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Case report: early class III correction using titanium dental implants and facemask therapy: a 24-year follow-up

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The management of a Class III malocclusion in the mixed dentition presents with many challenges, in particular, the post-treatment growth-related changes which can continue into adulthood. This case report describes the multidisciplinary management of a 9-year-old female using titanium dental implants, rapid maxillary expansion and a Delaire facemask. Pre-treatment, post-treatment and long-term follow-up records of the patient are presented.
(Aust Orthod J 2022; 38: 213 - 226. DOI: 10.2478/aoj-2022-0024)

Received for publication: December, 2021
Accepted: May, 2022

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Introduction

Skeletal Class III malocclusions are characterised by either midface deficiency and/or mandibular prognathism. The incidence of maxillary retrognathia in Class III individuals has been reported to range from 25 to 67%.[1–4] Without orthodontic, orthopaedic or surgical intervention, the malocclusion is unlikely to self-correct, but there is some evidence to suggest that optimal timing for the correction of maxillary retrognathia is either at the prepubertal or pubertal phase of development.[5–7]

In 1944, Oppenheim proposed that maxillary protraction could be used as an effective means of compensating for mandibular overgrowth.[8] This was supported by Delaire who introduced the use of a facemask (FM) and Petit who modified the design and increased the forces to achieve skeletal change over a shorter period of time.[9,10]

Early protraction devices in animal studies resulted in a forward displacement of the maxilla and the formation of new bone by sutural apposition.[11–13] Increased clinical adaptation and an evaluation of FM therapy resulted in the observation of orthopaedic (forward and downward movement of the maxilla, downward and backward movement of the mandible), orthodontic (extrusion and forward movement of maxillary molars, proclination of maxillary incisors, retroclination of mandibular incisors) and soft tissue changes (improved lip position, competence and posture).[5,14–17]

Although teeth were convenient anchors for maxillary protraction, undesirable tooth movements led to early researchers using alternative forms of anchorage, but mainly ankylosed primary teeth. However, the early and continuing resorption of these teeth along with the limitation of positioning, restricted the use of this treatment modality.[18,19] With the emergence of modern dental implantology, the use of osseointegrated implants, onplants, miniscrews and miniplates for maxillary protraction have been advocated.[20–26] With significant improvements in soft tissue variables, maxillary advancement, a decreased

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treatment time and the reduction of undesirable skeletal and dental effects, were observed.[27–35]

Maxillary retrognathia is often accompanied by a transverse discrepancy, leading many authors to believe that the disruption of the circummaxillary sutures as a result of RME produced more favourable maxillary protraction.[14,36–45] Additionally, the use of an alternate RME and constriction (ALT-RAMEC) approach has been advocated by Liou and colleagues, as a means to achieve even greater sutural stimulation and thus greater protraction.[46–48] However, there is disagreement regarding the use of RME with maxillary protraction, as some authors found no significant difference in the outcome of protraction with or without expansion.[5,49–52]

The changes observed in the early correction of maxillary retrognathia, using protraction devices, has been found as an effective orthopaedic treatment in the short term and, also, effective in significantly reducing the need for surgery in the long term (compared with untreated individuals). Currently, there is insufficient evidence to demonstrate that these orthopaedic gains are maintained in the long term[53–62] and, in particular, when skeletal anchorage systems are used.[24,63]

The present case report discusses maxillary protraction using titanium implants in a 9-year-old female presenting with oligodontia. A 24-year post-treatment follow-up is described.

History and clinical findings

A 9-year-old female presented to the Perth Dental Hospital in 1990 complaining of a significant "underbite", which had led to bullying at school. Medically she suffered from Asperger's syndrome with concomitant small kidneys, but whose function was normal.

A clinical examination revealed that the patient had recession of midfacial structures involving both infraorbital and maxillary regions. The mandible was prominent and generating relative protrusion of her lower lip (Figure 1). Dentally, the patient had a Class III malocclusion without a mandibular forward slide, and an increased overbite. The maxillary arch was sagittally and transversely deficient, which created a buccal crossbite relationship on the right hand side. There was submergence of teeth 75 and 85, and ectopic eruption of 16 and 26 (Figure 2). A panoramic radiograph revealed multiple congenitally missing teeth (12, 22, 14, 24, 15, 25, 35 and 45). A lateral cephalometric analysis revealed that the underlying skeletal pattern was a hyperdivergent Class III, characterised by a retrognathic maxilla and an orthognathic mandible (Figure 3).

Specific treatment objectives

The aims of treatment were to:

1. Improve facial aesthetics by addressing the transverse and sagittal maxillary skeletal deficiency by protraction and expansion of the maxilla.
2. Address the missing teeth in the upper arch by a combination of space closure (substituting the canines for the missing upper lateral incisors) and prosthetic replacements (dental implants) in the upper premolar region.
3. Address the missing teeth in the lower arch by protraction of the posterior dental segments.
4. Address the ectopic eruption of the maxillary first permanent molars, by extraction of the submerged and compromised deciduous teeth.
5. Achieve a stable functional occlusion.

Treatment alternatives

A number of alternatives were considered including the use of a removable appliance, first using the molars and canines as anchorage units and, the use of the ankylosed deciduous teeth. However, with the decreased number of dental units and poor remaining root structure of the deciduous teeth, these were not viable options. The use of the first molars and canines as anchorage units, would result in unfavourable tooth and skeletal movements. The use of combined orthodontic and surgical treatment at a later stage was considered; however, this would not address the presenting concerns.

As osseointegrated dental implants provided absolute anchorage and allowed the future replacement of the missing premolars in the region, this treatment option was chosen. At the time, the use of temporary anchorage devices was limited, as were long-term follow-up studies of implants placed in this young age group.

Treatment progress

Implant placement

Informed consent was obtained and treatment commenced under general anaesthesia with the removal



Figure 1. Pre-treatment photographs.

of the remaining maxillary deciduous teeth and the placement of two titantium implants (Brånemark, 3.75 × 7 mm) in the maxillary premolar regions.

RME and face mask

After a six-month period of healing, a rapid maxillary expander (RME) with bands on the upper first molars, canines and titanium implants, was inserted. The expansion protocol involved two quarter turns for the first three days, followed by one quarter turn per day for 6 weeks when and until the transverse relationship was deemed to be over-corrected. A Tubinger-designed facemask was inserted 5 weeks after the placement of the RME (Figure 4). A 500*g* force delivered at 30° to the occlusal plane with 14 hour/day wear was prescribed. The expansion was completed after 6 weeks. Eleven months after RME insertion, the appliance was removed, a transpalatal arch (TPA) was placed and the lower deciduous second molars were removed. The patient was 11 years and 1 month old at this time.

Fixed appliances

Two weeks after RME removal, upper fixed appliances were placed, followed by lower preadjusted 0.022 × 0.028-inch Lewis Lang Edgewise fixed appliances (Ormco Pty Ltd). The implants were used as anchorage in closing the spaces between the maxillary canines and central incisors. Lower space closure was completed using closing loops and an elastic (from the implant to the lower premolar) was used to correct the vertical discrepancy on the right hand side. Judicious use of Class III elastic traction was included in the therapy. However, the combination of the facemask and lower incisor compensation secondary to lower premolar space closure was the primary contributor to lower incisor repositioning. At 12 years and 11 months of age, the fixed appliances were removed and

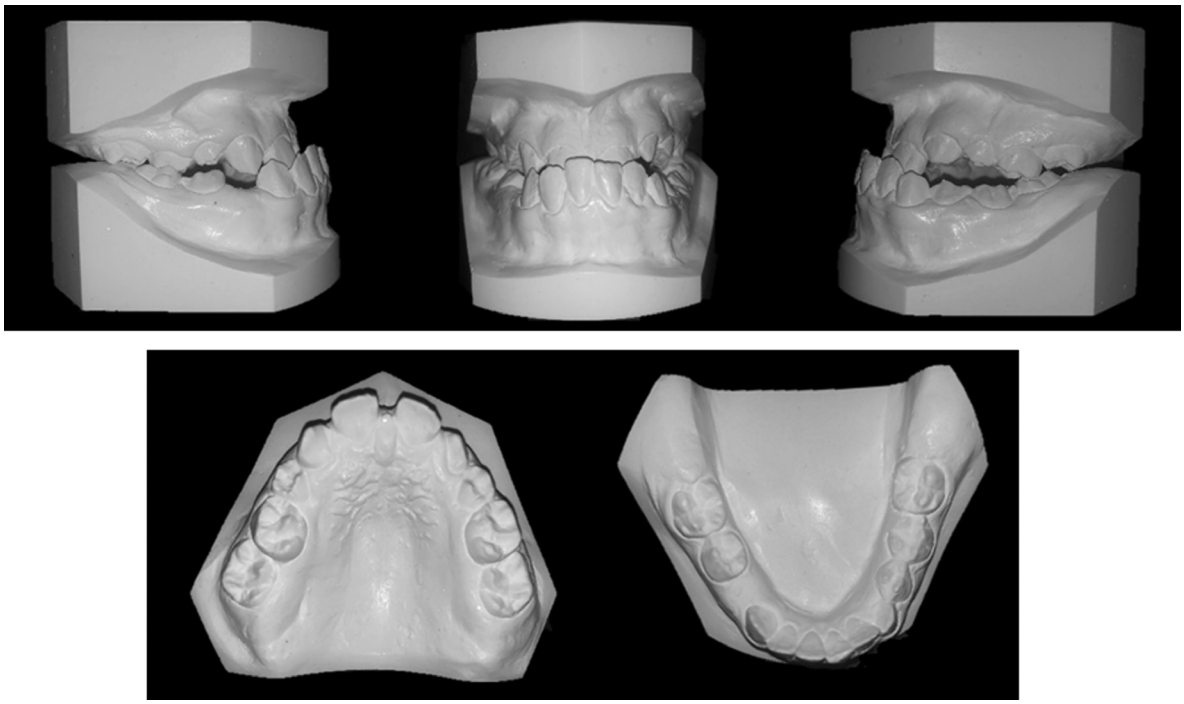


Figure 2. Pre-treatment dental casts.

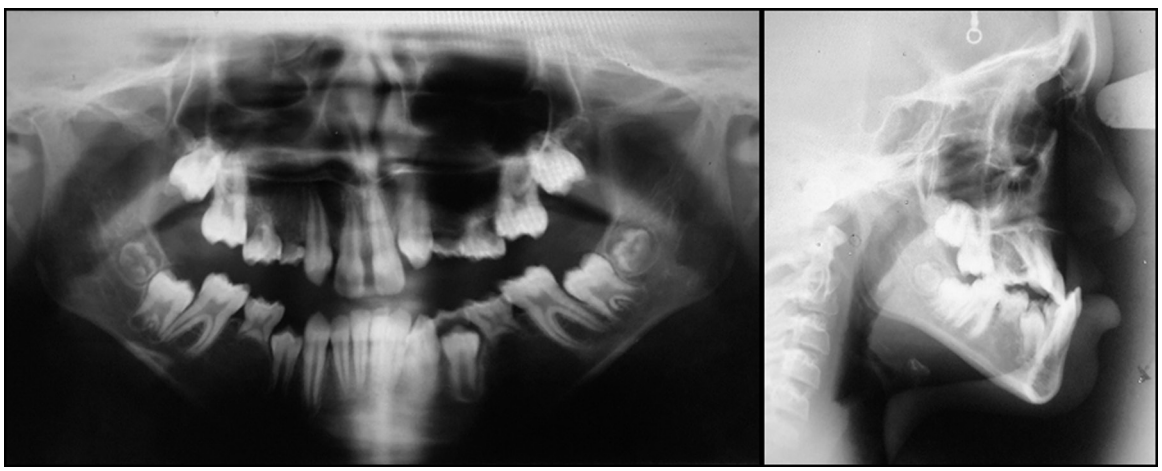


Figure 3. Pre-treatment lateral cephalogram and orthopantomogram.

the patient was issued with upper and lower Hawley retention appliances. The patient continued to use the facemask (from the implants) at night. Significant relative submergence of the implants occurred with ongoing growth (Figure 5).

Abutment placement

Six years after initial implant placement (at 15 years and 8 months), a prosthetic abutment was inserted to replace the congenitally missing maxillary premolars. Palatal cantilever arms were attached from the prosthetic teeth to the maxillary canines and first molars. The initial plan included the removal of the implants as they were not intended to serve as long term support for prosthetic teeth. However, a clinical assessment deemed the implants to be stable and healthy, and therefore suitable for restoration with fixed prostheses (Figure 6).

Retention and retreatment

The patient continued to use the Hawley retainers after abutment placement. Two years after FM

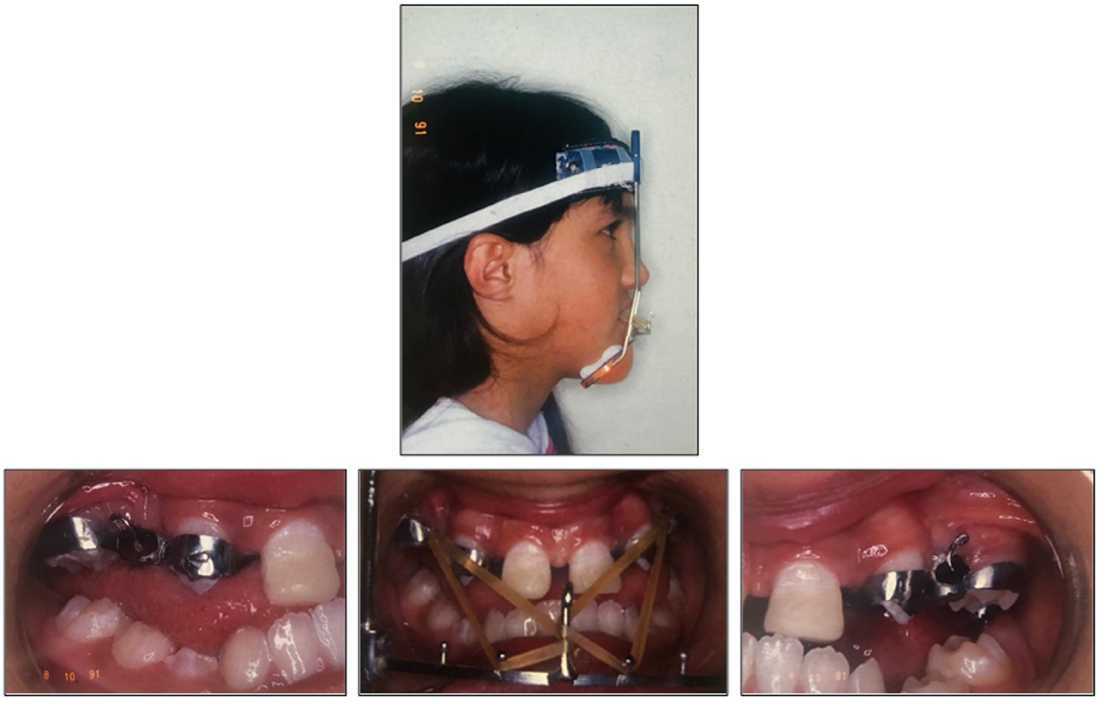


Figure 4. Tubinger facemask with photos demonstrating intraoral anchors.



Figure 5. Completion of full fixed appliances photographs (1994).

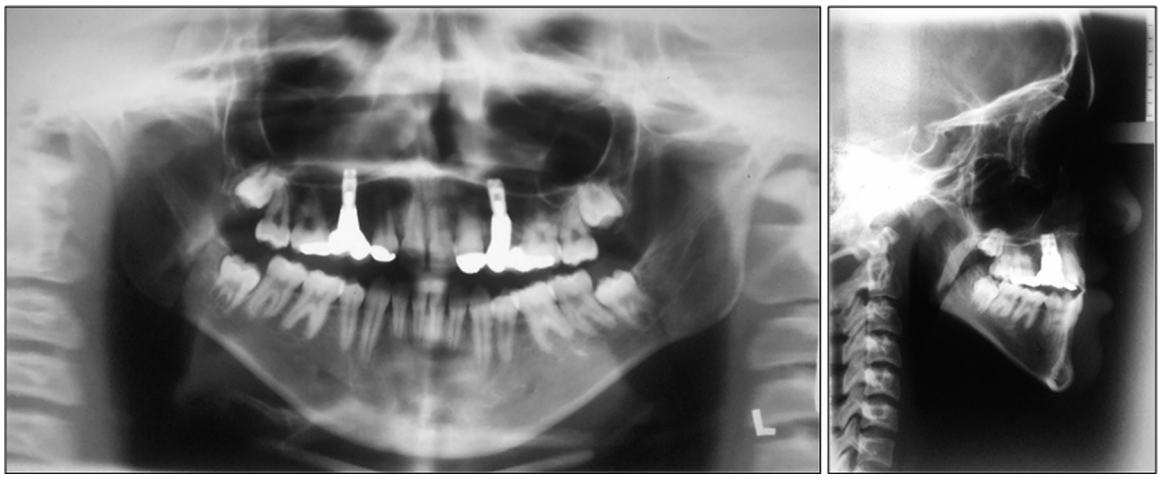


Figure 6. Post-Facemask lateral cephalogram and orthopantomogram (1996).

therapy was discontinued, the upper central incisors uprighted (retroclined) which generated a return of a Class III anterior dental relationship. Retreatment was undertaken 11 years after active treatment ended (at 26 years and 3 months) and involved the placement of full fixed appliances (FFA) which proclined the upper incisors and, coupled with interproximal reduction, uprighted the lower incisors. The retreatment took 13 months to complete and the patient was provided with removable retainers to maintain the result.

Results

The results were analysed clinically and radiographically. Lateral cephalograms were taken prior to orthodontic treatment, after RME removal, after full fixed appliance removal and at the end of FM therapy to assess the initial response. Medium and long-term observations were made at two, 11 and 24 years after FM cessation (Table II).

Initial effects

The improvement of the sagittal relationship (ANB –7° to –1.5°; Wits –13 mm to –8 mm) resulted in the correction of the anterior crossbite, a positive overjet (+2 mm) and an Angle Class I molar relationship. A cephalometric evaluation after RME/FM treatment, indicated modified anterior growth of the maxilla with a change in the SNA angle (76° to 78°) and a disproportionate increase in maxillary length compared with mandibular length (Co-A point: 69–75 mm; Co-Pog: 95–100 mm). At the end of fixed appliance treatment, the maxillary skeletal position was maintained but not improved (SNA remained at 78°) and the Class III pattern of growth returned with a greater increase in mandibular length compared to maxillary length (Co–Gn: 95 to 104 mm; Co–A point: 69 to 75 mm). However, the ANB angle continued to improve (ANB –3° to –2°) with a reduction in SNB (83° to 81°) as a result of a clockwise mandibular rotation, as indicated by an increase in SN-GoGn (34° to 38°) and an increase in lower anterior face height (56% to 59%).

After RME and fixed appliance treatment, a slight uprighting of the maxillary incisors (U1 - PP: 113° to 110°) and a significant uprighting of mandibular incisors (L1- MP: 76° to 68.5°) was noted; however, by the end of FM treatment, mandibular incisor position returned close to the initial value (L1- MP: 76° to 75°).

Pre- and post-treatment cephalometric radiographs were superimposed on anterior cranial base structures to identify the skeletal changes and support the clinical and measured cephalometric findings (Figure 8).

Transverse dental arch corrections were achieved by a 2 mm increase in maxillary intermolar width after RME treatment; however, by the end of FM treatment, the intermolar width returned to the pre-treatment level, but with dental compensation allowing for continued correction of the posterior crossbite.

Clinically, there was considerable improvement in the soft tissue profile as a result of the anterior forward displacement of the midface. There was an increase in the fullness of the infraorbital region, a

correction of the relative mandibular prognathism, an improvement in the relationship between the upper and lower lips and the nasolabial angle by movement of the nasal tip slightly upwards. Cephalometric measurements and superimpositions support the clinical findings (Figures 5–7, Tables I and II).

Table I. Clinical measurements.

	Pre treatment	RME completion	Full fixed appliance completion	Retention (1 year prior FM completion)	Prior to re-treatment (11 years post FM)	After re-treatment	24 Years Post treatment
Overbite (%)	60	40	10	15	10	40	20
Overjet (mm)	-5	4	2.5	2	-1	3	1
Incisor relationship	III	II	I	I	III	I	I
Molar relationship	III	II	I	I	I	I	I
Intermolar width Mx (mm)	45	47	45	45	45	43	42
Arch Depth Mx (mm)	25	20	21	21	19	21	20
Intermolar width Md (mm)	39	42	36	37	37	37	37
Arch Depth Md (mm)	23	18	15	15	15	15	16

Table II. Cephalometric Measurements.

		Immediate effects			Medium and long term observations		
Measurement	Pre-treatment	RME completion	Full fixed appliance completion	FM completion	2 Years post FM cessation	11 Years post FM cessation	24 Years post FM cessation
SNA ( )	76	78	79	79.5	79	79	79
SNB (°)	83	81	81	81	82	81.5	81
ANB (°)	-7	-3	-2	-1.5	-3	-2.5	-2
WITS (mm)	-13	-7	-8	-8	- 9	-5	- 5
NAPog (°)	-7	-3	-2.5	-3	-3	-3.5	-4
SN – PP (°)	8	7	3	8	7.5	4	3
SN-GoGn(°)	34	34	38	38	38	39	40
Co-A (mm)	69	75	75	76	76	77	785
Co- Pog (mm)	95	100	104	107	109	110	122
LAFH/TAFH (%)	56	58	60	59	61	60	61
U1 – PP (°)	113	111	110	110	110	106	110
U1 – NA (°)	28	27	28	28	25	18	28
L1-MP (°)	76	58	68.5	75	77	77	64
L1-NB (°)	15	3	10.5	15	19	19	10
Interincisal angle (°)	144	160	144	136	136	144	146
NLA (°)	60	90	92	94	94	106	104
Ulip-E line (mm)	-9	-4	-4	-7	-8	-9	-12
Llip-E line (mm)	3	1	0	-1	-1	-3	-3
OJ (mm)	-5	3	2	2	-1.5	-2	1
OB (mm)	4	2	3	2	1	2	1

The panoramic radiograph, taken at the end of FM treatment, showed minor generalised apical root resorption; however, greater resorption was noted on the maxillary central incisors, first molars, and the mandibular left lateral incisor. A vertical bone discrepancy was evident around the dental implants.

Medium and long term observations

During the follow-up period, at 2 years post FM cessation, a return of a Class III dental relationship was noted by a negative overjet (-1.5 mm), a worsening of the ANB angle (-1.5° to -3°) and Wits (-8 mm to -9 mm) value. A reduction in the SNA angle (79.5° to 79°) and an increase in the SNB angle (81° to 82°) accompanied the uprighting of the maxillary incisors and proclination of the mandibular incisors.

After discussing the post-treatment changes with the patient, a second short course of fixed appliances was undertaken. Following the second phase of treatment, the sagittal skeletal parameters improved along with proclination of the upper incisors and uprighting of the lower incisors. A disproportionate increase in mandibular relative to maxillary growth was observed (increase in Co-A point of 1 mm vs Co-Pog of 4 mm) in both the medium and long term (Figures 7 and 8).

A reduction in the SNB angle, an increase in SN-GoGn and an increase in lower anterior face height, indicated further downward and backward mandibular rotation. There was a slight decrease in maxillary intermolar width (of 2 mm) after re-treatment, likely a result of increase arch depth from the proclination of the maxillary incisors.

With growth, age-related soft tissue changes were observed, including a relative retrusion of the upper and lower lips compared with nose and chin position

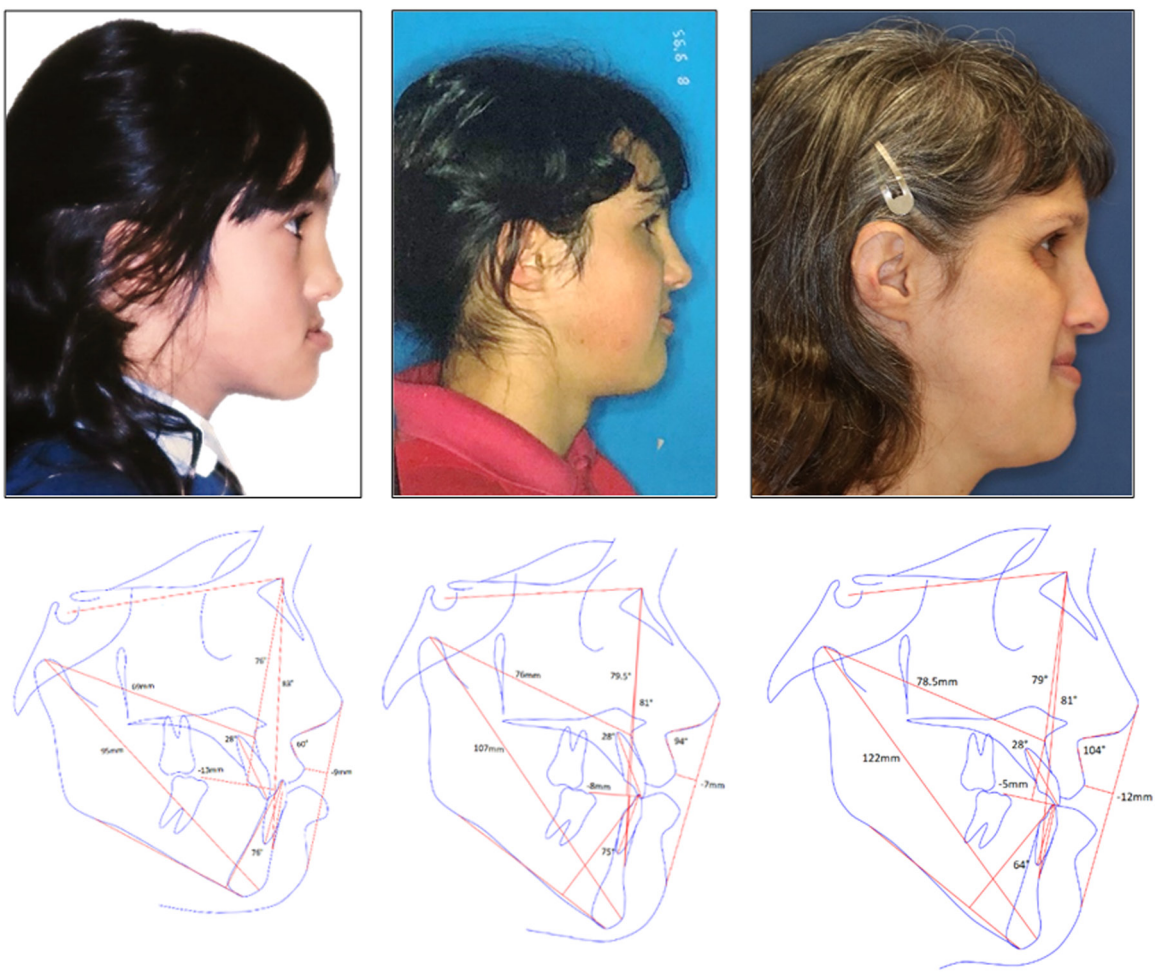


Figure 7. Profile view of Pre-tx (1991), Post FM treatment (1996) and 24 years post FM Treatment (2020).

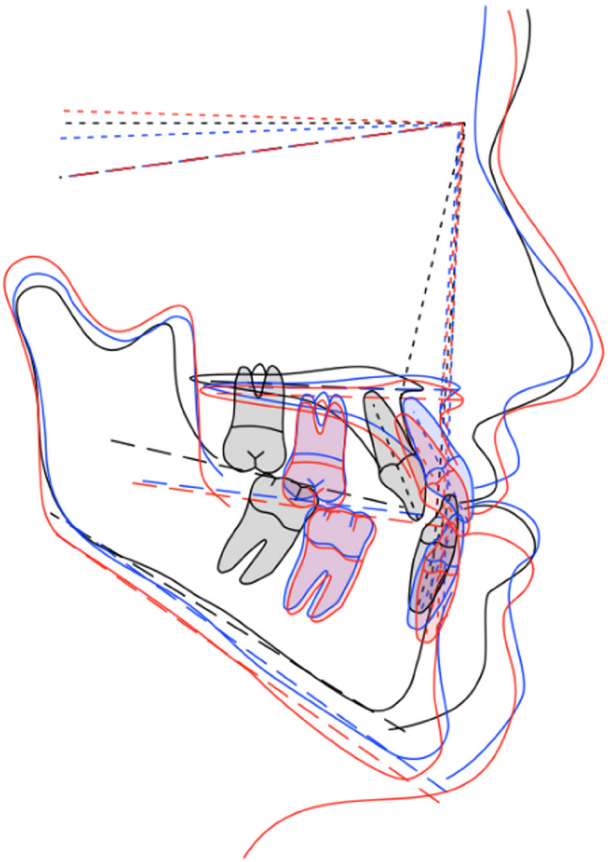


Figure 8. Superimposition of initial (1991; black), post treatment (1996; blue) and Twenty-four year retention (2020; red) on Sella-Nasion.

and a resultant decrease in the nasolabial angle. Clinically, the dental implants appeared infraoccluded accompanying the continued downward and forward growth of the maxilla. Prosthetic abutments were constructed to incorporate both gingival tissue and teeth. There was significant remodelling of the symphysis secondary to the dental compensation and an increase in the vertical dimension related to the backward rotation of the mandible. Although the bony alveolus was reduced in dimension, the periodontal health appeared sound (Figures 9–11).

Discussion

Orthodontists have endeavoured to modify facial growth by the application of orthopaedic forces delivered to the maxilla and/or mandible. In the short term, this may result in the successful treatment of a skeletal discrepancy; however, the wide biological variability in individual growth patterns can dilute positive gains.[42,60] The present case report describes the use of osseointegrated dental implants in the successful protraction of the maxilla and improvement in the Class III skeletal malocclusion in the short term. A subsequent return of the malocclusion in the medium term and re-treatment in the long term is also described.

The observed sagittal improvement of the maxillomandibular relationship resulted from a combination of maxillary protraction and mandibular downward and backward rotation. The forward displacement of the maxilla resulted in an increase in maxillary length and an improvement in the SNA angle and the Wits value. The improvements were achieved together with minimal changes in the angulation of the maxillary incisors which suggested anchorage preservation throughout treatment.

The contemporary literature supports the favourable results achieved by the use of skeletal anchorage systems for the treatment of maxillary retrognathia.[32] The recent popularisation of Bollard miniplates described by De Clerk and colleagues who reported favourable results of skeletal anchorage in achieving maxillary protraction when compared with conventional FM/RME; however currently, long term data using this technique have not been reported.[26,27,31,52]

Dental implants were placed in the edentulous region in the maxilla and healing abutments with bands placed to facilitate elastic traction; however, the orthopaedic force was directed along the occlusal plane, which resulted in a counter-clockwise rotation of the palatal plane during elastic traction. Along with extrusion of the maxillary molars, vertical maxillary movement can lead to a clockwise mandibular rotation, which affects the sagittal position of the mandible and increases lower anterior face height. In agreement with the long-term study by Ngan et al., the inclination of the maxilla returned to initial levels at the start of retention.[42] However, medium and long-term observations indicated a further counter-clockwise palatal plane rotation, a clockwise mandibular rotation and an increase in lower anterior face height. This was most likely an effect of normal growth and a major contributing factor in maintaining the skeletal position despite disproportionate mandibular growth.

Overjet correction invariably accompanied the skeletal change; however, in the present case, the lower incisors uprighted at the end of RME, resulting in a greater observed change, as a common side effect of RME/FM protraction.[27] The inclination of the teeth returned to initial angulations at the end



Figure 9. Twenty-four years post-FM cessation photographs.

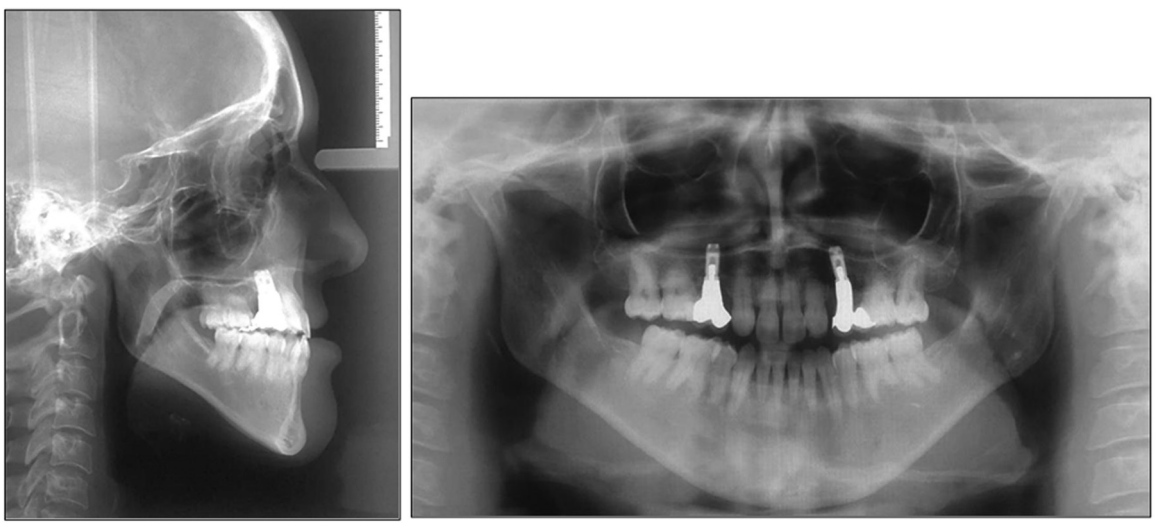


Figure 10. Twenty-four years post-FM cessation lateral cephalogram and orthopantomogram.

of the FM phase. In the medium term, a negative overjet accompanied growth, the uprighting of the maxillary incisors, and the proclination of the lower incisors was observed. Following retreatment, the upper incisors proclined and the lower incisors uprighted.

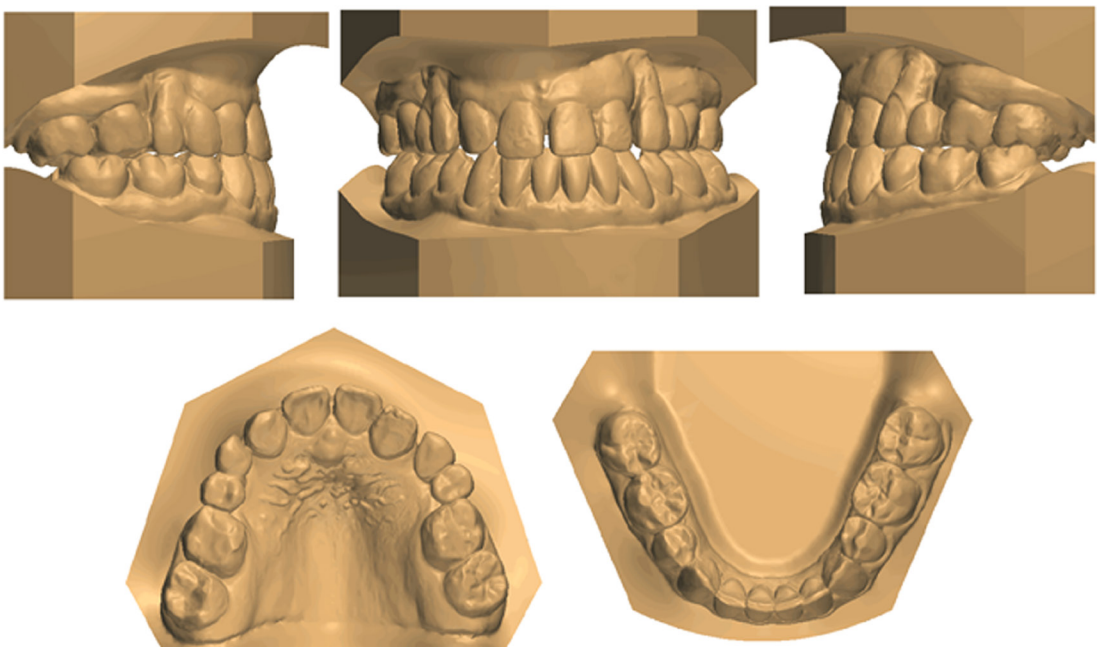


Figure 11. Twenty-four years post-FM cessation dental casts.

The use of a FM continued throughout retention, into the patient's mid-teens (15 years of age), to maintain rather than improve the skeletal gains. Studies by Vaughn et al. and Tortop et al. found that effective protraction can be achieved without RME, in support of previous studies,[49,51] which suggests that treatment timing plays an important role in achieving maxillary protraction. However, a decrease in treatment response is likely with increasing age.[64–67]

The combination of skeletal and dentoalveolar changes, generated significant soft tissue improvement, noted in fullness of the infraorbital regions, the nasolabial angle, forward movement of the upper lip and retraction of the lower lip. These findings are consistent with reports of other authors, who identified sagittal skeletal changes correlating to the observed soft tissue improvement.[49,68–70] The overall normalisation of the soft tissue parameters was maintained in the short-term; however, in the medium and long term, normal growth changes associated with continued nose and chin growth relative to lip thickness, reflected the observed changes.

With significant facial changes occurring during the late teenage years, a disproportionate mandibular to maxillary growth in the present case resulted in the re-emergence of the Class III malocclusion (at 17 years of age). This highlights the importance of reviewing patients into adulthood.

Critical appraisal of case and future recommendations

At the time of initial implant placement in the present case, the paucity of long-term data was primarily focused on edentulous individuals. Subsequent animal and human studies have identified the importance of case selection in regard to the infraocclusion of implants in growing individuals.[71–74] Therefore, a similar malocclusion may be treated by the use of skeletal anchorage systems for maxillary protraction; however, osseointegrated dental implants should be delayed until sufficient craniofacial and alveolar bone growth has been completed, typically in an adult.[71–74]

Limited long-term high-quality data and a clinically-derived consensus make the decision to treat Class III malocclusions early or waiting until growth is complete, a challenge.[54,56,57,60,75] Clinical decisions are often based on anecdotal experience, rather than scientific evidence. Additional research on the long-term impact of maxillary protraction supported by the use of skeletal anchorage systems and the psychological impact on patients is indicated. In particular, the 3-dimensional analysis of patients is required in the long term.

Conclusion

The present case report demonstrates the effective management of a Class III malocclusion in the short

term using a Tubinger FM anchored to osseointegrated dental implants followed by fixed orthodontic appliances and elastic traction to complement the dentoalveolar compensations. Subsequent growth and development, contributed to the infraocclusion of the dental implants and the return of the Class III skeletal pattern.

It is therefore recommended that a cautious approach with ongoing review of growth and treatment changes, be undertaken when performing comprehensive orthodontics in the management of a Class III malocclusion. This is particularly relevant to contemporary approaches that may be relatively invasive.

Conflict of Interest

The authors declare that there is no conflict of interest.

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