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Unwanted craniofacial fractures in MARPE/MASPE patients: a hidden risk?

Andre Walter^{1*}, Heinz Winsauer², Eduardo Crespo³, Ignacio Arcos¹, Adaia Valls-Ontañón⁴, Andreu Puigdollers -Perez^{1,5} and Federico Hernández-Alfaro^{4,6}

Abstract

Background Miniscrew-assisted palatal expansion techniques such as MARPE (Miniscrew-Assisted Rapid Palatal Expansion) and MASPE (Miniscrew-Assisted Slow Palatal Expansion) represents non-surgical alternatives for the correction of transverse maxillary deficiencies in adults. However, concerns have arisen regarding their potential to cause craniofacial complications due to the high forces applied for midpalatal suture opening in skeletally mature patients.

Methodology This article aims to present and describe isolated clinical cases of craniofacial complications observed in adult patients following MARPE and MASPE procedures, and to discuss the potential biomechanical mechanisms behind these events. Eleven clinical cases involving adult patients who underwent skeletal midface expansion with miniscrew-assisted devices are presented. All cases exhibited craniofacial unwanted dislocations identified through CBCT imaging, including zygomatic fractures, parasutural bone fractures, and asymmetrical disjunction of craniofacial sutures. These events were retrospectively documented through clinical follow-up and radiographic analysis.

Results Among the eleven cases presented, complications included seven asymmetric fractures of the frontonasal process, two orbital fractures, one zygomatic bone fracture, and one parasagittal fracture of the palatine bone. These complications were primarily observed in patients who underwent MARPE with rapid activation protocols. One minor complication occurred in a MASPE case, where the patient followed the prescribed slow activation schedule.

Conclusion Non surgical mid facial expansion is a potential source of unwanted and unpredicted dislocations in the craniofacial complex. According to this report the observed complications do not seem to be age related and are difficult to predict from the CBCT. A close clinical follow up including force monitoring and force limitation should be mandatory when performing MARPE. MASPE and minimally invasive SARPE could be alternatives to minimise the incidence of craniofacial complications.

Keywords MARPE, MASPE, SARPE, Miniscrews, Expansion, Cranial fractures

*Correspondence:

Andre Walter
andy@clinicawalter.com

¹Department of Orthodontics, Universitat Internacional de Catalunya, Barcelona, Spain

²Private Orthodontic Practice, Bregenz, Austria

³Private Orthodontic Practice, Santo Domingo, Dominican Republic

⁴Department of Maxillofacial Surgery, Universitat Internacional de Catalunya, Barcelona, Spain

⁵Chief of the Orthodontic department, Universitat Internacional de Catalunya, Barcelona, Spain

⁶Chief of the Maxillofacial department, Universitat Internacional de Catalunya, Barcelona, Spain

Introduction

Skeletal expansion of the maxilla in adult patients has become increasingly common due to the development of miniscrew-assisted devices, particularly MARPE (Miniscrew-Assisted Rapid Palatal Expansion) [1, 2]. This technique enables orthopedic disjunction of the midpalatal suture using four or more palatal mini-implants (OMIs) and reduces the likelihood of the need for surgically assisted rapid palatal expansion (SARPE) in many cases.

Despite its advantages, MARPE is not free of complications. High expansion forces are required to overcome resistance from ossified sutures and surrounding craniofacial structures in skeletally mature patients, increasing the risk of both soft tissue and skeletal complications [3, 4]. Documented issues include mini-implant failure, palatal mucosal trauma, bleeding, and deformation of the appliance under stress [5–7].

Of particular concern is the potential for deeper cranial involvement [8]. Finite element analysis (FEA) studies have shown that during expansion [9], forces as high as 100 N [10] can be transmitted to circummaxillary and cranial base structures, such as the zygomatic arch, infra-orbital rim, and pterygoid processes of the sphenoid bone [11–13]. These areas may act as unintended stress zones, particularly in cases of rapid expansion where the force is applied too abruptly. The dorsum sellae, sella turcica, and superior orbital fissure have been identified as zones of elevated strain, raising concerns about possible iatrogenic injury [13].

It is essential to distinguish between diastasis and fracture. Diastasis refers to an abnormal separation of a suture or synchondrosis without cortical bone disruption, representing a physiological or mechanically induced disjunction of craniofacial articulations when forces are properly controlled. By contrast, under excessive or misdirected loading, this separation may evolve into a fracture. A fracture implies discontinuity of cortical and trabecular bone, usually accompanied by irregular margins, displacement of bone segments, and potential soft tissue compromise. In the context of palatal expansion, diastasis constitutes the intended orthopedic outcome, whereas uncontrolled forces produce unintended fractures of adjacent craniofacial structures.

The aim of the present article is to address a currently underreported aspect of clinical practice by presenting cases in which cranial complications (diastasis and fractures) were observed following MARPE or MASPE (Miniscrew-Assisted Slow Palatal Expansion) procedures [4, 14]. These case reports illustrate the potential biomechanical consequences of applying excessive force in skeletally mature patients—particularly when such force is applied over too short a time span—and highlight the need for standardized force monitoring, force-limiting

protocols, and careful CBCT-based diagnostics during treatment planning and follow-up [15].

Materials and methods

This article reports isolated clinical cases of adult patients who developed cranial complications following miniscrew-assisted maxillary expansion procedures. These cases were retrospectively identified from private orthodontic and surgical practices with more than ten years of clinical experience in skeletal expansion techniques, including MARPE (Miniscrew-Assisted Rapid Palatal Expansion) [14] and MASPE (Miniscrew-Assisted Slow Palatal Expansion) [4, 7].

Case selection was based on the presence of post-treatment cranial findings considered clinically relevant. No formal inclusion or exclusion criteria were established, as the objective was to document incidental observational findings gathered across various real-world clinical settings since 2013. Due to the descriptive and retrospective nature of these isolated cases, formal approval from an Ethics Committee was not deemed necessary. Human ethics approval and informed consent for this paper are not applicable. Nonetheless, all procedures conformed to the ethical principles of the Declaration of Helsinki, and strict confidentiality was maintained for all patients involved. Importantly, adverse findings were observed in some cases; in accordance with the Declaration of Helsinki, such negative or unexpected outcomes must also be reported and made accessible to the scientific community available to ensure transparency and uphold ethical standards in medical research.

All patients underwent skeletal maxillary expansion for the correction of transverse maxillary deficiency. The appliances used were either bone-borne or hybrid skeletal expanders supported by four orthodontic mini-implants placed in the palatal vault. Activation protocols varied by technique:

- MARPE cases followed a conventional rapid expansion protocol of two activations per day.
- MASPE cases followed the Force-Controlled Polycyclic Protocol (FCPC), which involves alternating activation and deactivation cycles over a period of 3–6 months, maintaining torque wrench forces below 500 cN.

Results

A total of twelve cases were analyzed, with a mean patient age of 30.2 ± 9.7 years. Of these, ten were female and two were male. The documented complications and their respective severity are summarized in Table 1.

MARPE cases: Six patients exhibited asymmetric disjunction involving the frontonasal process of the maxilla (diastasis), defined as a transverse discrepancy greater

Table 1 Clinical history, findings, and radiographic features of the eleven documented fractures

Case	Age/sex	Technique used	Activation protocol (FCPC)	Key clinical findings	Radiographic findings	Time of onset	Outcome
1	36/F	MARPE Micro4-expander	2 turns day	Unilateral frontal pain Nasal asymmetry, maxilla unilateral opening, low transient diplopia?	Assymetric Fronto-nasal suture diastasis (fracture), asymmetry of 4 mm on the left side on CBCT, unilateral and assymetric maxilla suture opening	3rd week post-activation	Partial resolution after 2 months, no surgery needed
2	23/F	MARPE MSE-expander	3 turns day	Nasal asymmetry with esthetics compromise, maxilla unilateral opening	Aassymetric Fronto-nasal suture asymmetry diastaisi (4 mm) right side, Unilateral maxilla opening, Previous cranial asymmetry with mandible deviation of 4 mm	3rd week post-activation	Partial resolution after 3 months, no orthognatic surgery needed
3	36/F	MARPE Hybrid Skeletal expander with 4 miniscrews	2 turns day	Left mild facial asymmetry	Left zygoma fracture and Orbital rim, no infraorbital paresthesia	Day 18 post-activation	Stable, interruption of treatment, no surgery needed
4	34/F	MASPE Micro4-expander	FCPC-protocol	None, tear bone explanation by patient comments after 3 months of activations	Left posterior paramedian palatal bone fracture (2-3 mm), previous cranial asymmetry with mandible 4 mm right	Day 98 post activation Rutine control	Asintomatic, casual finding by CBCT control, end of treatment. No orthognatic surgery needed
5	16/F	MARPE Hybrid Skeletal Power-expander	2 turns day	Widening of the nose &telecanthus	Bilateral frontonasal diastasis of 5 mm, fracture	Day 20 post activation	Rhinoplasty pending
6	21/F	MARPE Hybrid Skeletal Power-expander	2 turns day	Orbital dystopia, Diplopia, epiphora (tearing)	Assymetric sutural opening, Unilateral orbital dislocation or diastasis, fracture (4 mm)	Day 26 post activation	Orbital dystopia
7	38/F	MARPE Hybrid Skeletal Power-expander	2 turns day	Orbital dystopia, diplopia, epiphora (tearing)	Unilateral orbital & frontonasal suture opening with diastasis (fracture)	Day 26 post activation	orbital dystopia
8	19/F	MARPE Hybrid Skeletal Power-expander	2 turns day	SYMMETRIC widening root of the nose, simetric suture opening	Bilateral frontonasal suture opening with diastasis, fracture, (3 mm bilateral)	Day 17 post activation	Rhinoplasty pending
9	32/F	MARPE Hybrid Skeletal Power-expander	1 turns day	Asymmetric widening of the nose, Epiphora (tearing)	Unilateral fronto-nasal diastasis, fracture (5 mm)	Day 28 post activation	Rhinoplasty pending
10	33/M	MARPE Hybrid Skeletal Power-expander	2 turns day	symmetric widening of the nose	Bilateral fronto-nasal diastasis, fracture (3 and 4 mm)	Not stated	Rhinoplasty pending
11	25/M	MARPE Hybrid Skeletal expander	2 turns day	symmetric widening of the nose	Bilateral fronto-nasal diastasis, fracture (3 and 3 mm)	Day 22 post-activation	Rhinoplasty pending
12	50/F	MARPE Hybrid Skeletal expander	1–2 turns day	Numbness of infra-orbital nerv	Right zygomaticomaxillary suture diastasis, fracture (3-4 mm)	4th week postactivation	Stable, interruption of treatment, no surgery needed. Numbness for 6 weeks. No surgery needed

than 3 mm between the hemimaxillae [17]. One patient sustained a zygomatic bone fracture, two cases presented with orbital fractures (diastasis) and one presented zygomaticomaxillary diastasis.

MASPE case: A single complication was observed, consisting of a parasagittal fracture of the horizontal plate of the palatine bone. This was an asymptomatic, incidental radiographic CBCT finding.

All cases were symptomatic to varying degrees, presenting with mild to severe clinical signs; however, none required emergency surgical intervention.

Of the twelve cranial complication cases presented in Table 1, imaging CBCT is available for seven patients (Figs. 1 and 2). This limitation arises because three of the cases are currently involved in legal proceedings, and

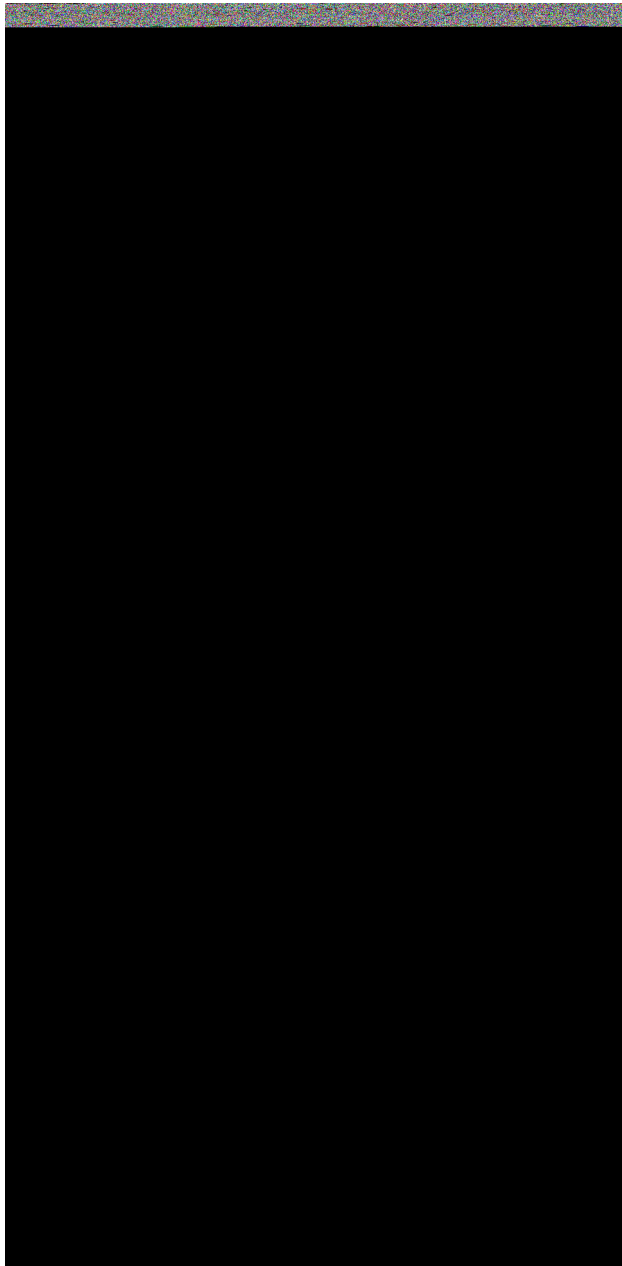


Fig. 1 Cranial complications observed in MARPE CBCTs cases with rapid activation protocols. (Red arrows indicate fracture lines; while the red line indicates the expander inclination). **a.** Asymmetric left maxillary opening > 3 mm with frontonasal and orbital fractures; note inclined jackscrew. **b.** Asymmetric right maxillary opening > 3 mm with frontonasal diastasis (fracture) and inclined jackscrew. **c.** Right frontonasal suture diastasis (fracture) > 4 mm associated with jackscrew inclination

their legal representatives have declined to release clinical documentation or radiographic images for review. However, the total number of patients treated by the corresponding clinicians is unknown, making it impossible to calculate a complication rate for this subgroup.

For the remaining cases, which were treated by four other orthodontists, less clinical information was available or could not be retrieved. Additionally, data from the Maxillofacial Surgery Department at Teknon Medical Center (Barcelona) were also collected.

From the records provided by the five contributors, information was obtained regarding adult patients treated with non-surgical maxillary expansion. However, the exact number of individuals who underwent MARPE and MASPE could not be determined, as the data were derived from interviews with the orthodontists who reported cranial fracture cases rather than from systematic registries.

As a result, only the presence of cranial complications could be confirmed and documented, while the total number of treated cases remains uncertain. This limitation prevents the calculation of reliable complication rates and should be considered when interpreting the findings.

Discussion

The Miniscrew-Assisted Rapid Palatal Expansion (MARPE) technique has proven effective in achieving midpalatal suture opening in many adult patients without the need for surgery; however, it is most commonly applied in adolescents and young adults [14, 18]. In mature patients—particularly those over the age of 33—success rates decline significantly due to increased cranial stiffness, progressive interlocking of the circummaxillary sutures, and suture ossification [4, 19]. In this age group, the success rate of midpalatal suture opening using skeletal expanders drops to approximately 50%, with a higher incidence of complications related to both hardware and patient-specific factors [4].

Therefore, although MARPE represents a valuable non-surgical alternative to Surgically Assisted Rapid Palatal Expansion (SARPE), this study—along with prior reports—suggests that uncontrolled activation protocols in skeletally mature patients may lead to rare but clinically significant cranial complications [18, 20–22]. SARPE, by contrast, involves corticotomy and pterygo-maxillary disjunction [23], which preemptively release areas of skeletal resistance [24, 25], allowing real maxillary—no mid face-expansion, as well as simultaneous maxillary protraction if needed [26]. This explains why SARPE rarely results in cranial bone injury [25]. Nonetheless, although complications are less common, they may still occur depending on the surgical technique and patient-specific anatomical factors, such as nerve

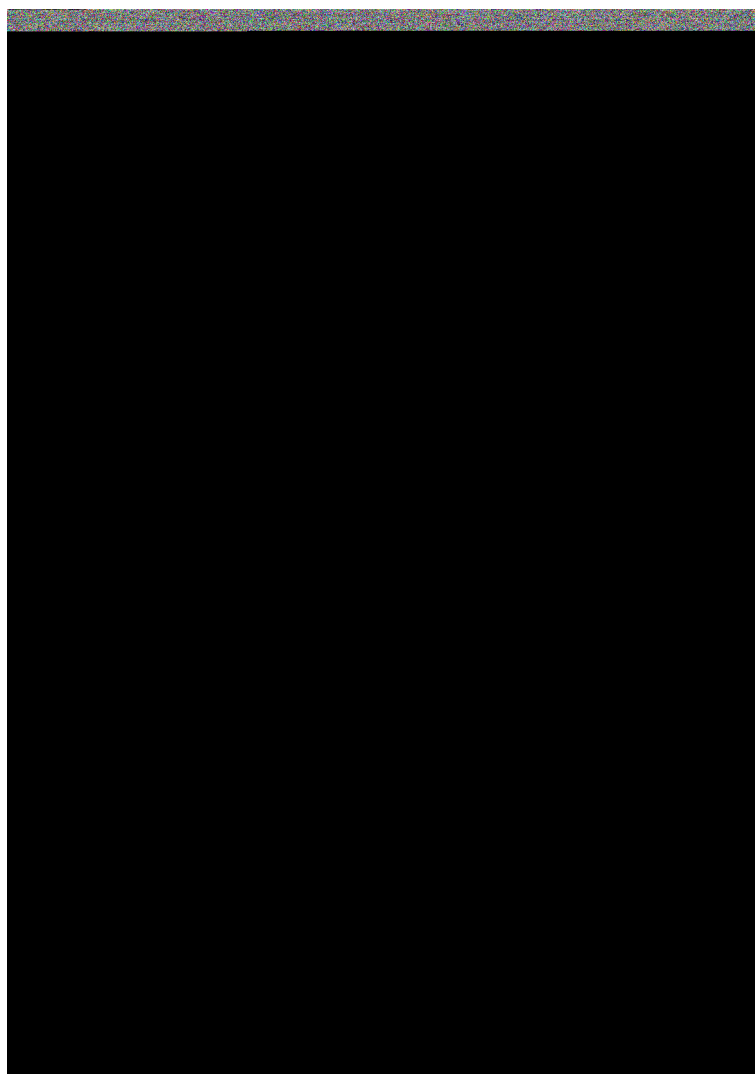


Fig. 2 Craniofacial fractures associated with MARPE and MASPE. **a.** Frontal facial view showing bilateral frontonasal diastasis (fracture) in a MARPE case. **b.** Frontal facial view showing left frontonasal diastasis (fracture) in a MARPE case. **c.** Axial CBCT view showing a left frontonasal diastasis (fracture) in a MARPE case (red arrow). **d.** Axial CBCT image showing an asymptomatic left posterior palatal bone fracture associated with MASPE using the FCPC ultra-slow expansion protocol, detected during routine radiographic follow-up (red arrow). **e, f.** Coronal and axial CBCT views showing a left zygomatic bone fracture in a MARPE case (red arrows). **g.** Frontal CBCT images showing a left zygomatic bone fracture in a MARPE case. **h.** Diastasis (fracture) of the right zygomaticomaxillary suture

paresthesias, maxillary canting, asymmetrical maxilla opening greater than 3 mm and dental side effects [27].

CBCT (Cone-Beam Computed Tomography) has recently been validated as an effective tool for evaluating clinical bone and dental landmarks, as well as measuring changes in the widths of midpalatal and circummaxillary sutures [16, 28]. Despite ongoing discussion, the risk of cranial base fractures associated with skeletal expansion remains unconfirmed. To date, only one case of cranial complication associated with MARPE has been officially reported in the literature [29]. This remarkably low number may be attributed to professional discretion, under-reporting, or commercial motivations.

It has been reported that conventional tooth-borne palatal expanders and skeletal expanders, during their expansion, produced cranial base deformations in the pterygoid process of the sphenoid bone, with lateral deformations around 2 mm per side [12]. The authors suggest that the pterygoid process should be surgically sectioned in narrow maxilla cases with SARPE [11, 12, 23]. Similarly, finite element studies on skeletal expanders with additional molar anchorage incorporated into their design (such as hybrid skeletal expanders) show higher cantilever arms on the pterygoid process, increasing the risk of deformations in the process [30, 31]. Although no basal cranial fractures have been reported to date, deformations of the pterygoid processes have been identified

through CBCT imaging, particularly in cases treated with the MARPE/ MASPE technique [32]. In the Cantarella study [32], pterygoid deformations ranged from 1.35 to 2.17 mm per side, whereas another MARPE/ MASPE investigation reported deformations between the pterygoid processes of 0.87–1.35 mm (approximately 0.44–0.68 mm per side) [16]. Taken together, these findings demonstrate that maxillary expansion has a measurable impact on midcranial structures, and the observed changes in the pterygoid processes suggest that activations should be performed in a more controlled manner, with a gradual and carefully managed opening of the palatal suture post-split, supported by updated and individualized protocols.

However, isolated cases of infraorbital nerve numbness and temporary hearing loss have also been documented following MARPE treatment (Table 1, patient 12) [20]. Most of the reported complications are localized to the maxillary region, frequently manifesting as asymmetric opening of the maxillary halves [33] (Fig. 1a–c), a pattern that closely resembles the asymmetric cranial complications occasionally observed in SARPE procedures [34]. Therefore, pre-existing skeletal nasomaxillary asymmetry is considered of a high risk procedure induced by MARPE when the chin deviation is greater than 3 mm or the initial asymmetric position of the midpalatal suture are greater than 1 mm [35]. In the above mentioned study a high rate of asymmetric expansion was found in 46.9% of the treated MARPE cases [35].

Expansion forces on cranial structures and force-controlled protocol justification: safety first

Finite element studies have shown that during MARPE activations, expansion forces are transmitted to deep craniofacial structures, including the pterygoid processes, while the zygomatic arch offers substantial resistance to midpalatal suture opening [9, 36]. This biomechanical behavior is especially pronounced in adult skulls, where sutural elasticity is significantly diminished, leading to increased stress concentrations across the cranial base and facial skeleton [8, 9, 32, 36]. Isaacson's clinical findings further support this trend, demonstrating that as patient age increases, greater expansion forces are required to achieve midpalatal suture opening, with corresponding rises in force peaks and stress levels observed in older adolescents—reaching values as high as 100 N [10].

These expansive forces, recorded by a measuring machine, progressively decreased in intensity over time between activations, suggesting a gradual adaptive absorption of the expansion forces by the surrounding tissues. However, when generated rapidly and without control of the applied force—and in the context of uncontrolled variations in expander design—these stress

patterns may contribute to localized bone overload and cranial complications, such as asymmetric openings, particularly when post-split activation protocols are not precisely managed (Table 1).

We believe that reducing the rate of activation and spacing the turns of skeletal expanders over a longer period of time may help decrease cranial stress, since the greatest number of complications has been observed around the third week of activation (Table 1).

During mechanical expansion of the midface using skeletal expanders, forces primarily affect the lower midfacial structures, such as the maxilla and palatal bone, but also propagate to more distant craniofacial components, including the frontonasal sutures (Figs. 1 and 2a–c) and the zygomatic bone [8, 9, 36]. Von Mises stress simulations involving molar-anchored expanders have demonstrated particularly high stress concentrations in the zygomatic arch, attributable to its mechanical resistance to maxillary displacement in adult patients with increased cranial stiffness [13]. Clinically, this may present—as illustrated in Fig. 2e–h—as unilateral zygomatic fractures, with the risk significantly heightened by the accumulation of stress through excessive or uncontrolled activation of skeletal expanders [37]. Therefore, the availability of an instrument to measure applied activations, together with continuous monitoring of torque values by both clinician and patient, may greatly contribute to reducing cranial complications [4, 6, 7]. In this regard, we believe that future developments by manufacturers should incorporate design improvements to ensure better control of activations and expansive forces.

Why force control?

In an in vitro study involving Micro4-expanders [7], activation forces limited to 500 cN generated expansion forces in the range of approximately 100–130 N, aligning with the values reported by Isaacson in a 15-year-old adolescent patient [10]. It is important to note that these results were obtained under idealized laboratory conditions, and actual force values can vary considerably lower depending on the specific design and mechanical properties of the expander used. Key factors such as implant geometry, internal and external thread diameters, neck design, abutment configuration, cantilever arm dimensions, placement site, angulation and improper appliance positioning, as shown in Fig. 2e can all significantly influence the magnitude and direction of the expansion forces [38, 39].

The MARPE technique often employs rapid activation protocols (e.g., 2–3 activations per day over a 2–3 week period) with uncontrolled, progressive expansion in an effort to open the midpalatal suture [14]. This approach increases the potential risk of excessive cranial stress as illustrated in the accompanying Fig. 2 resulting in

asymmetrical nasal (Fig. 2 b,c) or palatal expansion (as observed with the Micro4-expander PowerScrew, Fig. 2d) or zygomatic bone fractures (as observed with Hybrid skeletal expanders placement, Fig. 2e–h). Therefore, as the saying goes, “*what can be measured can be controlled*”; limiting the initial activation force (torque wrench) to 500 cN significantly enhances patient safety, minimizes the risk of iatrogenic complications for the clinician, and reduces the likelihood of expander breakage [7]. With a torque wrench set at 500 cN (corresponding to approximately 100–130 N of expansion force), if no sutural opening occurs after 4 weeks, we recommend proceeding with SARPE. Other protocols, such as those proposed for the MSE-expander, suggest reducing the rate of activation once the suture has opened, thereby providing greater control of maxillary expansion and consequently reducing the risk of cranial complications [14, 32].

The concept of controlled post-split activation expansion and the controlled-force or Force Control approach refer to two different appliances with distinct safety protocols. In this context, the Force Control approach constitutes the first stage and a key feature of the FCPC protocol (Force-Controlled PoliCyclic protocol) [4], ensuring safety in maxillary expansion. In addition, experimental adult animal studies with controlled light forces have demonstrated that continuous forces of 50 g applied over 29 days are effective in promoting midpalatal and midpalatal suture opening—indeed, even more so than intermittent forces [40].

In recent years, the corticotomy of the midpalatal suture has been used to reduce its mechanical resistance by inducing localized inflammation and temporarily decreasing the density of bone and sutural tissue [41]. While this approach facilitates the opening of the midpalatal suture and initially reduces the mechanical demands placed on the expander, it does not affect the adjacent circummaxillary sutures. Consequently, the risk of cranial complications cannot be fully eliminated, as the pterygopalatine and zygomaticomaxillary sutures—which significantly contribute to craniofacial rigidity—remain unaltered by this technique [13, 24, 29]. New microsurgical techniques may be required to facilitate the disruption of these deeper sutural structures in resistant cases.

The role of SARPE

SARPE is aimed at producing pure maxillary expansion through the interruption of the buttresses which connect the maxilla with the rest of the craniofacial structures [42]. Hence it is the only procedure that can produce pure maxillary expansion leaving untouched the rest of craniofacial bones. Cranial complications associated with SARPE and MARPE to date differ significantly in terms of frequency, severity, and underlying mechanisms.

Although SARPE has been associated with rare cases of neurosensory disturbances and cranial nerve injury [34, 43, 44], with the minimally invasive protocol published by the senior author of this paper [45] they are minimized. The rationale behind is that SARPE limits the expansion (and hence the possible complications) to the maxilla. The potential risks of complications in non surgical expansion with MARPE/ MASPE involves the mid face and cranial base since the applied forces are transmitted to those areas through the buttresses. To date only isolated case reports describing visual disturbances or infraorbital nerve hypoesthesia remain anecdotal and lack systematic follow-up or imaging confirmation [20–22].

SARPE, due to its reliance on surgical osteotomies, facilitates maxillary disjunction by reducing structural resistance, and limits the expansion to the maxilla not disturbing any structures above this bone, which in turn significantly decreases the risk of uncontrolled cranial fractures during expansion [46–48]. Although osteotomies carry inherent surgical risks—such as paresthesia or injury to the oculomotor, nasopalatine, and infraorbital nerves [34, 49]—they are unusual if minimally invasive surgical techniques are applied [45]. Moreover, they allow for a more predictable distribution of expansion forces, particularly in adults with increased craniofacial stiffness. In contrast, MARPE avoids osteotomies hence applying forces to all midfacial bones. It relies solely on skeletal anchorage, which, while less invasive, may lead to concentrated transmission of mechanical stress to cranial structures. Isolated complications such as orbital rim fractures have been reported [29]. More importantly, this article presents novel evidence of cranial complications associated with MARPE/MASPE maxillary expansions, including headaches due to excessive structural loading, asymmetric maxillary disjunction [33], and cranial fractures [29]—findings not previously documented in the literature. However, the radiographic findings highlight the potential for cranial involvement in skeletal expansion—particularly when rapid activation protocols are employed.

Biomechanical considerations on the transition from sutural opening to fracture

The transition from a physiological sutural opening to a pathological fracture can be explained through the interplay of force magnitude, rate of activation, and the resistance of craniofacial sutures and surrounding bone. Under controlled conditions—particularly in growing patients—the midpalatal suture is capable of separating gradually, redistributing stresses across adjacent articulations. This constitutes a sutural opening, which is usually self-limiting and reversible once the activation protocol is discontinued.

However, when the applied forces exceed the adaptive capacity of the sutural and peri-sutural tissues, or when activation is too rapid to allow for progressive remodeling, the mechanical stresses are transmitted to adjacent craniofacial articulations. This concentration of tensile and shear stresses along areas of structural weakness can lead to a sutural diastasis, which biomechanically resembles an indirect fracture, seen in some cases in Table 1. In such cases, instead of the expected midpalatal opening, the forces dissipate asymmetrically, producing abrupt separations in other sutures (frontomaxillary, nasomaxillary, zygomaticomaxillary, separations between 4 and 6 mm, Table 1) or even propagating as microfractures within thin cortical plates (maxillary, palatal bone and zygoma fractures, Table 1). Therefore, the management and handling of post-split suture opening with controlled, slower-rate activation, force control protocols etc. is crucial to avoid unexpected fractures.

During midpalatal suture opening, several factors must be considered to ensure safety: the patient's age and the degree of sutural ossification, as fused sutures in adults resist physiological opening and redirect forces toward structurally weaker craniofacial sites; the magnitude and rate of force application, since rapid activation protocols generate abrupt stress accumulation, whereas force-controlled approaches such as the FCPC maintain mechanical loads within adaptive thresholds; the expander design and the Maxillary Opening Ratio of Expansion (MORE) factor, given that low values may reflect energy dissipation through mini-implant micromovements or surrounding bone deformation, thereby increasing the likelihood of uncontrolled stress release; and potential asymmetries in skeletal resistance, as variations in cortical thickness, maxillary pneumatization, or previous trauma can alter stress distribution, predisposing to unilateral diastasis or fracture.

In summary, while sutural opening represents the intended, controlled separation of the midpalatal suture under physiological or guided orthopaedic conditions, fracture or diastasis arises when the applied mechanical environment surpasses the biological tolerance of the sutural complex, leading to uncontrolled and pathological bone separations.

Evaluating craniofacial response to MARPE/MASPE: a case series reflection

Given that this is a descriptive case series rather than a randomized study, the conclusions drawn must be interpreted with caution and should be regarded as preliminary clinical insights rather than definitive evidence.

In the cases exposed in the Table 1 several factors may contribute to the risk of craniofacial fractures during adult skeletal expansion with MARPE or MASPE. These include, different expander designs, operator variability,

post-split activation handling (most complications appears in week 3) [20], maxillary underlying cranial asymmetries (Table 1, patient 4) [35], improper three-dimensional positioning or opening of the expander—such as inclination (Fig. 1a–c), which may result in unilateral maxillary intrusion or extrusion—and the lack of consistent monitoring of secondary miniscrew stability, with possible implant displacements [20, 39].

This mechanical complexity, when compounded by anatomical vulnerabilities—such as highly pneumatized maxillary sinuses with thin cortical bone at the zygomatic buttresses (Fig. 2f)—and by uncontrolled rapid activation protocols, different expansion protocols, or variations in expander design with miniscrews placed more anteriorly or posteriorly, may further predispose patients to asymmetric or unfavorable disjunction patterns. However, these patterns and their specific characteristics were not analyzed in the present study, and therefore no definitive conclusions can be drawn regarding the different risk factors associated with fractures. Further randomized studies are needed to clarify these associations. Additionally, age-related cranial rigidity exacerbate these risks. Further studies are warranted to explore these mechanisms in greater depth and to validate safer protocols for adult patients.

In light of these biomechanical and anatomical challenges, ultra-slow, torque wrench controlled expansion protocols and controlled handling post-split expansions with slower activations protocols emerge as a potentially safer and more biologically compatible alternative for adult cases. Other alternative protocols, such as ultra-slow MASPE with rest cycles, have been proposed to reduce risks while still achieving stable skeletal expansion [1, 2]. Recent studies show that controlled activation lowers stress on maxillary resistance areas, improves patient comfort, and decreases complications compared with rapid expansion. New devices, like the ATOZ expander, also aim to distribute forces more evenly and support safer outcomes [3, 4].

It is noteworthy that, of the 12 cases presented in the table and the 8 managed in the maxillofacial surgery service, none have, to date, required orthognathic surgery for the correction of orbital dystopia or asymmetric nasal widening. In any case, our recommendation for clinicians facing such a situation is to progressively deactivate the appliance in order to reverse the cranial fracture or diastasis and to allow a prudent healing period of a few weeks, since in many cases the symptoms of diplopia, infraorbital nerve hypoesthesia, and epiphora tend to be reversible and without long-term consequences in the patients listed in the table.

However, keeping the appliance activated after a cranial fracture may lead to irreversible outcomes, creating permanent craniofacial asymmetries (orbital dystopia, nasal

deviation) that may eventually require corrective surgical intervention.

It is recommended that, for this type of appliance, clinical experience be considered an essential requirement, and that both their placement and management be supported by mandatory training programs. Such programs should provide academic credits that officially certify and authorize the professional for their use. For example, in the case of the last patient in the table, the clinician was managing his first case, which highlights the need for adequate prior experience and specific training in the handling of these appliances.

Conclusion

Non surgical mid facial expansion is a potential source of unwanted and unpredicted dislocations in the craneofacial complex. According to this report these complications happens more frequent in the 3rd week, do not seem to be age related and are difficult to predict from the CBCT. A close clinical follow up should be mandatory when performing continuous rapid uncontrolled MARPE protocols, uncontrolled post-split maxillary expansion handling or non force-controlled MASPE protocols. Therefore, minimally invasive SARPE could be alternative to minimise the incidence of complications. While force monitoring is prudent, recommendations should specify customization for appliance type and emphasize careful control after suture opening to prevent complications. The monitoring and limitation of expansive forces should be recommended until further data become available.

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Author contribution

Andre Walter, Heinz Winsauer and Federico Hernández-Alfaro wrote the main manuscript and participated in the study conception, participated in the data collection, data interpretation and study conception for factors related to radiology. Andre Walter, Heinz Winsauer, Eduardo Crespo, Ignacio Arcos and Federico Hernández-Alfaro provided images of the craneofacial fractures: clinical images, CBCTs and participated in the data collection. Adaia Valls-Ontañón participated in the manuscript elaboration and ethical analysis. Andre Walter and Federico Hernández-Alfaro prepared the table. Andre Walter and Federico Hernández-Alfaro prepared the figures of the manuscript. Andre Walter, Andreu Puigdollers -Perez and Federico Hernández-Alfaro participated in the manuscript final revision. All authors read and approved the final manuscript.

Author's information

The micro-implant supported skeletal expanders used in the present study—Micro4-Expander, MSE-Expander, and Power-Expander, all featuring a four-miniscrew design—have been in clinical use since 2013. These devices are currently widely implemented at the Universitat Internacional de Catalunya and in private orthodontic practices across various countries, including Spain, Austria, and the Dominican Republic, where part of this study was conducted.

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Data availability

The data supporting the findings of this study are not publicly available due to legal restrictions. Some of the clinical craniofacial cases involve trauma-related complications currently under legal investigation, and therefore cannot be shared.

Declarations

Ethics approval and consent to participate

This retrospective descriptive study involved incidental clinical observations since 2013 gathered from the experiences of multiple clinicians and did not require formal approval from an Ethics Committee at the Universitat Internacional de Catalunya or TeknonHospital (IRB not applicable). Nonetheless, all procedures were conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Written informed consent for the use of anonymized clinical and radiographic data was obtained from all patients or their legal guardians, where applicable.

Human or animal rights

Not applicable.

Competing interest

The authors declare no competing interests.

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