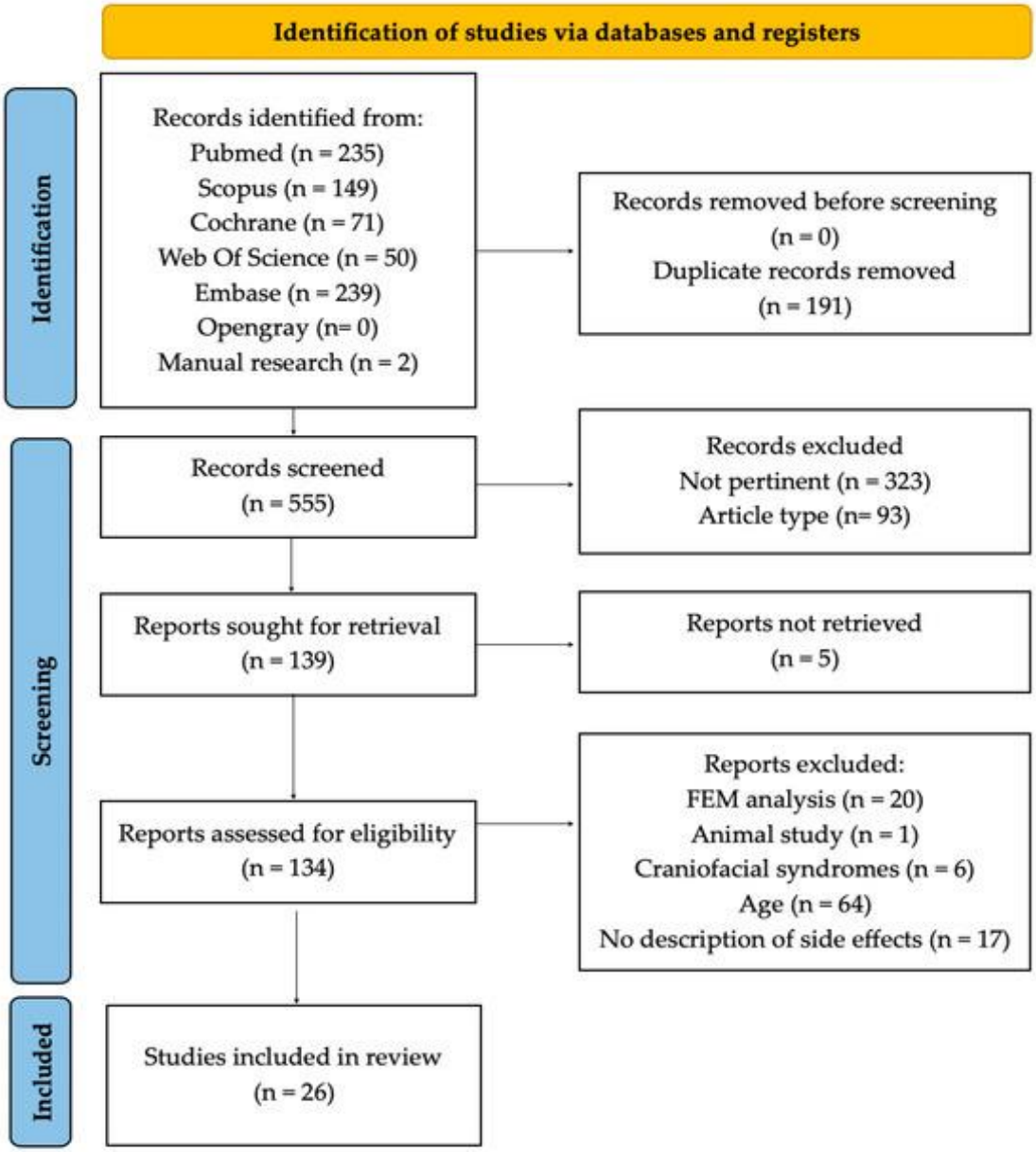

Figure 2. Flow diagram of literature retrieval and selection in accordance with PRISMA-ScR.

Description of included evidence

The features of the included material [30–55] are reported in **Table 2** and **Table 3**. To aid readability, study descriptors (authors, design, year, sample, mean age) are in **Table 2**, while **Table 3** outlines methodology, expansion approach, appliance type, and activation details.

Table 2.

Lead Author [Citation]	Publication Year	Country of Origin	Research Type	Number of Participants	Average Age (Years)
Abate *et al.* [30]	2023	Italy	Retrospective Analysis	20	27.3
Al-Ouf *et al.* [31]	2010	Austria, Syria	Prospective Investigation	17	30.7
Basu *et al.* [32]	2023	India	Randomized Controlled Study	18	20.8
Choi *et al.* [33]	2023	Republic of Korea	Randomized Controlled Trial	32	23

Contar *et al.* [34]	2009	Brazil	Retrospective Review	14	33.5
Daif [35]	2014	Egypt	Prospective Study	30	24
Drobyshev *et al.* [36]	2021	Russia	Retrospective Evaluation	665	25.3
Fernández Sanromán *et al.* [37]	2010	Spain	Prospective Research	8	28.5
Goldenberg *et al.* [38]	2007	Brazil	Prospective Analysis	15	24.5
Gunbay *et al.* [39]	2008	Turkey	Prospective Examination	10	22.3
Karabiber *et al.* [40]	2019	Turkey	Prospective Study	16	18.4
Kayalar *et al.* [41]	2015	Turkey	Randomized Clinical Experiment	20	19.4
Leyder *et al.* [42]	2018	France	Prospective Investigation	55	23.6
Lim *et al.* [43]	2017	Republic of Korea	Retrospective Study	29	21.6
Pereira *et al.* [44]	2017	Brazil	Prospective Research	90	26.1
Ploder *et al.* [45]	2020	Germany	Retrospective Analysis	54	28.8
Rachmiel *et al.* [46]	2020	Israel	Prospective Study	32	19–54
Sant'Ana *et al.* [47]	2016	Brazil	Prospective Evaluation	24	24.29
Seeberger *et al.* [48]	2015	Germany	Retrospective Review	33	26
Sendyk *et al.* [49]	2018	Brazil	Prospective Study	17	25–45
Smeets *et al.* [50]	2019	Belgium	Retrospective Assessment	111	26
Sygouros *et al.* [51]	2014	Turkey	Retrospective Study	26	18.8
Wang *et al.* [52]	2023	China	Prospective Analysis	40	22.42 ± 3.38
Williams *et al.* [53]	2012	USA	Retrospective Investigation	120	29.5 (22–39)
Winsauer *et al.* [54]	2021	Austria	Retrospective Review	33	29.1 ± 10.2 (18–58)
Yoon *et al.* [55]	2020	USA	Retrospective Study	75	30.5 ± 8.5

Table 3.

Lead Author and Year [Citation]	Data Gathering Methods	Expansion Method	Appliance Type	Expansion Protocol (Until Target Expansion Achieved)
Abate *et al.*, 2023 [30]	EMG Assessments	SARPE (Le Fort I osteotomy + midpalatal osteotomy)	Tooth-borne Hyrax-type device	7-day wait period, followed by two daily activations (0.25 mm each)
Al-Ouf *et al.*, 2010 [31]	Dental casts	SARPE (Bilateral osteotomies along midpalatal suture from posterior to anterior piriform aperture)	Tooth-borne Hyrax-type device	Four intraoperative activations (0.25 mm each); 7-day wait period, daily activation protocol unspecified

Basu *et al.*, 2023 [32]	Clinical exams, intra/extraoral photos, cephalograms, OPT, dental casts, CBCT scans	MARPE (Group A: corticopuncture-assisted BBRME; Group B: standard MARPE)	Group A: tooth-bone-borne Hyrax-type; Group B: bone-borne	Both groups: one intraoperative activation; two daily activations until midline diastema appeared, then one daily activation
Choi *et al.*, 2023 [33]	CBCT scans, periapical radiographs	MARPE	Tooth-bone-borne Hyrax-type device	One daily activation (0.2 mm)
Contar *et al.*, 2009 [34]	Clinical exams, dental casts, cephalograms, periapical X-rays	SARPE (modified Le Fort I osteotomy + midpalatal osteotomy)	Tooth-borne Hyrax-type device	5-day wait period; two daily activations (0.25 mm each, 12-hour intervals)
Daif , 2014 [35]	Photos, dental casts, cephalograms, CBCT scans	SARPE (Bilateral zygomatic buttress osteotomy + midpalatal osteotomy)	Tooth-borne Hyrax-type device	Eight intraoperative activations (0.25 mm each); 5-day wait period, then two daily activations
Drobyshev *et al.*, 2021 [36]	CBCT scans	SARPE (Le Fort I osteotomy + midpalatal osteotomy)	Bone-borne TPD device	7-day wait period, then daily activations ranging from 0.3 mm to 1 mm
Fernández Sanromán *et al.*, 2010 [37]	Clinical exams, OPT, cephalograms, dental casts	SARPE (Zygomaticomaxillary buttress osteotomy + midpalatal osteotomy)	Bone-borne and tooth-bone-borne Hyrax-type devices	7-day wait period; three daily activations (0.2 mm each)
Goldenberg *et al.*, 2007 [38]	Photos, dental casts, cephalograms, CBCT scans	SARPE (modified Le Fort I osteotomy + midpalatal osteotomy)	Tooth-borne Hyrax-type device	Four intraoperative activations (0.25 mm each); 3-day wait period, then two daily activations
Gunbay *et al.*, 2008 [39]	Clinical exams, cephalograms, dental casts	SARPE (osteotomies of anterior, lateral, and medial maxillary sutures)	Bone-borne TPD device	7-day wait period; five daily activations (0.2 mm each)
Karabiber *et al.*, 2019 [40]	Intra/extraoral photos, CBCT scans	Unilateral SARPE (asymmetric anterior/lateral osteotomies + asymmetric PMD + midpalatal osteotomy)	Asymmetrically designed tooth-borne Hyrax-type device	5-day wait period, then two daily activations (0.25 mm each)
Kayalar *et al.*, 2015 [41]	CBCT scans	SARPE (Le Fort I osteotomy + midpalatal osteotomy + PMD)	Tooth-borne and tooth-bone-borne Hyrax-type devices	Intraoperative activation until 1 mm diastema; two daily activations (0.25 mm each)
Leyder *et al.*, 2018 [42]	Clinical exams, CBCT scans, dental casts	SARPE (Le Fort I osteotomy + down fracture + medial/single lateral corticotomy)	Tooth-borne (n = 36), bone-borne (n = 11), tooth-bone-borne (n = 8) TPD devices	Intraoperative activation for <3 mm osseous separation; 4-day wait period, then 0.53 mm daily activation
Lim *et al.*, 2017 [43]	CBCT scans	MARPE	Modified tooth-bone-borne Hyrax-type device	Two daily activations (0.2 mm each)
Pereira *et al.*, 2017 [44]	Clinical exams, dental casts, cephalograms, OPT, periapical/occlusal X-rays	SARPE (Le Fort I osteotomy + PMD)	Tooth-borne Haas-type (n = 29) and Hyrax-type (n = 61) devices	Eight intraoperative activations (0.2 mm each); 4-day wait period, then two daily activations
Ploder *et al.*, 2020 [45]	Clinical exams, radiographic assessments, dental casts	SARPE (Le Fort I osteotomy + midpalatal osteotomy + PMD)	Tooth-borne splint, bone-borne TPD, bone-borne OMI devices	Tooth-borne: 6-day wait period, three daily activations (0.2 mm each); TPD: 4–6-day wait period, two daily activations (0.5 mm each); OMI: 5-day wait period, three daily activations (0.17 mm each)

Rachmiel *et al.*, 2020 [46]	Clinical exams	SARPE	Tooth-borne Hyrax-type device	Two daily activations (0.25 mm each)
Sant'Ana *et al.*, 2016 [47]	Clinical exams, occlusal radiographs, pain surveys	SARPE (Group 1: partial bilateral maxillary antero-lateral osteotomies + midpalatal osteotomy; Group 2: bilateral maxillary antero-lateral osteotomies)	Tooth-borne Hyrax-type device	Four intraoperative activations (0.25 mm each); 2-day wait period, then one activation twice daily
Seeberger *et al.*, 2015 [48]	CBCT scans	SARPE (Subtotal Le Fort I osteotomy + PMD)	Tooth-borne Hyrax-type and bone-borne TPD devices	Tooth-borne: four intraoperative activations (0.2 mm each), 5–7-day wait period, two daily activations; Bone-borne: same protocol, but each activation 0.25 mm
Sendyk *et al.*, 2018 [49]	Clinical exams	SARPE (Le Fort I osteotomy + PMD + anterior maxillary osteotomy)	Tooth-borne Hyrax-type device	Two daily activations (morning and night)
Smeets *et al.*, 2019 [50]	Clinical exams, CBCT scans	SARPE (Le Fort I osteotomy + PMD + midpalatal osteotomy)	Tooth-borne Hyrax-type and bone-borne TPD devices	7-day wait period, then two daily activations (0.25 mm each)
Sygouros *et al.*, 2014 [51]	CBCT scans	SARPE (Le Fort I; Group 1: with PMD; Group 2: without PMD)	Tooth-borne Hyrax-type device	Eight intraoperative activations (0.25 mm each); 3-day wait period, then two daily activations
Wang *et al.*, 2023 [52]	CBCT scans	MARPE	Tooth-borne Hyrax-type device	Two daily activations (0.2 mm each) until maxillary central incisor diastema observed, then one daily activation
Williams *et al.*, 2012 [53]	Clinical exams	SARPE (Le Fort I osteotomy + midpalatal osteotomy + interdental osteotomy + PMD)	Tooth-borne (n = 118) and bone-borne (n = 2) devices	5–7-day wait period; two daily activations (0.25 mm each)
Winsauer *et al.*, 2021 [54]	Clinical exams, CBCT scans	MARPE; SARPE for patients without diastema after 4 months	Bone-borne MICRO-4 device	MARPE: two daily activations (0.17 mm each) for first week, then six activations/deactivations daily plus 0.17 mm every third day; SARPE: 5-day wait period, three daily activations (0.5 mm total)
Yoon *et al.*, 2020 [55]	CBCT scans, polysomnography, questionnaires	SARPE (Le Fort I + midpalatal osteotomy)	Tooth-bone-borne device	5–7-day wait period, then one daily activation (0.25 mm)

Abbreviations used: CBCT = cone beam computed tomography; EMG = electromyography; MARPE = miniscrew-assisted rapid palatal expansion; OMI = orthodontic mini-implant; OPT = orthopantomography; PMD = pterygomaxillary disjunction; SARPE = surgically assisted rapid palatal expansion; TPD = transpalatal distractor.

The research was conducted in multiple regions: Austria (n = 2) [31, 54], Belgium (n = 1) [50], Brazil (n = 5) [34, 38, 44, 47, 49], China (n = 1) [52], Egypt (n = 1) [35], France (n = 1) [42], Germany (n = 2) [45, 48], India (n = 1) [32], Israel (n = 1) [46], Italy (n = 1) [30], Republic of Korea (n = 2) [33, 43], Russia (n = 1) [36], Spain (n = 1) [37], Syria (n = 1) [31], Turkey (n = 4) [39–41, 51], and the USA (n = 2) [53, 55].

Among the 26 papers, retrospective designs accounted for 11 [30, 34, 36, 43, 45, 48, 50, 51, 53–55], prospective for 12 [31, 35, 37–40, 42, 44, 46, 47, 49, 52], and randomized clinical trials for 3 [32, 33, 41]. Patient enrollment ranged from 8 [37] to 665 [36], with reported mean ages clustering between 30 and 34 years.

Assessment tools varied: CBCT was most common (n = 15) [32, 33, 35, 36, 38, 40–43, 48, 50–52, 54, 55], while radiographs (periapical/occlusal, n = 5) [33, 34, 44, 45, 47], dental casts (n = 10) [31, 32, 34, 35, 37–39, 42, 44, 45], clinical inspection (n = 13) [32, 34, 37, 39, 42, 44–47, 49, 50, 53, 54], and patient questionnaires (n = 2) [47, 55] were also employed. Supplementary tools included photographs (n = 4) [32, 35, 38, 40], cephalometric films

(n = 7) [32, 34, 35, 37–39, 44], and panoramic x-rays (n = 3) [32, 37, 44]. Special techniques included surface EMG for muscle function [30] and polysomnography in cases of OSAS [55].
Regarding treatment types, SARPE dominated (n = 21) [30, 31, 34–42, 44–47, 48–51, 53, 55]. MARPE was evaluated in 4 reports [32, 33, 43, 52], and 1 described SARPE following failed MARPE [54].
Anchorage approaches were distributed as follows: tooth-borne expanders (n = 18) [30, 31, 34, 35, 38, 40–42, 44–47, 48–53], bone-borne (n = 10) [32, 36, 37, 39, 42, 45, 48, 50, 53, 54], and hybrid appliances (n = 7) [32, 33, 37, 41–43, 55]. Nine publications compared different device types [32, 37, 41, 42, 44, 45, 48, 50, 53].
Intraoperative activations were described in 10 studies [31, 32, 35, 38, 41, 42, 44, 47, 48, 51]. Daily activation regimens varied from 0.2 mm to 1 mm. A waiting period between surgery and activation was adopted in 19 SARPE studies [30, 31, 34–40, 42, 44, 45, 47, 48, 50, 51, 53–55].
All expansion techniques and activation protocols are detailed in **Table 3**.

Outcomes reported in the included studies
Adverse effects described in the reviewed literature are presented in **Table 4**.

Table 4. Overview of complications according to expansion method (SARPE or MARPE), organized by category. When available, complication frequencies are listed

Lead Researcher, Year [Citation]	Procedure	Expansion Non-Success	Uneven Expansion Issues	Tooth and Bone Complications	Surgical Adverse Events	Equipment Issues
Abate *et al.*, 2023 [30]	SARPE	N/R	N/R	N/R	Hematoma (100%), Swelling (100%)	N/R
Al-Ouf *et al.*, 2010 [31]	SARPE	N/R	N/R	N/R	Swelling	N/R
Basu *et al.*, 2023 [32]	MARPE	N/R	N/R	Tooth angulation (100%, Group B > Group A), Buccal bone reduction (100%, Group B > Group A)	N/R	N/R
Choi *et al.*, 2023 [33]	MARPE	16%	N/R	Tooth angulation (100%)	Nasal mucosa thickening	Screw malfunction
Contar *et al.*, 2009 [34]	SARPE	N/R	N/R	Gum recession (14%)	Pain (14%), Wound opening (14%)	Device distortion (7%)
Daif, 2014 [35]	SARPE	N/R	N/R	Temporary loss of tooth pulp sensitivity	Edema, Discomfort	N/R
Drobyshev *et al.*, 2021 [36]	SARPE	Inadequate expansion (5%), Relapse (3%)	4%	Gum recession (0.7%), Tooth color change (0.5%), Bone loss (0.3%)	Sensory disturbance (30%), Palatal tissue inflammation (9%) or necrosis (0.1%), Bleeding (1.1%), Sinus perforation (0.9%)	Device displacement (9%), Distractor detachment (3%)
Fernández Sanromán *et al.*, 2010 [37]	SARPE	N/R	N/R	N/R	Palatal tissue irritation (erosions, ulcers) (100%)	N/R
Goldenberg *et al.*, 2007 [38]	SARPE	N/R	N/R	Tooth mobility (13%)	Pain (80%), Edema	N/R
Gunbay *et al.*, 2008 [39]	SARPE	N/R	N/R	Tooth necrosis (20%), Left alveolar segment buccal shift (10%)	Pain (30%), Nasal bleeding (20%), Wound opening (20%), Inter-incisal septum fracture (20%)	Distractor loosening (20%)

Karabiber *et al.*, 2019 [40]	SARPE	N/R	N/R	Tooth angulation (100%), Buccal bone reduction (100%)	N/R	N/R
Kayalar *et al.*, 2015 [41]	SARPE	N/R	N/R	Tooth angulation (100%), Buccal bone reduction (50%), Root resorption (100%)	N/R	N/R
Leyder *et al.*, 2018 [42]	SARPE	Inadequate expansion (1.8%), Target diastema not achieved (3.6%)	20%	Tooth necrosis (3.6%), Gum recession (3.6%)	Palatal tissue sloughing (3.6%)	Screw distortion (3.6%), Osteosynthesis removal (3.6%)
Lim *et al.*, 2017 [43]	MARPE	17%	N/R	Tooth angulation (100%), Buccal bone reduction (100%)	N/R	N/R
Pereira *et al.*, 2017 [44]	SARPE	N/R	6%	Tooth color change (6%)	Pain (4%), Localized infection (2%)	N/R
Ploder *et al.*, 2020 [45]	SARPE	N/R	4%	Periodontal attachment loss (4%), Tooth necrosis (4%), Tooth mobility (2%), Root resorption (4%)	N/R	Screw loosening (9%), Screw fracture (4%)
Rachmiel *et al.*, 2020 [46]	SARPE	N/R	N/R	Gum recession (6%), Bone loss (3%)	N/R	N/R
Sant'Ana *et al.*, 2016 [47]	SARPE	29% (group without midpalatal osteotomy)	N/R	N/R	Discomfort, Pain, Edema	N/R
Seeberger *et al.*, 2015 [48]	SARPE	N/R	N/R	Tooth angulation (100%)	N/R	N/R
Sendyk *et al.*, 2018 [49]	SARPE	N/R	N/R	Periodontal attachment loss (100%), Gum recession (100%)	N/R	N/R
Smeets *et al.*, 2019 [50]	SARPE	N/R	9%	Midline bone resorption (3%), Gum recession (2%), Tooth mobility (2%)	Bleeding (4%), Pain (13%), Sensory disturbances (27%), Infection (4%), Lacrimation (1%)	Mechanical failure (3%)
Sygouros *et al.*, 2014 [51]	SARPE	N/R	N/R	Tooth angulation (100%), Alveolar bending (100%)	N/R	N/R
Wang *et al.*, 2023 [52]	MARPE	N/R	N/R	Tooth angulation (100%), Bone loss (100%)	N/R	N/R
Williams *et al.*, 2012 [53]	SARPE	Inadequate expansion (7%)	8%	Tooth color change (4%), Gum recession (10%), Bone loss (6%), Tooth loss (2%)	Epistaxis (3%), Hematoma (n = 3), Wound infection (7%), Palatal tissue necrosis (0.8%), Hypoesthesia (3%), Sinus infection (2%), Subcutaneous emphysema (2%)	N/R

Winsauer *et al.*, 2021 [54]	MARPE	15%	N/R	N/R	N/R	Screw distortion (15%)
	SARPE	N/R	N/R	N/R	Soft tissue inflammation (3%)	Abutment detachment (3%)
Yoon *et al.*, 2020 [55]	SARPE	N/R	Slight uneven expansion	Tooth necrosis (5%), Periodontal attachment loss (3%)	Sensory disturbance, Wound dehiscence (3%), Palatal fistula (1%)	N/R

N/R = Not reported.

The side effects were grouped into five main classes: (1) expansion failure, (2) asymmetry, (3) dentoalveolar problems, (4) surgical complications, and (5) appliance-related events.

Expansion failure

Incomplete separation of the midpalatal suture was identified in 4 of the 22 SARPE studies [36, 42, 47, 53] and in 3 of 5 MARPE investigations [33, 43, 54]. Failure rates ranged between 2% and 29%. Situations such as limited widening, relapse, or inability to create the intended diastema were also considered failures.

Asymmetry in expansion

Seven SARPE papers documented uneven expansion patterns [36, 42, 44, 45, 50, 53, 55]. No MARPE study reported asymmetry.

Dentoalveolar complications

Dentoalveolar changes were the most frequently described, appearing in 21 of 26 studies [32–36, 38–46, 48–53, 55].

- **Periodontal effects:** Gingival recession was noted in 7 articles [34, 36, 42, 46, 49, 50, 53], alveolar bone loss in 8 [32, 36, 40, 41, 43, 46, 52, 53], and attachment loss in 3 [45, 49, 55].
- **Dental tipping:** Eight investigations [32, 33, 40, 41, 43, 48, 51, 52] described buccal tipping, with MARPE studies [32, 33, 43, 52] contributing half of these reports. Winsauer *et al.* [54] was the only MARPE paper that found no tipping. In 2 cases [39, 51], tipping coincided with bending of the alveolar bone.
- **Pulp/necrosis/discoloration:** Eight studies [35, 36, 39, 42, 44, 45, 53, 55] mentioned pulpal sensitivity loss, necrosis, or tooth discoloration—none of them related to MARPE. Most teeth were managed with root canal treatment, but Williams *et al.* [53] described two extractions.
- **Root resorption:** Two articles [41, 45] reported resorption in anchoring or anterior maxillary teeth.
- **Mobility:** Three studies [38, 45, 50] noted temporary tooth mobility that resolved over time.

Surgical side effects

Complications of surgical origin were largely confined to SARPE, except for a case reported by Choi *et al.* [33], where a miniscrew perforated the nasal floor, leading to mucosal inflammation after MARPE.

- **Pain:** The most common finding, mentioned in six papers [34, 38, 39, 44, 47, 50], occurring either after surgery or during expansion. Relief was achieved with protocol changes, analgesics, or expander removal. Two additional studies [35, 47] described general discomfort during activation.
- **Palatal trauma:** Five articles [36, 37, 42, 53, 55] reported trauma from appliances, leading to inflammation, ulceration, necrosis, fistulas, or mucosal sloughing.
- **Bleeding:** Noted in four publications [36, 39, 50, 53], either as mucosal bleeding or epistaxis. Nasal complications included thickened mucosa [33], sinus perforation [36], and sinus infection [53].
- **Minor sequelae:** Hematomas (n = 2) [30, 53], edema (n = 3) [35, 38, 47], and swelling (n = 2) [30, 31] were typically self-limiting. Williams *et al.* [53] additionally documented subcutaneous emphysema.
- **Neurological issues:** Four SARPE studies [36, 50, 53, 55] described altered sensation (paresthesia/hypoesthesia) involving V2, infraorbital, or nasopalatine nerves.
- **Other surgical issues:** Infections, wound dehiscence, and lacrimation were reported only in SARPE cases (n = 6) [34, 39, 44, 50, 53, 55].

Device-related problems

Technical failures were described in 8 studies [33, 34, 36, 39, 42, 45, 50, 54] and included both MARPE and SARPE.

- For MARPE, Leyder *et al.* [42] and Winsauer *et al.* [54] noted screw deformation.
- Ploder *et al.* [45] reported screw loosening and fracture in 13% of cases.
- Winsauer *et al.* [54] also observed abutment loss during retention and further screw damage.
- Other issues included deformation, dislodgement, or loss of distractors, described in four reports [34, 36, 39, 50].

Synthesis of results

Considerable heterogeneity was present across the analyzed studies, with variations in device configuration, activation strategy, evaluation methods, and other influencing factors.

Among the reported complications, dentoalveolar and surgical outcomes were most frequent. MARPE was more commonly linked with dental effects such as tipping, whereas SARPE was mainly associated with surgical sequelae.

Overview of the evidence

This systematic review aimed to examine adverse outcomes arising from two adult maxillary expansion techniques: MARPE and SARPE.

Across the 26 eligible papers, side effects were organized into five groups: failed expansion, asymmetric widening, dentoalveolar effects, surgical issues, and appliance-related complications. Dentoalveolar alterations were the most frequently reported in both approaches. Though these events cannot be fully avoided, their intensity is highly dependent on the technique applied. Expansion failure and asymmetry are among the most problematic because they often require retreatment, thereby prolonging therapy and increasing biological risk. Such events are influenced by patient-specific factors, including age and skeletal maturity, in addition to the expansion protocol. Surgical complications are mostly seen with SARPE, reflecting its invasive nature, while appliance configuration contributes significantly to both dental and device-related problems.

Dental tipping remains one of the most consistently described effects, found in both MARPE and SARPE cohorts [32, 33, 40, 41, 43, 48, 51, 52]. Several authors even suggest that tipping is an inherent biomechanical response rather than a true adverse outcome, since it often resolves during retention.

Lim *et al.* [43] observed, one year after MARPE expansion, that buccal inclination relapse was greater in dental units than in alveolar segments, suggesting a more stable skeletal component long-term compared with immediate post-treatment results. Similarly, Sygouros *et al.* [51] regarded tipping as a natural part of expansion that diminishes spontaneously during follow-up.

The absence of tipping in many reports likely reflects the predominance of SARPE in those studies. Basu *et al.* [32] showed that conventional MARPE produced more tipping than MARPE combined with corticopuncture, whereas Karabiber *et al.* [40] found that unilateral osteotomy lessened tipping and alveolar bone loss on the operated side. This may be due to the initial force transfer primarily through the teeth until the suture separates, a factor countered by midpalatal osteotomy in SARPE or corticopuncture in MARPE.

Both tooth-borne and bone-borne expanders have been implicated in tipping, though prevalence is strongly tied to appliance design. Ning *et al.* [56] found significant differences between hybrid and fully bone-borne devices. Cozzani *et al.* [57] highlighted increased stress on anchor teeth with tooth-borne expanders, absent in skeletal-borne appliances. Likewise, Lin *et al.* [58] documented less alveolar bone loss and reduced tipping of premolars in bone-borne designs.

More severe dental outcomes—including necrosis, discoloration, tooth loss, and mobility—were predominantly seen in SARPE cases [36, 38, 39, 42, 44, 45, 50, 53, 55]. In every instance, a palatal osteotomy was part of the surgical plan. Four studies also carried out pterygomaxillary disjunction (PMD) [44, 45, 50, 53], and one incorporated a down-fracture via Le Fort I osteotomy [42]. This pattern suggests that the extent of surgical intervention correlates with a higher risk of negative dental consequences.

Periodontal complications were identified in nine reports [34, 36, 41, 42, 43, 45, 46, 49, 50], most often gingival recession, probing depth increases, and clinical attachment loss. Nearly all of these used tooth-borne expanders, with the exception of Drobyshev *et al.* [36], who employed a bone-borne appliance and observed recession in only 0.7% of patients. These findings emphasize that dental anchorage can impair hygiene and provoke gingival

inflammation, echoing the meta-analysis by Bi *et al.* [59], which advocates tailoring anchorage type to clinical context and weighing periodontal risks when selecting hybrid or tooth-supported expanders.

Root resorption, reported in two studies [41, 45], occurred exclusively with dental anchorage. Though less common in adults treated with skeletal anchorage [60], resorption remains a recognized complication regardless of technique [61].

Asymmetric expansion, documented with both MARPE and SARPE, generally appeared in the sagittal plane with a pyramidal pattern. This is attributed to greater posterior resistance at the pterygomaxillary suture and zygomatic buttress, combined with the rotational center of the zygomaticomaxillary complex located above the frontozygomatic suture [62]. Nonetheless, transverse asymmetry—where one side opens more than the other—has also been described.

Such asymmetry is often tied to the surgical protocol and may necessitate corrective reintervention, causing substantial patient burden [63]. In this review, the average rate of asymmetry in SARPE cases was 8.5%, higher than the 4.4% reported by Carvalho *et al.* [64]. Carvalho attributed this difference to factors such as omission of PMD and the use of slower activation. However, our synthesis did not find a consistent association, since asymmetry was also seen with rapid activation and PMD protocols. These discrepancies point to the need for further well-designed research to clarify risk factors for asymmetric expansion in SARPE.

Asymmetry and expansion failures

Although none of the papers reviewed here recorded asymmetry after MARPE, earlier reports in the literature describe its occurrence. Kim *et al.* [65] attributed such outcomes not simply to uneven opening of the midpalatal suture, but rather to irregular fractures of the circummaxillary articulations. Patients with facial asymmetries in the frontal plane, such as chin deviation, appeared particularly vulnerable, and MARPE treatment could make these irregularities less predictable. In that investigation, the incidence was 30% and considered unpredictable [65].

Problems with incomplete or unsuccessful expansion were mentioned in eight studies [33, 36, 42, 43, 47, 53, 54, 55]. Of these, two specifically evaluated MARPE and reported failure in 16% [33] and 17% [43] of cases. These figures mirror the overall success levels for MARPE (roughly 84–88%) documented in other sources [66, 67]. A plausible explanation is that most MARPE investigations involved younger adults, whereas efficiency decreases sharply with age. For instance, in individuals aged 30–37 years, where midpalatal sutures are commonly classified as stage D or E, success drops to ~20% [68]. Yoon *et al.* [67] also observed that 68% of unsuccessful expansions occurred in patients older than 25. Interventions such as corticopuncture prior to expansion appear to enhance results. Similarly, Winsauer *et al.* [54] reported a 15% failure rate for MARPE, noting that the unsuccessful cases (average age 41.3 years) required conversion to SARPE, underscoring the strong inverse relation between age and MARPE predictability.

Comparison of MARPE and SARPE outcomes

In general, SARPE demonstrates lower rates of failure compared to MARPE. The exception is a trial by Sant'Ana *et al.* [47], which found a 29% failure rate in patients treated without a palatal osteotomy. These findings suggest SARPE may be more reliable for adults with advanced suture maturation (D or E) [8]. A modified strategy, Distraction Osteogenesis Maxillary Expansion (DOME), described by Yoon *et al.* [55], integrates the Maxillary Skeletal Expander (MSE) with SARPE but omits pterygomaxillary separation. This protocol, tested in patients with a mean age of 30 years, yielded 100% success and also led to a measurable reduction in Apnea-Hypopnea Index (AHI), pointing to improvement in Obstructive Sleep Apnea symptoms such as fatigue and disrupted breathing—consistent with other MARPE reports [33].

Emerging, less invasive protocols

Recently, efforts have been made to refine expansion strategies and minimize complications. Haas Junior *et al.* [21] presented a SARPE method completed in ~19 minutes under local anesthesia with a bone-supported expander. Importantly, pterygomaxillary disjunction was excluded, which Sangsari *et al.* [69] had already suggested was not strictly necessary for suture release. This approach shortened treatment time, decreased operative trauma, and was better tolerated by patients. Despite the potential benefits—especially in adults with higher MARPE failure—its evidence remains limited due to the small sample and lack of long-term monitoring.

Reported surgical complications

Adverse surgical outcomes were primarily seen in SARPE procedures [30, 31, 33- 39, 42, 44, 47, 50, 53, 54]. Minor issues such as nasal bleeding, swelling, edema, or hematoma generally resolved spontaneously. More severe consequences included paresthesia [36, 53, 55], necrosis of palatal mucosa [53], and wound breakdown [34, 39]. Only one MARPE-related surgical issue was described, where Choi *et al.* [33] reported thickening of the nasal mucosa due to a miniscrew piercing the nasal floor. Carvalho *et al.* [64] emphasized that surgical complications appeared in studies both with and without PMD, indicating that no single surgical maneuver predicts complications reliably. Nonetheless, the more invasive the surgery, the higher the risk of severe sequelae. Further clinical trials are needed to refine SARPE so it combines predictability with minimal risk.

Technical and appliance-related issues

Mechanical complications were most frequently linked with bone-supported transpalatal distractors (TPDs) [36, 39, 45, 50], which are regarded as challenging to manage clinically. In MARPE studies, the leading problems involved screw instability or deformation. Yoon *et al.* [67] associated screw loss mainly with peri-implant inflammation and suboptimal hygiene, while Bud *et al.* [70] described tissue overgrowth, mucosal hyperplasia, and loosening as typical MARPE-related problems.

One of the main triggers for mucosal irritation was contact of miniscrews or appliance arms with the palate. To reduce this, a clearance of 1 mm between screw and palate, and 3–4 mm between the arms and the palatal vault, has been recommended. Interestingly, many inflammatory reactions arose during the retention period, likely because partial relapse of the palatal halves creates tissue pressure, while screw dimensions remain unchanged [71].

Influence of appliance type

The analysis of selected studies demonstrates that the design of the expansion device strongly influences adverse outcomes. Among them, transpalatal distractors (TPDs) are the most complex to manage clinically and show the highest likelihood of mechanical failure. Tooth-anchored appliances negatively affect the supporting teeth, raising the risk of periodontal deterioration, dental tipping, and root resorption. In contrast, miniscrew-supported bone-borne expanders, although still producing some dental or alveolar side effects, seem to protect the dentition more effectively. Thus, device choice must be individualized, taking into account the patient's periodontal condition, dental health, and oral hygiene capacity.

Both MARPE and SARPE carry risks when applied to adults. Careful evaluation of the patient before treatment is therefore essential. Age is the most critical determinant: individuals younger than 25 years typically achieve predictable midpalatal suture opening with MARPE [72], making it preferable as a conservative alternative that avoids surgery and its possible complications. For patients older than 25, the likelihood of success decreases substantially; for those above 30, the probability of opening the suture falls to around 20% [68].

Attempts to improve stability, such as adding extra miniscrews for MARPE [73], increase invasiveness and potential complications without guaranteeing consistent outcomes. Skeletal maturation, which parallels chronological age, is another key variable. CBCT can identify patients with D or E suture stages, for whom purely orthopedic expansion is rarely sufficient; in such cases, surgery combined with expansion is advisable.

This review, in agreement with previous findings [72], indicates that gender does not influence success rates in MARPE. From a clinical–economic perspective, surgical adjuncts should be prioritized in adults with advanced suture stages (D or E) to reduce the risk of failure and re-intervention. In contrast, younger patients with stages A–C benefit from MARPE due to its lower biological burden and avoidance of extensive surgery.

Future perspectives

Upcoming research should aim to optimize strategies for adult patients with transverse maxillary deficiency by integrating skeletal anchorage expanders with minimally invasive surgical protocols. Such combinations could increase effectiveness while reducing the morbidity classically associated with SARPE.

Key objectives include: establishing a standardized surgical protocol, defining clear guidelines for distraction, and refining appliance design for skeletal anchorage. Research should specifically include adults with palatal suture stages D or E [8] and incorporate long-term monitoring to assess treatment stability and relapse risk.

Because expansion protocols varied considerably among studies, it was impossible to directly link specific adverse effects with a particular method. Although some prior reports suggested a greater tendency for asymmetry in slow

expansion [64], the articles reviewed here found asymmetry in both rapid and slow protocols. Future investigations comparing these modalities in detail are needed to clarify their distinct risk profiles.

Study limitations

To our knowledge, this is the first review that directly contrasts complications between MARPE and SARPE in adults. Nevertheless, several important limitations should be acknowledged.

The included studies were highly heterogeneous, particularly in terms of expansion protocols and the criteria used to evaluate complications. Moreover, the type of research group differed by technique: most SARPE studies originated from maxillofacial surgery teams, while MARPE was primarily studied within dentistry. This disciplinary divide likely shaped both the outcomes measured and the adverse events reported, complicating direct comparisons.

Finally, this review did not employ a systematic methodology and therefore lacks qualitative assessment of evidence quality [74]. As such, findings must be interpreted with caution. Future studies should adopt standardized methodologies and include interdisciplinary collaboration to produce more consistent and reliable insights.

Conclusion

The purpose of this review was to evaluate complications associated with the two main skeletal expansion methods in adults, providing clinicians with guidance for evidence-based treatment planning. Despite the heterogeneity of existing literature, several conclusions can be drawn:

- Patient age is decisive: as age increases, reliance on SARPE rather than MARPE becomes necessary for predictable success.
- Adjunctive techniques matter: weakening the midpalatal suture via corticopunctures, when combined with MARPE or SARPE, reduces buccal tipping; spontaneous correction often follows during retention.
- Severe dental complications are rare with SARPE, but their likelihood rises with surgical invasiveness.
- Dentoalveolar risks can be minimized by using devices independent of dental anchorage.
- Appliance design remains crucial: poor design increases inflammation, which is the leading cause of miniscrew failure.

Clinicians should ensure patients are fully informed about risks and alternatives for both methods. Yoon *et al.* [67] provided a comprehensive informed consent model for MARPE, but no comparable guideline yet exists for SARPE. Moving forward, standardized treatment protocols combining skeletal anchorage with minimally invasive surgery are needed to enhance predictability while minimizing complications.

Acknowledgments: None

Conflict of interest: None

Financial support: None

Ethics statement: None

References

1. da Silva Filho OG, Santamaria M Jr, Capelozza Filho L. Epidemiology of posterior crossbite in the primary dentition. J Clin Pediatr Dent. 2007;32:73–8.
2. Bucci R, D'Antò V, Rongo R, Valletta R, Martina R, Michelotti A. Dental and skeletal effects of palatal expansion techniques: a systematic review of the current evidence from systematic reviews and meta-analyses. J Oral Rehabil. 2016;43:543–64.
3. Smalley WM, Shapiro PA, Hohl TH, Kokich VG, Brånemark PI. Osseointegrated titanium implants for maxillofacial protraction in monkeys. Am J Orthod Dentofacial Orthop. 1988;94:285–95.
4. Landes CA, Laudemann K, Petruchin O, Mack MG, Kopp S, Ludwig B, et al. Comparison of bipartite versus tripartite osteotomy for maxillary transversal expansion using 3-dimensional preoperative and postexpansion computed tomography data. J Oral Maxillofac Surg. 2009;67:2287–301.

5. Bays A, Karadede I, Hekimoglu S, Ucar F, Ozer T, Veli I, et al. Evaluation of root resorption following rapid maxillary expansion using cone-beam computed tomography. Angle Orthod. 2012;82:488–94.
6. Shayani A, Merino-Gerlach MA, Garay-Carrasco IA, Navarro-Cáceres PE, Sandoval-Vidal HP. Midpalatal suture maturation stage in 10- to 25-year-olds using cone-beam computed tomography—a cross-sectional study. Diagnostics. 2023;13:1449.
7. Yang P, Zhu M, Guo Y, Su C, Wang Y, Bai Y, et al. Evaluation of midpalatal suture maturation stage in 5- to 20-year-olds using cone-beam computed tomography. Am J Orthod Dentofacial Orthop. 2024;166:572–82.
8. Angelieri F, Cevidanes LH, Franchi L, Gonçalves JR, Benavides E, McNamara JA Jr. Midpalatal suture maturation: classification method for individual assessment before rapid maxillary expansion. Am J Orthod Dentofacial Orthop. 2013;144:759–69.
9. Bays RA, Greco JM. Surgically assisted rapid palatal expansion: an outpatient technique with long-term stability. J Oral Maxillofac Surg. 1992;50:110–13.
10. Magnusson A. Evaluation of surgically assisted rapid maxillary expansion and orthodontic treatment. Effects on dental, skeletal and nasal structures and rhinological findings. Swed Dent J Suppl. 2013;229:1–104.
11. Timms DJ, Vero D. The relationship of rapid maxillary expansion to surgery with special reference to midpalatal synostosis. Br J Oral Surg. 1981;19:180–96.
12. Glassman AS, Nahigian SJ, Medway JM, Aronowitz HI. Conservative surgical orthodontic adult rapid palatal expansion: sixteen cases. Am J Orthod. 1984;86:207–13.
13. Bell WH, Epker BN. Surgical-orthodontic expansion of the maxilla. Am J Orthod. 1976;70:517–28.
14. Morselli PG. Surgical maxillary expansion: a new minimally invasive technique. J Craniomaxillofac Surg. 1997;25:80–84.
15. Lindorf HH, Müller-Herzog R. Die chirurgisch gesteuerte maxillare expansion (GME) durch selektive Schwachung der Gesichtspfeiler. Zahnheilkd Manag Kult. 2006;22:6–18.
16. Haas OJ Jr, Matje PRB, Rosa BM, Rojo-Sanchis C, Guijarro-Martínez R, Valls-Ontañón A, et al. Minimally invasive surgical and miniscrew-assisted rapid palatal expansion (MISMARPE) in adult patients. J Craniomaxillofac Surg. 2022;50:211–17.
17. Mommaerts MY. Transpalatal distraction as a method of maxillary expansion. Br J Oral Maxillofac Surg. 1999;37:268–72.
18. Kraut RA. Surgically assisted rapid maxillary expansion by opening the midpalatal suture. J Oral Maxillofac Surg. 1984;42:651–55.
19. Messer EJ, Bollinger TE, Keller JJ. Surgical-mechanical maxillary expansion. Quintessence Int. 1979;10:13–16.
20. Pogrel MA, Kaban LB, Vargervik K, Baumrind S. Surgically assisted rapid maxillary expansion in adults. Int J Adult Orthodon Orthognath Surg. 1992;7:37–41.
21. Mehra P, Cottrell DA, Caiazzo A, Lincoln R. Life-threatening, delayed epistaxis after surgically assisted rapid palatal expansion: a case report. J Oral Maxillofac Surg. 1999;57:201–4.
22. Suri L, Taneja P. Surgically assisted rapid palatal expansion: a literature review. Am J Orthod Dentofacial Orthop. 2008;133:290–302.
23. Benetti M, Montresor L, Cantarella D, Zerman N, Spinas E. Does miniscrew-assisted rapid palatal expansion influence upper airway in adult patients? A scoping review. Dent J. 2024;12:60.
24. Lee RJ, Moon W, Hong C. Effects of monocortical and bicortical mini-implant anchorage on bone-borne palatal expansion using finite element analysis. Am J Orthod Dentofacial Orthop. 2017;151:887–97.
25. Cantarella D, Dominguez-Mompell R, Mallya SM, Moschik C, Pan HC, Miller J, et al. Changes in the midpalatal and pterygopalatine sutures induced by micro-implant-supported skeletal expander, analyzed with a novel 3D method based on CBCT imaging. Prog Orthod. 2017;18:34.
26. Choi SH, Shi KK, Cha JY, Park YC, Lee KJ. Nonsurgical miniscrew-assisted rapid maxillary expansion results in acceptable stability in young adults. Angle Orthod. 2016;86:713–20.
27. Yildirim M, Akin M. Comparison of root resorption after bone-borne and tooth-borne rapid maxillary expansion evaluated with the use of microtomography. Am J Orthod Dentofacial Orthop. 2019;155:182–90.
28. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, Moher D, Peters MD, et al. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. Ann Intern Med. 2018;169:467–73.

29. PRISMA. Available from: https://www.prisma-statement.org/scoping (accessed 30 Nov 2024).
30. Abate A, Lanteri V, Marcolongo L, Solimei L, Maspero C. Evaluation of masticatory muscles in adult patients with maxillary hypoplasia treated with surgically assisted rapid maxillary expansion (SARME): a retrospective study. J Clin Med. 2023;12:607.
31. Al-Ouf K, Krenkel C, Hajeer MY, Sakka S. Osteogenic uni- or bilateral form of the guided rapid maxillary expansion. J Craniomaxillofac Surg. 2010;38:160–65.
32. Basu S, Goje SK. Comparative evaluation of skeletal and dental effects of mini-implant assisted and corticopuncture-facilitated rapid palatal expansion in adults: a randomized clinical study. J Datta Meghe Inst Med Sci Univ. 2023;18:629–42.
33. Choi EA, Lee KJ, Choi SH, Jung HD, Ahn HJ, Deguchi T, et al. Skeletal and dentoalveolar effects of miniscrew-assisted rapid palatal expansion based on the length of the miniscrew: a randomized clinical trial. Angle Orthod. 2023;93:390–97.
34. Contar CM, Muller PR, Brunetto AR, Machado MA, Rappoport A. Surgical treatment of maxillary transverse deficiency: retrospective study of 14 patients. J Maxillofac Oral Surg. 2009;8:249–53.
35. Daif ET. Segment tilting associated with surgically assisted rapid maxillary expansion. Int J Oral Maxillofac Surg. 2014;43:311–15.
36. Drobyshev A, Klipa I, Drobysheva N, Ilina N, Zhmyrko I. Surgically assisted rapid maxillary expansion: retrospective analysis of complications 2012–2017. Georgian Med News. 2021;311:58–62.
37. Fernández-Sanromán J, Donascimento MG, López AC, Ferro MF, Berrondo IA. Transverse maxillary distraction in patients with periodontal pathology or insufficient tooth anchorage using custom-made devices. J Oral Maxillofac Surg. 2010;68:1530–36.
38. Goldenberg DC, Alonso N, Goldenberg FC, Gebrin ES, Amaral TS, Scanavini MA, et al. Using computed tomography to evaluate maxillary changes after surgically assisted rapid palatal expansion. J Craniofac Surg. 2007;18:302–11.
39. Günbay T, Akay MC, Günbay S, Aras A, Koyuncu BO, Sezer B. Transpalatal distraction using bone-borne distractor: clinical observations and dental and skeletal changes. J Oral Maxillofac Surg. 2008;66:2503–14.
40. Karabiber G, Yılmaz HN, Nevzatoğlu Ş, Uğurlu F, Akdoğan T. Three-dimensional evaluation of surgically assisted asymmetric rapid maxillary expansion. Am J Orthod Dentofacial Orthop. 2019;155:620–31.
41. Kayalar E, Schauseil M, Kuvat SV, Emekli U, Fıratlı S. Comparison of tooth-borne and hybrid devices in surgically assisted rapid maxillary expansion: a randomized clinical cone-beam computed tomography study. J Cranio Maxillofac Surg. 2016;44:285–93.
42. Leyder P, Altounian G, Quilichini J. Adjustable selective maxillary expansion combined with one-stage maxillomandibular surgery: a prospective study of osseous widening in fifty-five consecutive patients. J Cranio Maxillofac Surg. 2018;46:1408–20.
43. Lim HM, Park YC, Lee KJ, Kim KH, Choi YJ. Stability of dental, alveolar, and skeletal changes after miniscrew-assisted rapid palatal expansion. Korean J Orthod. 2017;47:313–22.
44. Pereira MD, Koga AF, Prado GPR, Ferreira LM. Complications from surgically assisted rapid maxillary expansion with HAAS and HYRAX expanders. J Craniofac Surg. 2018;29:275–8.
45. Ploder O, Winsauer H, Juengling K, Grill F, Bissinger O, Wolff KD, Kolk A. Is there a significant difference in relapse and complication rate of surgically assisted rapid palatal expansion using tooth-borne, bone-borne, and orthodontic mini-implant-borne appliances? J Oral Maxillofac Surg. 2021;79:213–24.
46. Rachmiel A, Turgeman S, Shilo D, Emodi O, Aizenbud D. Surgically assisted rapid palatal expansion to correct maxillary transverse deficiency. Ann Maxillofac Surg. 2020;10:136–41.
47. Sant'Ana LF, Pinzan-Vercelino CR, Gurgel JA, Carvalho PS. Evaluation of surgically assisted rapid maxillary expansion with and without midpalatal split. Int J Oral Maxillofac Surg. 2016;45:997–1001.
48. Seeberger R, Abe-Nickler D, Hoffmann J, Kunzmann K, Zingler S. One-stage tooth-borne distraction versus two stage bone-borne distraction in surgically assisted maxillary expansion (SARME). Oral Surg Oral Med Oral Pathol Oral Radiol. 2015;120:693–8.
49. Sendyk M, Sendyk WR, Pallos D, Boaro LCC, Paiva JB, Rino Neto J. Periodontal clinical evaluation before and after surgically assisted rapid maxillary expansion. Dent Press J Orthod. 2018;23:79–86.
50. Smeets M, Da Costa Senior O, Eman S, Politis C. A retrospective analysis of the complication rate after SARPE in 111 cases, and its relationship to patient age at surgery. J Cranio Maxillofac Surg. 2020;48:467–71.

51. Sygouros A, Motro M, Ugurlu F, Acar A. Surgically assisted rapid maxillary expansion: cone-beam computed tomography evaluation of different surgical techniques and their effects on the maxillary dentoskeletal complex. Am J Orthod Dentofacial Orthop. 2014;146:748–57.
52. Wang C, Liu C, Mao Q, Zhou L, Xiang X. Skeletal and dentoalveolar modifications in adults with different sagittal facial patterns after personalized miniscrew-assisted rapid palatal expansion: a prospective cone-beam computed tomography study. Am J Orthod Dentofacial Orthop. 2023;164:843–54.
53. Williams BJ, Currimbhoy S, Silva A, O'Ryan FS. Complications following surgically assisted rapid palatal expansion: a retrospective cohort study. J Oral Maxillofac Surg. 2012;70:2394–402.
54. Winsauer H, Walter A, Katsaros C, Ploder O. 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.
55. Yoon A, Guilleminault C, Zaghi S, Liu SY. Distraction osteogenesis maxillary expansion (DOME) for adult obstructive sleep apnea patients with narrow maxilla and nasal floor. Sleep Med. 2020;65:172–6.
56. Ning R, Chen J, Liu S, Lu Y. Treatment effects after maxillary expansion using tooth-borne vs tissue-borne miniscrew-assisted rapid palatal expansion appliance. Am J Orthod Dentofacial Orthop. 2023;164:545–53.
57. Cozzani M, Nucci L, Lupini D, Tripodi D, Noori N, Hasani M, Jamilian A. Two different designs of mini-screw assisted maxillary expanders, using FEM to analyse stress distribution in craniofacial structures and anchor teeth. Int Orthod. 2022;20:100607.
58. Lin L, Ahn HW, Kim SJ, Moon SC, Kim SH, Nelson G. Tooth-borne vs bone-borne rapid maxillary expanders in late adolescence. Angle Orthod. 2015;85:253–62.
59. Bi WG, Li K. Effectiveness of miniscrew-assisted rapid maxillary expansion: a systematic review and meta-analysis. Clin Oral Investig. 2022;26:4509–23.
60. Alcin R, Malkoç S. Does mini-implant-supported rapid maxillary expansion cause less root resorption than traditional approaches? A micro-computed tomography study. Korean J Orthod. 2021;51:241–9.
61. Verdecchia A, Suárez-Fernández C, Miquel A, Bardini G, Spinas E. Biological effects of orthodontic tooth movement on the periodontium in regenerated bone defects: a scoping review. Dent J. 2024;12:50.
62. Cantarella D, Dominguez-Mompell R, Moschik C, Mallya SM, Pan HC, Alkahtani MR, Elkenawy I, Moon W. Midfacial changes in the coronal plane induced by microimplant-supported skeletal expander, studied with cone-beam computed tomography images. Am J Orthod Dentofacial Orthop. 2018;154:337–45.
63. Dergin G, Aktop S, Varol A, Ugurlu F, Garip H. Complications related to surgically assisted rapid palatal expansion. Oral Surg Oral Med Oral Pathol Oral Radiol. 2015;119:601–7.
64. Carvalho PHA, Moura LB, Trento GS, Holzinger D, Gabrielli MAC, Gabrielli MFR, Pereira Filho VA. Surgically assisted rapid maxillary expansion: a systematic review of complications. Int J Oral Maxillofac Surg. 2020;49:325–32.
65. Kim KA, Oh SH, Kim BH, Kim SJ. Asymmetric nasomaxillary expansion induced by tooth-bone-borne expander producing differential craniofacial changes. Orthod Craniofac Res. 2019;22:296–303.
66. Park JJ, Park YC, Lee KJ, Cha JY, Tahk JH, Choi YJ. Skeletal and dentoalveolar changes after miniscrew-assisted rapid palatal expansion in young adults: a cone-beam computed tomography study. Korean J Orthod. 2017;47:77–86.
67. Yoon A, Payne J, Suh H, Phi L, Chan A, Oh H. A retrospective analysis of the complications associated with miniscrew-assisted rapid palatal expansion. AJO-DO Clin Companion. 2022;2:423–30.
68. Oliveira CB, Ayub P, Angelieri F, Murata WH, Suzuki SS, Ravelli DB, Santos-Pinto A. Evaluation of factors related to the success of miniscrew-assisted rapid palatal expansion. Angle Orthod. 2021;91:187–94.
69. Hamedi Sangsari A, Sadr-Eshkevari P, Al-Dam A, Friedrich RE, Freymiller E, Rashad A. Surgically assisted rapid palatomaxillary expansion with or without pterygomaxillary disjunction: a systematic review and meta-analysis. J Oral Maxillofac Surg. 2016;74:338–48.
70. Bud ES, Bică CI, Păcurar M, Vaida P, Vlasa A, Martha K, Bud A. Observational study regarding possible side effects of miniscrew-assisted rapid palatal expander (MARPE) with or without the use of corticopuncture therapy. Biology. 2021;10:187.
71. Chamberland S. Maxillary expansion in nongrowing patients. Conventional, surgical, or miniscrew-assisted, an update. J World Fed Orthod. 2023;12:173–83.
72. Baik HS, Kang YG, Choi YJ. Miniscrew-assisted rapid palatal expansion: a review of recent reports. J World Fed Orthod. 2020;9:S54–S58.

73. Kapetanović A, Odrosslij BMMJ, Baan F, Bergé SJ, Noverraz RRM, Schols JGJH, Xi T. Efficacy of miniscrew-assisted rapid palatal expansion (MARPE) in late adolescents and adults with the Dutch Maxillary Expansion Device: a prospective clinical cohort study. Clin Oral Investig. 2022;26:6253–63.
74. Peters MDJ, Godfrey C, McInerney P, Khalil H, Larsen P, Marnie C, et al. Best practice guidance and reporting items for the development of scoping review protocols. JBI Evid Synth. 2022;20:953–68.