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Nour Eldin Yehia Tarraf
Benedict Wilmes

The applications of the Hybrid Hyrax in Class III growth modification

KEY CONCEPTS

- The advantages of using skeletal anchorage in growth modification for maxillary deficiency.
- Clinical steps in the treatment with the Hybrid Hyrax appliance.
- Explanation of the different Hybrid Hyrax designs and different setups for Class III treatment using facemask and miniplates.
- Design modifications for different Class III cases for optimal results.
- Long term retention strategies after Class III growth modification.

10.1 Introduction

Skeletal Class III malocclusion is among the more challenging malocclusions to treat in growing children. It is defined as a skeletal facial deformity characterised by a forward position of the mandible in relation to the cranial base and/or the maxilla.1 Earlier reports on Class III management targeted the mandible, aiming to restrain mandibular growth since it was believed that excess mandibular growth was the main culprit in the malocclusion.[2-4] In fact, the term 'mandibular prognathism' was used synonymously with 'Class III malocclusion'.4 Cephalometric studies, however, highlighted clearly that in the majority of Class III patients the malocclusion was due maxillary deficiency.[5-7]

Several approaches directed towards the orthopaedic correction of Class III malocclusion have been studied. They can be broken down into chin cup therapy,[8-13] Class III functional appliances and maxillary protraction with facemask.

Chin cup therapy aimed to restrain mandibular growth and redirect it.[8-13] However, most long-term reports showed chin cup therapy to be insufficient, with many cases experiencing rebound growth and relapse.[13] Additionally, treatment times were very long, and the protocol was demanding in terms of patient compliance.[8-13] When taking into account the fact that maxillary deficiency is a significant contributor in the greater percentage of Class III cases[5-7] it is understandable that chin cup therapy has fallen out of favour in recent years.

The aim in modern Class III treatment is to stimulate downwards and forwards maxillary growth while restraining and/or redirecting mandibular growth.[14] Several animal and human studies in the 1960s, 70s and 80s showed that sutural growth can be stimulated by protraction and expansion.[15-20] Maxillary expansion and protraction using various iterations of the protraction facemask became a mainstay of Class III treatment.[14] The appliance is usually tooth-borne and can be used with or without maxillary expansion.[21,22] Rapid maxillary expansion (RME) is thought to aid in stimulating a better sutural response to protraction forces through disarticulation of the circummaxillary sutures. While the literature remains divided on this issue,[23-25] maxillary expansion is

still usually indicated as the majority of Class III cases not only present with maxillary anteroposterior deficiency but also a transverse deficiency.[26] A recent long term randomized clinical trial by Mandall et al. demonstrated that early Class III treatment with facemask can significantly reduce the need for orthognathic surgery emphasizing the importance early growth modification plays in managing Class III malocclusion.[27]

10.2 Effects of conventional tooth borne maxillary protraction using facemask and its limitations

The goal with the protraction facemask is growth modification in an orthopaedic sense, with the aim of stimulating maxillary growth in all three dimensions – anteroposterior, vertical, and transverse, while also restraining and/or redirecting mandibular growth.[21,22] However, the appliance being tooth borne relies on dental anchorage to transmit orthopaedic forces to the jaws. While for decades this tooth borne approach made sense, since the dentition was the only way to transmit forces to the jaws, there are several limitations mostly since teeth respond to sustained loading by moving in the direction of the applied force.

Firstly, there are several undesirable dental side effects, such as mesial movement of the maxillary dentition, extrusion of the maxillary molars and tipping and proclination of the incisors with, counterclockwise rotation of the occlusal plane.[21,22] Secondly, the mesial movement of the maxillary buccal segments can result in less space in the anterior maxilla and increased upper anterior crowding,[28] while the mandibular incisors tend to tip lingually, which can increase mandibular crowding.[21,22] These dental side effects are undesirable as they compensate dentally for what is originally a skeletal problem. Additionally, in more severe cases, there is already some natural dento-alveolar compensation[29] and exaggerating it can be aesthetically undesirable. Thirdly, dental anchorage may be insufficient during the mixed dentition phase, especially the latter parts, throughout which the shedding of the deciduous molars and the eruption of permanent premolars is taking place.[30] During this phase, the

deciduous molars would provide little or no support for heavy orthopaedic forces. The loosening of the teeth in the presence of appliances can also make the appliances uncomfortable and reduce compliance with facemask wear, due to the pain caused by pulling on mobile teeth. Further to the dental side effects, the amount of skeletal correction is relatively small with tooth-borne RME-facemask treatment and may not be sufficient to completely resolve skeletal problems, especially in more severe cases. Studies typically show an improvement of 0.9-2.5 degrees in the ANB angle and 2-4 mm in the Wits appraisal.[21,23,25,27,31] In addition, the results for facemask therapy seem to be poor in older children. The overall correction is even smaller in children older than 10 years[32-34] and those who are at or closer to the pubertal growth spurt.[28,32]

Lastly, the facemask is a cumbersome extraoral appliance, which can reduce its acceptance by patients. The wear time requirements are also quite high. Most studies have required patients to wear the appliance for 13-16 hours a day,[21,23,25,32] which can be challenging for most children, especially if they engage in extracurricular activities.

Summary of the limitations of conventional tooth-borne facemask therapy:

1. *Undesirable dental side effects*
2. *Poor dental anchorage in the late mixed dentition*
3. *Small and (in more severe cases) potentially insufficient overall skeletal correction*
4. *Poor results in older children*
5. *Demanding wear time protocol*
6. *Complete reliance on patient compliance*
7. *Obtrusive and extraoral nature of the appliance.*

The use of skeletal anchorage allows the applied forces to be transmitted directly to the jaw thus eliciting a true orthopaedic response.

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10.3 History of skeletal anchorage in Class III correction

The introduction of skeletal anchorage has revolutionized many aspects of Class III treatment. Skeletal anchorage has been used in conjunction with facemasks[35,36] but also with completely intraoral applications, such as miniplates and Class III elastics.[37] It has been found to increase the skeletal effect in Class III growth modification and to reduce or eliminate the dental side effects.[38-40]

10.3.1 History of skeletal anchorage in Class III correction

The earliest attempts to provide skeletal anchorage for facemask therapy came through intentional ankylosis of the maxillary deciduous canines by extraction and replantation, followed by maxillary protraction.[41] The results showed that skeletal anchorage can reduce dental side effects and maximise the skeletal response. However, it wasn't until two decades later that early attempts to use TADs to reinforce anchorage for maxillary protraction were recorded. In 2003 Enacar et al.[42] used one maxillary implant to bolster anchorage to manage a 10-year-old girl with oligodontia and maxillary hypoplasia with a protraction facemask. The effects were significant forward and downward development of the nasomaxillary complex, setting up the case with a positive overjet for future prosthetic management.[42] Kircelli et al.[43] in 2006 were the first to combine bone-borne expansion using four miniscrews with maxillary protraction, zygomatic miniplates and facemask in a case with hypodontia and severe maxillary hypoplasia. They showed a significant amount of maxillary expansion and protraction without dental side effects. Following Kircelly et al.'s case report, several studies were conducted using miniplates in the maxilla combined with a protraction facemask.[33,35,44-51] Miniplates were either placed in the lateral nasal wall or the infrazygomatic crest. Nevertheless, one of the major turning points in orthopaedic correction of Class III malocclusion would have to be the introduction of the bone anchored maxillary protraction (BAMP) protocol by Dr Hugo DeClerk in 2009.[52] DeClerk used pure bone anchorage through maxillary and

mandibular miniplates for intraoral Class III traction with elastics. The results with skeletal anchorage were remarkable, with most studies showing two to three folds the skeletal correction when compared to conventional tooth borne maxillary expansion and protraction without any negative dental side effects. [33,35,44-51]

A major drawback of miniplates in the maxilla in children is the invasiveness of the procedure. The placement of miniplates requires flap surgery, which is usually done under a general anaesthetic. General anaesthetic is not risk-free and can be costly, which presents a significant obstacle to patients and their families in terms of cost and availability. Furthermore, the removal of the miniplates would require another surgery.

It was Wilmes et al.[53,54] in 2008 that simplified the use of skeletal anchorage using palatal miniscrews to support maxillary expansion with the introduction of the Hybrid Hyrax appliance, which they also advocated for effective maxillary protraction.[36]

10.4 The Hybrid Hyrax appliance

The Hybrid Hyrax[53,55] relies on two miniscrews in the anterior palate (Fig. 10.1) to share the load of expansion and protraction with two maxillary molars. There are several practical, biologic and biomechanical advantages to this approach. Firstly, the placement of miniscrews is simple, safe and can be done in the orthodontic office with local analgesia with relatively little risk when compared to flap surgery required for miniplates or onplants.[56] Secondly, miniscrews in the palate show a higher success rate than buccal interradicular miniscrews[57,58] as well as miniplates.[59] In fact, the anterior palate provides some of the best reported success rates 96-98%.[57,58] This can be attributed to the quality of bone and soft tissue in the anterior palate. The best cortical bone thickness in the maxilla can be found in the anterior palate,[60,61] and the area paramedian to the suture along the third Rugae line (designated the 'T-Zone'[62,63])(Fig. 10.1) has become a recommended site for miniscrew placement in

the palate. This recommendation was based on several CT and CBCT studies.[60,61,64,65] A study by Kang et al.66 found that the best available bone in adults was in the anterior palate in the Rugae area, as well as at midpalatal suture and in the 1 mm on either side of the suture going distally. They indicated that the paramedian part of the palate posterior to the first premolar area and in the molar area had very thin bone. Similar findings were also reported by Hourfar et al.6[4,65] In another study that included younger adolescent subjects, Becker et al.[60] confirmed that cortical bone thickness was best in the anterior palate and that the area along the line connecting the first premolars (which coincides with the third Rugae line) was the most ideal area for placement. They also mentioned that anterior to that line, the risk for perforating

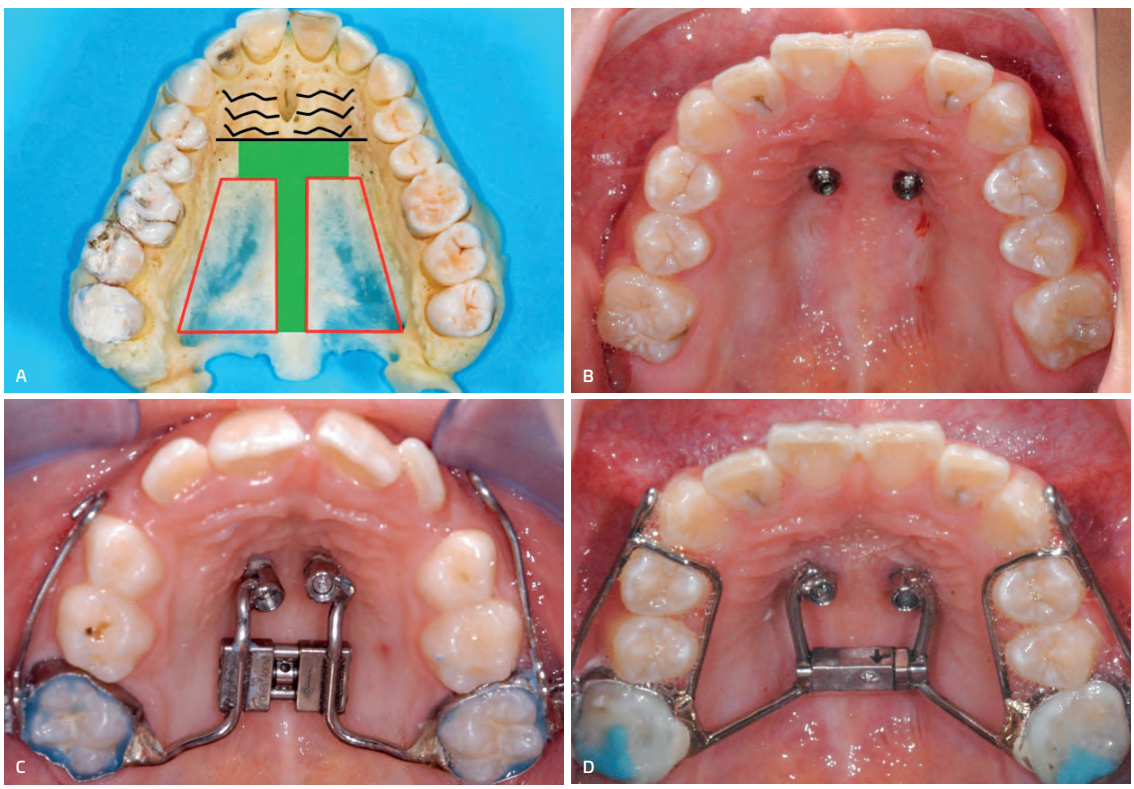

Figure 10.1: (**A**) The T-Zone marked as area with best quality cortical bone thickness marked in green. (**B**) Two Benefit miniscrews placed in the anterior palate in the T-Zone at the third Rugae line. (**C**) Hybrid Hyrax with hooks for facemask. (**D**) Hybrid Expander with Super Screw instead of Hyrax.

the nasopalatine canal and injuring the neovascular bundle increased, as did the risk of injuring the roots of the incisors. Another factor that contributes to the success rate in the anterior palate is the thin and keratinized mucosa. Areas of thick soft tissue require a miniscrews with a longer neck or collar.[67] If the mini-implant does not have a long neck or collar, the screw threads will be in soft tissue, which may cause irritation and inflammation of the peri-implant soft tissue, which has been found by a number of studies to contribute significantly to mini-implant loosening and an increase in failure rate.[68-70] The thin and keratinized mucosa in the anterior palate[71] allows the miniscrews to have a short neck and makes the force application closer to the bone surface thus reducing the lever arm on the miniscrews and loading moment on the bone surface.[67] Overall, the literature indicates that the paramedian area in the anterior palate along the third Rugae line seems to provide a good combination of good cortical bone thickness, safe distance from roots, nerves and blood vessels and thin keratinised mucosa, making it ideal for mini-implant placement.

Thirdly, from a biomechanical perspective, using the Hybrid Hyrax, maxillary expansion and protraction can be incorporated in the same appliance increasing the skeletal effect in both dimensions. Several studies have examined the effect of the Hybrid Hyrax with maxillary protraction using a facemask,[36,38,39] Class III elastics[72] and Class III elastics to miniplates.[38,73,74]

10.4.1 The Benefit Miniscrew system

Although the anterior palate provides several advantages for miniscrew placement from a biological standpoint, it is challenging from a biomechanical standpoint. This is because the miniscrews are at a distance from the dentition, where forces are usually applied. The position of the miniscrews in the anterior palate makes it difficult to apply forces directly, and indirect anchorage is thus required. This may be difficult to achieve using traditional mini-implant designs where the head is designed to receive orthodontic forces directly via coil springs, elastics or wires. The Benefit system (PSM Medical Solutions, Tuttlingen, Germany) introduced by Wilmes and Drescher[53]

in 2008 offers a solution to this challenge by offering a miniscrew system with interchangeable abutments (Fig. 10.1), thus allowing the miniscrew to act in a manner similar to osseointergated implants, where the implant has an internal thread to which a variety of attachments can be fixed using small fixation screws and abutments. The appliance manufacturing would occur indirectly in the laboratory, but direct intraoral adjustment and placement of the appliance supra structures was also possible. The Benefit miniscrews (PSM Medical Solutions, Tuttlingen, Germany) were designed with two diameters (2 mm and 2.3 mm) and four lengths (7, 9, 11 and 13 mm).

10.4.2 Clinical and laboratory steps for Hybrid Hyrax construction

Two palatal miniscrews (Benefit PSM Medical Solutions, Gunningen, Germany) are placed paramedian in the anterior palate in line with the third Rugae line or a line across the palate along the mesial half of the first deciduous molars in the T-Zone, where the best cortical bone can be found.[14,15] Cone beam computed tomography (CBCT) can be used to plan the length of the miniscrews, however, this is not essential. The use of CBCT can be advocated to aid selection of the correct length of miniscrew if the aim is to achieve bicortical engagement by engaging the thick cortical bone of the anterior palate and the cortical bone at the floor of the nose. A miniscrew long enough to engage both cortices can be selected. There is some emerging evidence from finite element analysis that this increases miniscrew stability and reduces stresses on the screws' necks.[16] Additionally, in cases with impacted teeth, clefts or very narrow palates a CBCT can be used to construct an insertion guide to facilitate the safe insertion of the miniscrews.[75]

Following miniscrew placement there are two possibilities to proceed with appliance fabrication, conventional analogue construction, or digital CAD/CAM.

10.4.2.1. Analogue construction

In conventional analogue construction after mini-implant placement (Fig. 10.2), an impression is obtained. Impression caps or copings are placed over the mini-implant designed to transfer the position of the miniscrew through the impression to the laboratory. Once the impression is taken, laboratory analogues are placed, and the impression is casted for appliance manufacturing on a plaster working model. The analogues then transfer the exact position of the miniscrews accurately to the lab. The superstructure can then be bent, adjusted, and welded to the abutments, which are designed to fit the threads accurately in the mini-implant head.

10.4.2.2. Digitized construction

If a digital workflow is adopted then appliance fabrication can be carried out using the method published by Graf et al.[76] Following mini-implant placement, a stereolithography (STL) file of the maxillary arch is created using an intraoral scanner (Trios Pod Version, 3Shape, Copenhagen, Denmark) and the STL file is sent to the technical laboratory (Fig. 10.3). Some scanners require the use of "scan bodies" placed over the mini-implant (Fig. 10.2), which facilitate the digitization of the mini-implants, however, most modern scanners will not need them (Fig. 10.3).

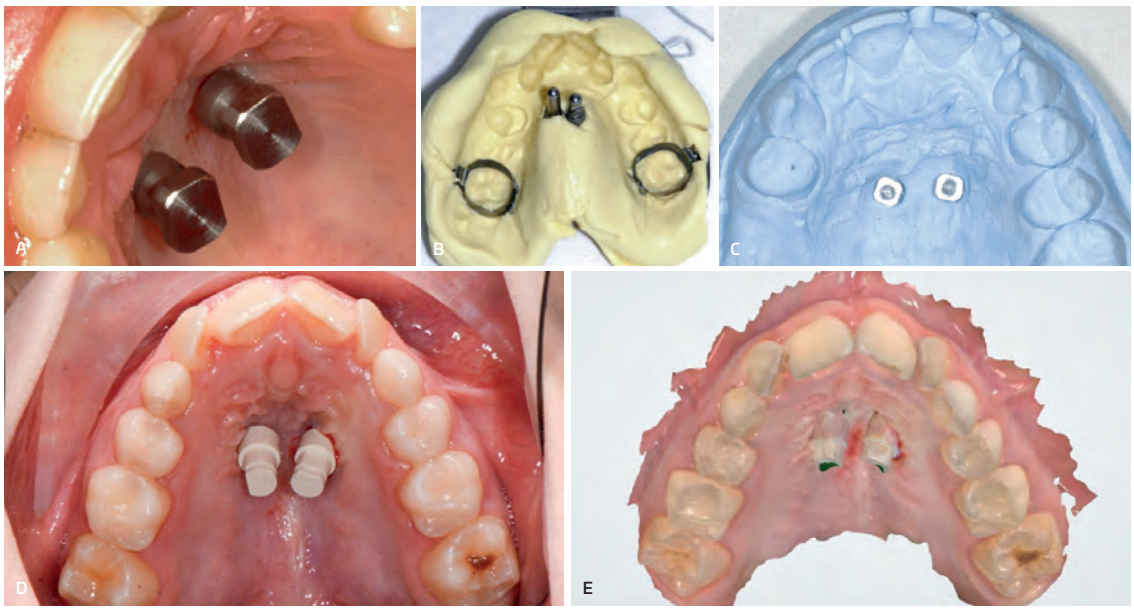

Figure 10.2: Analogue workflow. (**A**) Impression caps in position for impression taking. (**B**) Impression with analogue implants placed in the impression caps to transfer the mini-implant location to the working model. (**C**) Working model with analogue implants. (**D**) Scan bodies in place for intra oral scanner that are not able to scan the implants well. (**E**) Scan with the scan bodies which are then digitally replaced with a digital analogue.

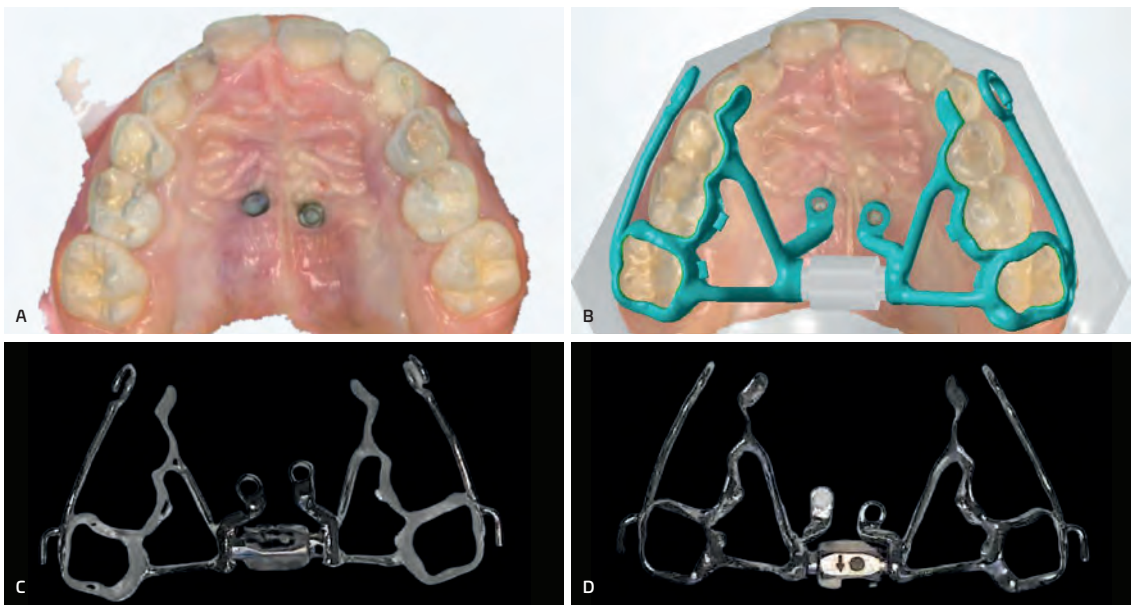

Figure 10.3: Digital workflow for CAD/CAM Hybrid Hyrax with facemask hooks. (**A**) Scan taken with 3Shape scanner clearly displays the mini-implants without the need for scan bodies. (**B**) Digital framework design. (**C**) The fitting surface of the appliance treated to improve bonding. (**D**) The polished surface of the appliance. Here the Hyrax screw was replaced with a Power Screw.

The framework is then digitally designed using 3Shape Appliance Designer software (3Shape, Copenhagen, Denmark), with the aim of ensuring the framework conforms well to the palatal contours, is as compact as possible and provides sufficient rigidity. The final design is then exported to a laser melting machine (Concept Laser, General Electric Company, CT, USA) and printed using the alloy Remanium (Dentaurum, Ispringen, Germany). Remanium is widely used in the printing of prosthodontic appliances and has recently been introduced to orthodontic appliance CAD-CAM manufacturing by Graf et al.[18] Following printing, the framework is polished, and the expansion mechanism is laser-welded to the bedding prepared in the framework, after which the appliance is polished. The CAD-CAM hybrid expander design can be seen in the figure. The fitting surface of the appliance is then treated to improve bonding by sandblasting using CoJet Sand (3M Unitek Corp, Monrovia, CA, USA) for 10-15 seconds, followed by the application of a 3M ESPE SIL silane coupling agent (3M Unitek Corp, Monrovia, CA, USA). The finished appliance is then cemented to the teeth using a resin cement in case of CAD/CAM appliances and Glass Ionomer in case conventional bands. The expander rings are then secured to the mini-implant using two fixation screws (Benefit PSM Medical Solutions, Gunningen, Germany) to provide the skeletal anchorage component (Fig. 10.3).

10.5 Hybrid Hyrax with facemask therapy

10.5.1 Skeletal and dental effects of Hybrid Hyrax facemask treatment

The Hybrid Hyrax[53,55] can be effectively used for maxillary protraction with a facemask by adding hooks either on the buccal side to emerge near maxillary canine area[36] (Fig. 10.4) or on the palatal side (Hybrid Hyrax Advancer).[54] Several studies have examined the effect of the Hybrid Hyrax with maxillary protraction using a facemask.[36,38,39,77]

Nienkemper et al.[36] reported on the skeletal and dental effects of the Hybrid Hyrax and facemask combination on 16 consecutively treated patients. The mean patient age was 9.5 years old. The authors reported significant skeletal changes, with SNA increasing by 2 degrees, a 1.2-degree reduction in SNB and a 3.2-degree improvement of the ANB, with no dental side effects such as incisor proclination or molar mesial movement. The effects of the Hybrid Hyrax in combination with facemask were then compared with conventional RME facemask treatment in another study,[39] where the maxillary advancement was shown to be a little over two-fold with the Hybrid Hyrax. The dental side effects were significantly higher in the RME facemask group while the vertical changes were reduced with the Hybrid Hyrax-facemask combination. The authors concluded that the incorporation of the miniscrews eliminated the dental side effects and improved the vertical control of the appliance. Case 1 illustrates an example of the treatment effects (Figs. 10.5, 10.6 and 10.7).

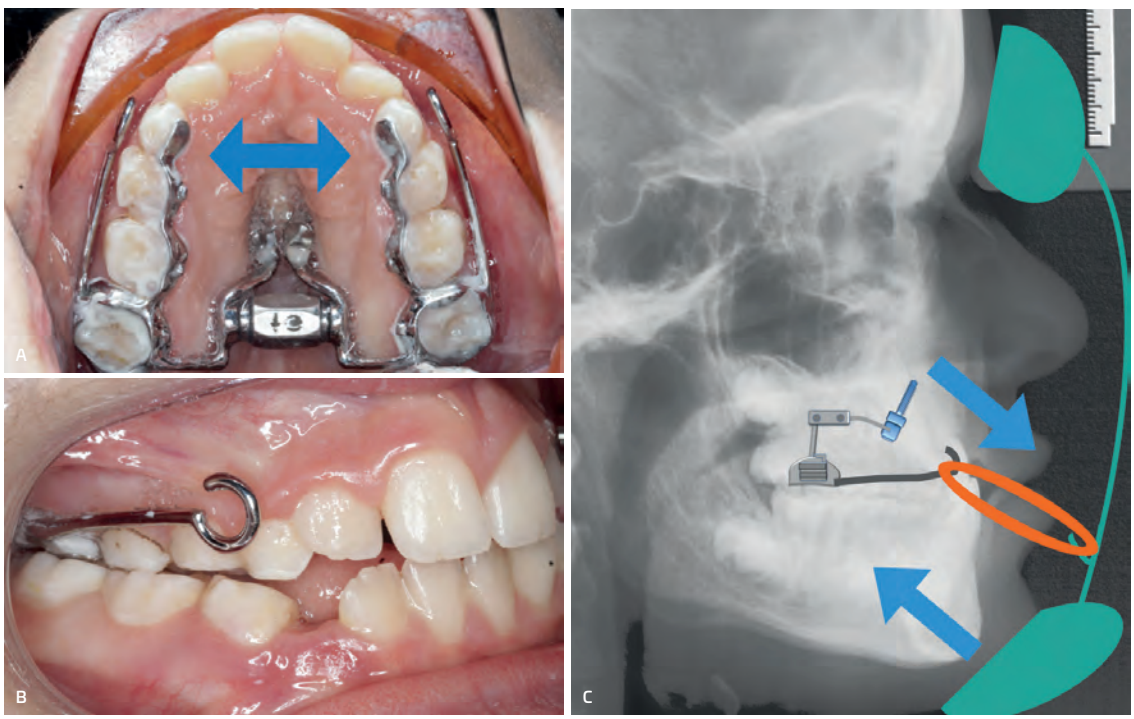

Figure 10.4: Hybrid Hyrax with facemask. (**A**) Occlusal view of the appliance the blue arrow shows the vector for the orthopaedic expansion force. (**B**) Buccal view with facemask hook. (**C**) Diagrammatic representation of the orthopaedic forces acting on the maxilla and mandibular with the protaction facemask.

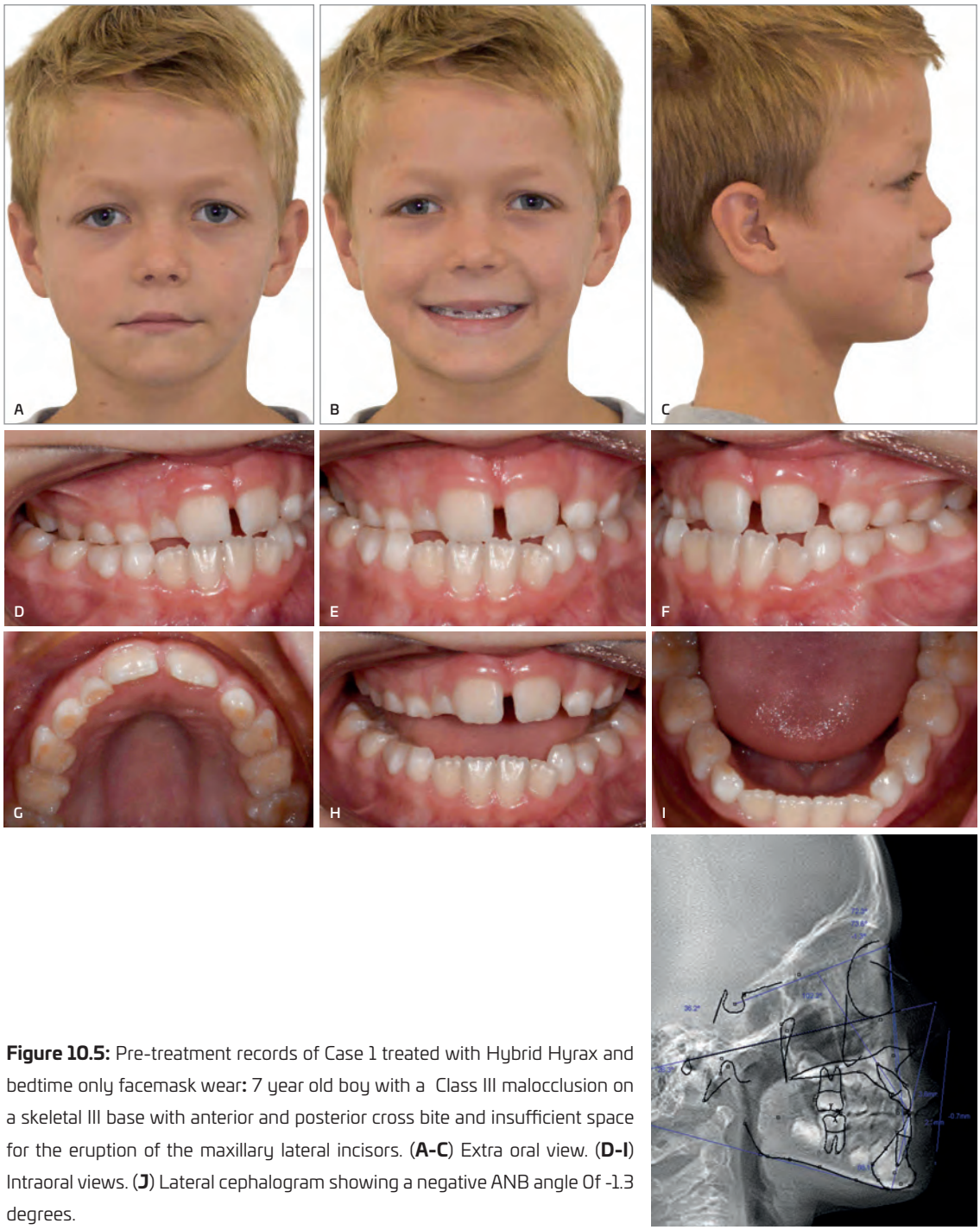

Figure 10.5: Pre-treatment records of Case 1 treated with Hybrid Hyrax and bedtime only facemask wear**:** 7 year old boy with a Class III malocclusion on a skeletal III base with anterior and posterior cross bite and insufficient space for the eruption of the maxillary lateral incisors. (**A-C**) Extra oral view. (**D-I**) Intraoral views. (**J**) Lateral cephalogram showing a negative ANB angle Of -1.3 degrees.

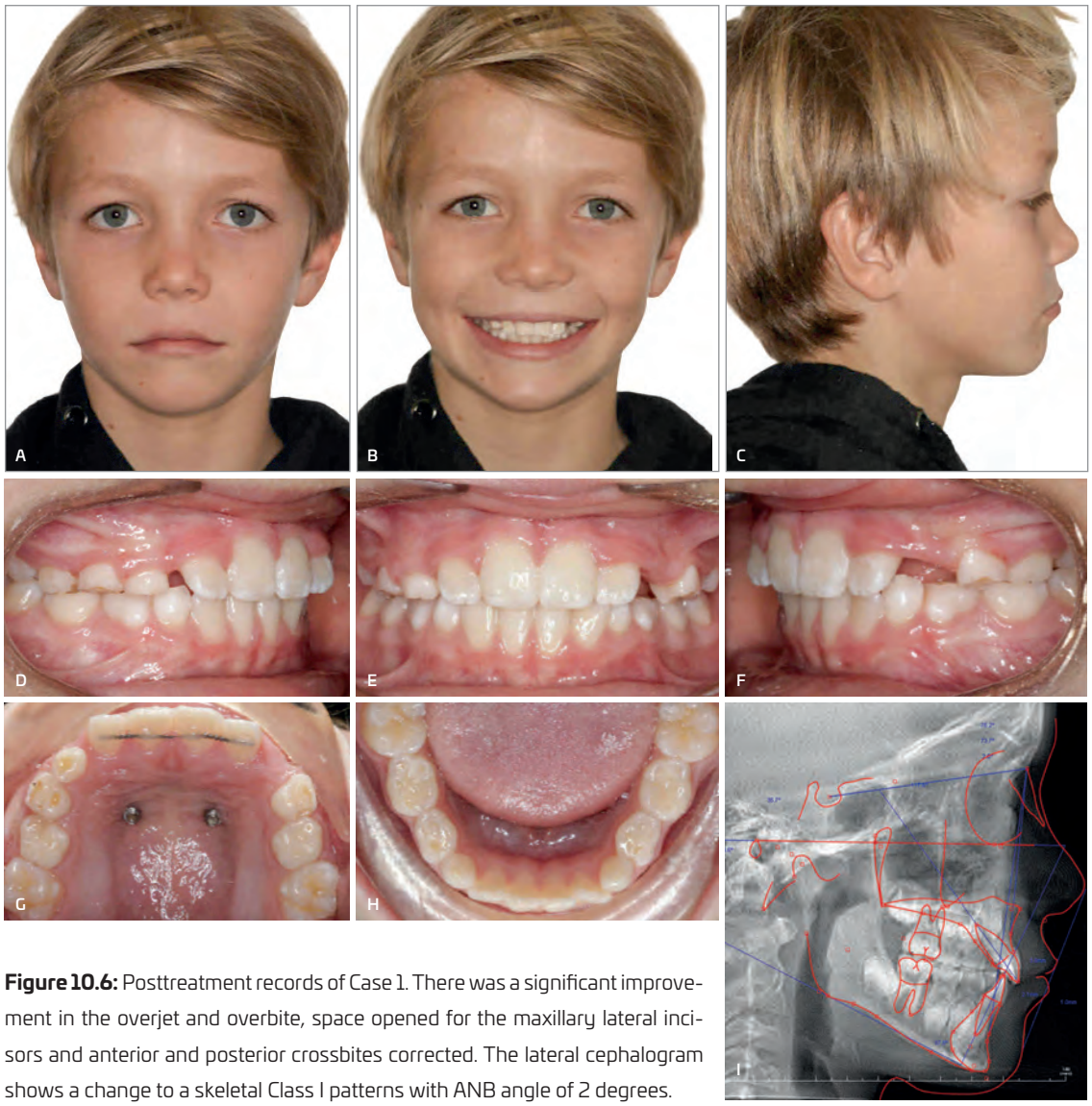

Figure 10.6: Posttreatment records of Case 1. There was a significant improvement in the overjet and overbite, space opened for the maxillary lateral incisors and anterior and posterior crossbites corrected. The lateral cephalogram shows a change to a skeletal Class I patterns with ANB angle of 2 degrees.

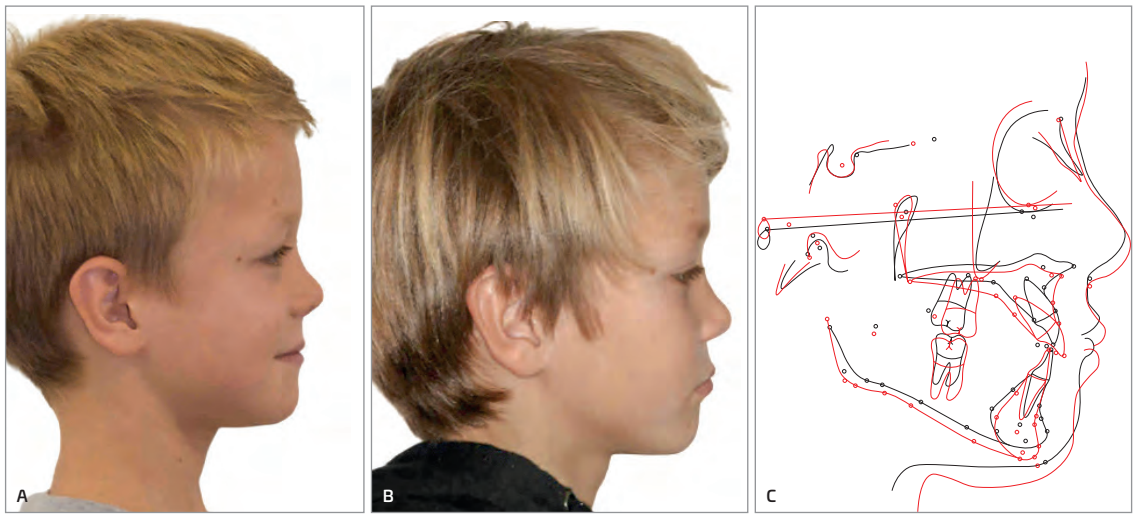

Figure 10.7: (**A**) Pre-treatment profile photo. (**B**) Posttreatment profile photo with significant improvement. (**C**) Cephalometric superimposition pre-treatment black and post treatment red, showing maxillary downwards and forwards displacement and backwards rotation of the mandible.

10.5.2 Facemask and expansion protocol

In most studies patients were asked to complete a period of 2-3 weeks of expansion prior to commencing facemask therapy. While most Class III cases present with a transverse maxillary deficiency and so require expansion as part of the treatment, maxillary expansion is often incorporated for another reason. Maxillary expansion is believed to aid sutural response to maxillary protraction by disarticulation of the circummaxillary sutures thus facilitating a better response to the facemask forces. Some authors have gone so far as to alternate maxillary expansion and contraction (Alt-RAMEC) to further enhance the maxillary sutural response.[78] The use of palatal miniscrews to support the repeated expansion and contraction should also reduce the risk of root damage to the dentition from the cyclic loading.[72]

At the end of initial expansion period or after the completion of the 7-9 week cycle of Alt-RAMEC, facemask wear can be initiated. The elastic force should be adjusted to a minimum of 6-8 ounces or 200-300 g per side, which is equal to 400-600 g total protraction force. This force serves to stimulate an orthopaedic response while

ensuring the facemask remains securely in place during sleep. The elastic force vector should be adjusted to run approximately 30 degrees down from the maxillary occlusal plane (Fig. 10.4), as described by Ngan,[79] to bring the line of force as close as possible to the centre of resistance of maxilla. Patients are usually required to wear the facemask between 13-16 hours a day for a period ranging from 6-12 months. Ideally, the treatment should aim for an overcorrection of the malocclusion.

10.5.3 Facemask wear time modification

Achieving good compliance is key to successful facemask therapy. Although most studies refer to the above-mentioned wear times,[21-23,46,51,80] This wear regimen would be quite demanding and laborious for most children at a young age, especially those engaging in after-school activities and hobbies. This requirement alone could lead to poor acceptance of treatment, as well as poor compliance. Studies on the adherence of patients to medical regimens have shown that treatments requiring greater patient lifestyle changes can lead to poor compliance, and thus poor outcomes.[81] Most studies on the facemask, however, have not objectively measured compliance with prescribed wear times. When compliance was objectively measured using thermal sensors, it was shown that patients wore appliances for 50-65% of the prescribed wear time.[82,83] On average, patients wore the facemask for 8.6 hours of the prescribed 13 hours.[82]

In a recent study, Tarraf et al. assessed the effect of CAD/CAM Hybrid Expander with bedtime only facemask wear and compared the results to tooth borne RME facemask where patients were requested to wear the facemask 16 hours a day. It was evident that use of skeletal anchorage significantly enhanced the skeletal response, especially that of the maxilla while there were no negative dental side effects. The maxilla advanced by an additional 3.6 degrees at SNA with the with the CAD/CAM Hybrid Expander and an additional 2.4 mm of advancement were recorded at A-point (Fig. 10.8). This was despite the fact patients were requested to wear the facemask to bed only in the skeletal anchorage group. The authors hypothesized that by limiting facemask wear to bedtime only, the treatment may seem easier to adhere to and can more easily fit into the child's normal routine without too much disruption. This factor alone may result

in better acceptance from patients and their families, and potentially result in better overall compliance and more regular facemask wear. Although objective wear time monitoring was not used in that study, it is unlikely that patients would have exceeded the prescribed hours of facemask wear. Children under the age of 11 years are expected to sleep between 10 and 12 hours every night.[84] It can be postulated that since skeletal anchorage increases the efficacy of facemask therapy, sufficient skeletal correction can be achieved with fewer hours of wear. Older children and adolescents sleep fewer hours85 and so this may be an effective strategy for them.

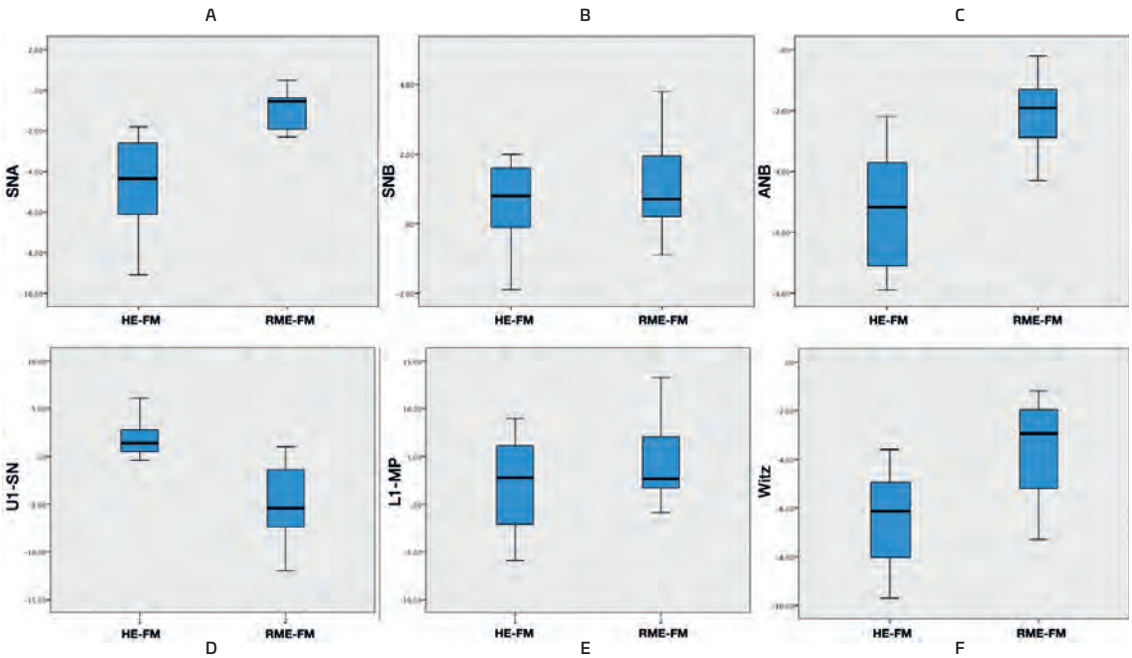

Figure 10.8: Box plots of the results of Tarraf et al. (**A**) Changes in the SNA angle were greater with the Hybrid Expander and facemask combination HE-FM when compared to the tooth borne RME facemask (RME-FM). (**B**) Similar effect on the mandible as shown by the SNB angle. (**C**) Overall greater skeletal change with the HE-FM as shown by the ANB angle. (**D**) Showing greater linear skeletal change in the Witz appraisal. (**E**) Upper incisor to SN (U1-SN) showing no dental change in the upper with the HE-FM and significant proclination with RME-FM. (**F**) No significant difference in the effect on the lower anterior Lower incisor to mandibular plane (L1-MP).

10.5.4 Retention following Hybrid Hyrax facemask therapy

For long term stability one of the main goals of the treatment should be to achieve a positive overjet and overbite with a degree of overcorrection. Following removal of the expander, the stability of the miniscrews should be assessed. To maintain transverse expansion, a rigid stainless steel miniplate can be placed between the miniscrews and fixed with two fixation screws (Benefit PSM Medical Solutions, Gunningen, Germany) and left for approximately 12 months (Fig. 29). In children the Beneplate should be removed after the 12 months of retention in order not to impede transverse maxillary growth.

It is also recommended that Class III cases are followed yearly to monitor subsequent growth and to assess the need for subsequent treatment. Although data is not yet available on the long-term stability of treatment with the Hybrid Hyrax and facemask one can infer from data available on long term stability of conventional tooth borne expansion and protraction, which show a stable positive overjet in 60-75% of the cases.[28,86] Considering the skeletal response is greater with Hybrid Hyrax facemask, one can expect the long-term results will be at least on par if not better than those reported with the tooth borne method.

Although the facemask has been widely used for several decades, the extraoral nature of the appliance can be problematic in terms of patient acceptance, which can reduce compliance with treatment. The BAMP protocol by De Clerck[52] in 2009 offered a good intraoral alternative.

10.6 Maxillary protraction with purely intraoral mechanic

The introduction of the bone-anchored maxillary protraction (BAMP) protocol[52] by Dr Hugo De Clerck was a significant turning point in the orthopaedic management of Class III malocclusion. He used bilateral maxillary infrazygomatic and mandibular symphysial miniplates to apply Class III elastic traction directly to the maxilla and mandible without any dental loading (Fig. 10.9). The mandibular miniplates were placed between the mandibular canine and lateral incisor, meaning that the treatment was only possible after eruption of the mandibular canines, which happens (on average) around the age of 11. For the placement of the miniplates, a small flap was raised and a type of miniplates termed 'bollard plates' (Bollard; Tita-Link, Brussels, Belgium) were adapted and secured with 2-3 titanium screws (2.3 mm x 5 mm) each.[87] The placement was usually carried out under general anaesthesia. Three weeks post-surgery, intermaxillary Class III elastic wear was started for protraction.

When compared with untreated Class III controls BAMP cases exhibited 4 mm more maxillary advancement.[88] This was not limited to the dento-alveolar region but extended to the orbital ridge and pterygomaxillary fissure. A novel finding of the study was a tendency for the lower incisors to advance and procline with the treatment, which is contrary to the finding of most other Class III treatment studies.[88] Several other studies examined the effects of this protocol using cone beam computed tomography (CBCT),[37,40,89-91] which also demonstrated that the changes resulting from the orthopaedic treatment were highly variable between patients; while there was significant maxillary forward and downward displacement in some, the effect seemed to be more pronounced on the mandible in others. The authors also showed that there was significant remodelling taking place at the level of the glenoid fossa and mandibular condyle.[89] When compared to conventional RME facemask treatment, the BAMP protocol resulted in significantly more maxillary protraction (2-3 mm greater), without the dental side effects.[92] Overall, results of the BAMP method were significantly better than those for the conventional tooth-borne RME facemask across several studies,[40,88,92,93] and this was attributed to the absence of dental loading.

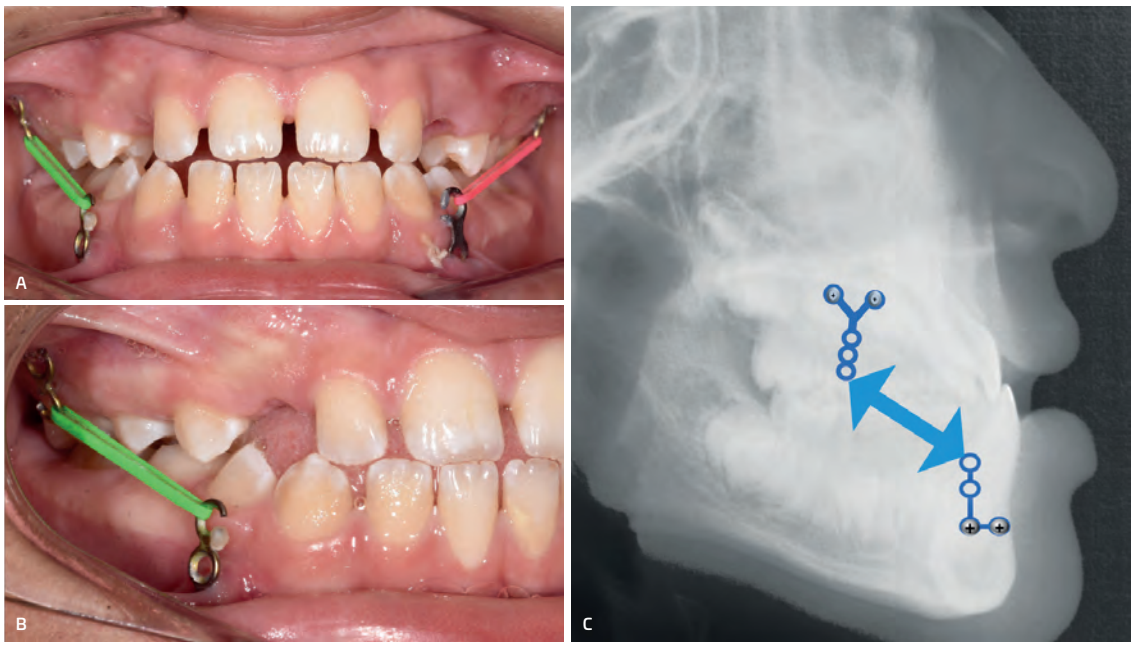

Figure 10.9: (**A**) The BAMP protocol with two maxillary and two mandibular miniplates and continuous elastic wear. (**B**) In this case conventional plates were used and converted by cutting open the top loop with highspeed handpiece. (**C**) Diagrammatic representation of the BAMP protocol.

The use of miniplates, although an attractive option that avoids the extraoral facemask, does not incorporate maxillary expansion. Additionally, it does require the surgical placement of the miniplates. The process can be considered slightly invasive in comparison to the use of miniscrews. Each miniplate requires a flap procedure[87] to place it, this process has to be repeated to remove the plates at the conclusion of treatment. In most cases, this is done under a short general anaesthesia.

Wilmes et al.[73] proposed the use of the Hybrid Hyrax in combination with a skeletal anchorage plate placed in the chin apical to the permanent mandibular incisors (Fig. 10.10), which they called the Mentoplate. A mucoperiosteal flap is raised and one miniplate is placed and fixed with 3-4 screws apical to the mandibular incisors (Fig. 10.11). The extensions of the Mentopate are adapted and bent into hooks for Class III elastics.

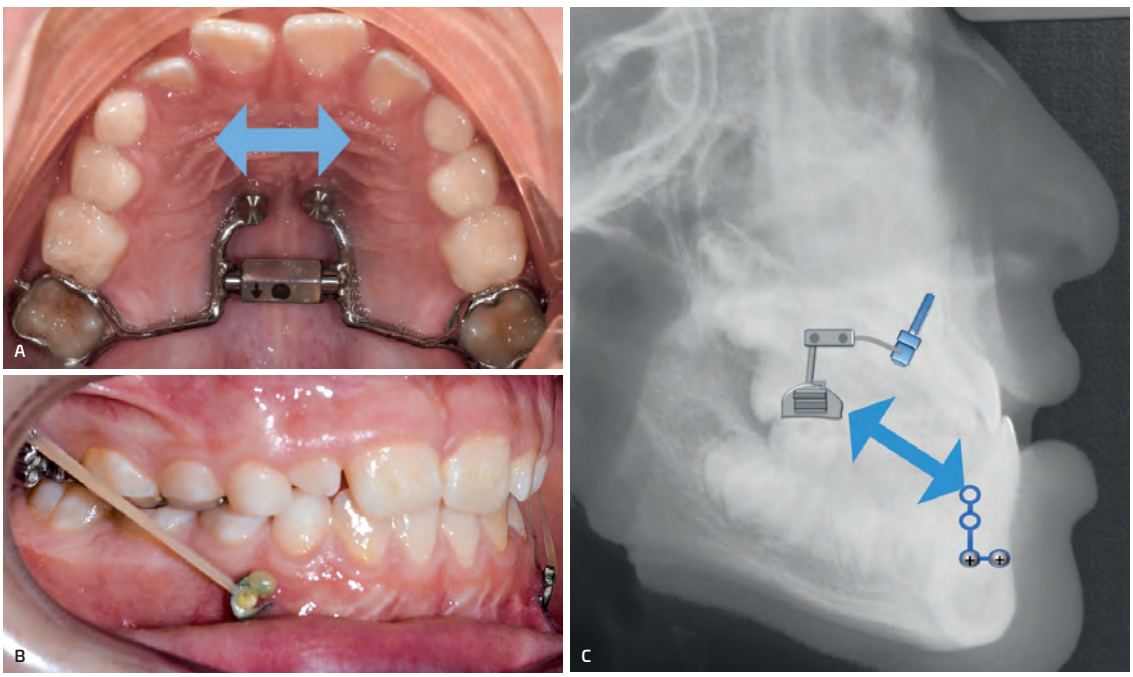

Figure 10.10: The Hybrid Hyrax Miniplate protocol. (**A**) Occlusal view of the Hybrid Hyrax with the blue arrow highlighting the vector for the orthopaedic expansion. (**B**) Elastic forces running from the hook on the band on the first molars to miniplate in the anterior mandible. (**C**) Diagrammatic representation of the force vector in blue between maxilla and mandible.

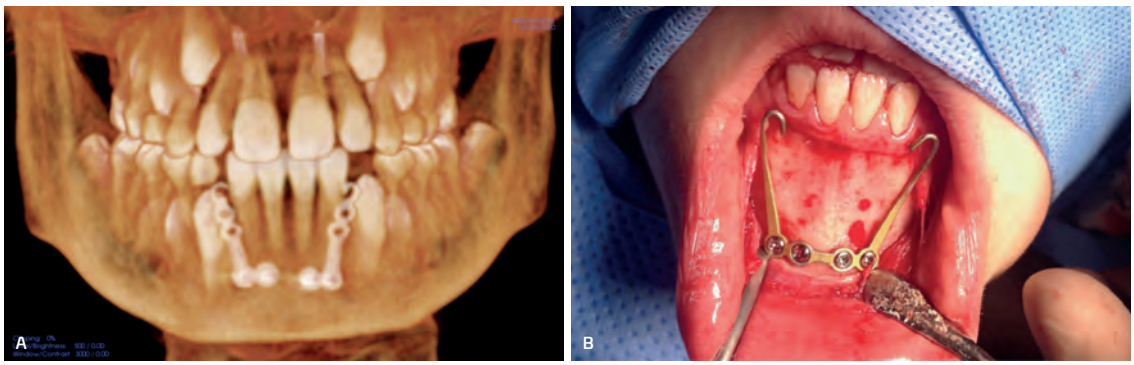

Figure 10.11: (**A**) Mandibular L-plates placed apical to the mandibular incisors. (**B**) Proprietary Mentoplate placed apical to the lower incisors in thick cortical bone of the chin. the ends are then bent into hooks for elastic wear.

10.6.1 Maxillary anchorage for intraoral elastic protraction: The Hybrid Hyrax vs. miniplates in the maxillary zygomatic region

When compared, the Hybrid Hyrax miniplate (Fig. 10.10) combination offers several advantages over the BAMP method (Fig. 10.9). Firstly, by eliminating the maxillary miniplates, it eliminates four surgical procedures, namely insertion and subsequent removal. Secondly, it reduces complications and increases the predictability of the maxillary anchorage unit. Miniscrews in the anterior palate have a success rate of over 96% with very few complications,[57,58] as opposed to the maxillary zygomatic miniplates which show a much lower success rate, especially in younger children.[94] In a multi-centre study between Belgium and the Netherlands,[94] looking at a 872 miniplates used for maxillary protraction in 218 growing patients, 25% of patients had complications with 10% of the patients needing to terminate the treatment due to failure of one or more of the miniplates. However, most noteworthy was the finding that the miniplate failure rate was six times higher in the maxilla, with 85% of the failures occurring in the maxilla and only 15% in the mandible, where the overall success rate for all plates was 98%. The authors explained this in terms of the lower cortical bone density in the maxilla in children. They also argued that a good alternative to maxillary miniplates could be the use of a Hybrid Hyrax,[55] which would rely on palatal miniscrews (which have a higher success rate for anchorage).[94]

Thirdly, by having the Hybrid Hyrax in the maxilla the treatment can incorporate skeletal maxillary expansion, which is often needed26 and may also enhance the sutural response to protraction (Fig. 10.10).[21]

10.6.2 Mandibular Miniplate anchorage for maxillary protraction

The placement of skeletal anchorage in the anterior mandible facilitates the application of protraction forces to the maxilla through purely intraoral means. There are three possible ways to use the miniplates in the mandible (Fig. 10.11):

- The first method was presented by De Clerck et al. used bilateral maxillary infrazygomatic and mandibular symphysial miniplates to apply Class III elastic traction directly to the maxilla and mandible without any dental loading. The mandibular miniplates were placed between the mandibular canine and lateral incisor, meaning that the treatment was only possible after eruption of the mandibular canines, which happens (on average) around the age of 11.

- The second method by Wilmes et al.[73] proposed in conjunction with the Hybrid Hyrax one skeletal anchorage plate placed in the chin apical to the permanent mandibular incisors, called the Mentoplate (Fig. 10.11).

A larger mucoperiosteal flap is raised and one miniplate is placed and fixed with 3-4 screws apical to the mandibular incisors. The extensions of the Mentoplate are adapted and bent into hooks for Class III elastics.

The third is a modification to this protocol by Tarraf et al. who used two L-plates (Stryker Universal Orthognathic; Stryker, Kalamazoo, MI, USA). Two small mucoperiosteal flaps were raised and two L-shaped plates were placed, one on each side. The L-plates were chosen so that the screws were placed apical to the mandibular central and lateral incisors on each side (Fig. 10.11). This was particularly important in the younger patients, whose mandibular canines had not yet erupted. The plate then emerged in the attached gingiva or just at the junction of attached and unattached gingiva.

The use of the Mentoplate and L-plates allows for the treatment to start earlier, as the L-plates can be placed before the eruption of the mandibular canines. This is a significant advantage as it is well documented that maxillary protraction is more effective in younger pre-adolescent children.[32,33] L-plates offer a slight advantage over the Mentoplate, as they make the right and left plates independent of each other, allowing the surgeon more freedom to vary the position of the plates to find the best cortical bone. Furthermore, the use of traditional trauma plates, as opposed to proprietary plates such as the Mentoplates (PSM Medical Solutions, Gunningen, Germany) or the Bollard plates (Bollard; Tita-Link, Brussels, Belgium), makes the protocol more accessible to patients and potentially reduces the cost, as most surgical theatres will be equipped with traditional orthognathic trauma plates.

10.6.3 Skeletal and dental effects of the Hyrbid Hyrax Miniplate combination in Class III treatment

Several studies have examined this protocol so far.[73,74,77] Katyal[74] et al. analysed the records of 14 consecutively treated cases with a mean age of 10.4 years old. The results showed significant maxillary protraction, with a 2.1-degree improvement in the SNA angle. The overall skeletal pattern improved, with a 1.9-degree improvement in the ANB and a 3.1 mm increase in the Wits appraisal. The effect on the mandible seemed smaller than that reported in facemask studies. There were no significant dental side effects. Case 2 highlights an dexample for this treatment (Fig. 10.12 to Fig. 10.15) When the Hybrid Expander and miniplate combination was compared with conventional tooth borne RME facemask the differences were significant. The maxillary protraction was significantly higher with the Hybrid expander and miniplate combination with two fold the improvement in the SNA angle and 2.4 mm more advancement of the A-point with no dental side effects (Fig. 10.16). One noteworthy finding was tendency for the lower incisors to advance slightly in the skeletal anchorage group while they significantly retroclined in the RME facemask group a similar finding was also reported by with BAMP protocol.[92] This seems to be an effect that is distinctive to the use of miniplates in the mandible. The mechanism may be explained by two potential causes. Firstly, during Class III elastic wear to the miniplates, there is no direct load transfer to the lower teeth. At the same time, the upper incisors are moving forwards as part of the downwards and forwards movement of the maxilla, in the presence of an anterior crossbite the upper teeth indirectly drive the lower incisors forward. Secondly, once there is a positive overjet the tongue can now freely put pressure on the lingual surface of the lower incisors and thus move them to a newly established neutral zone for equilibrium between the tongue and lips.[92]

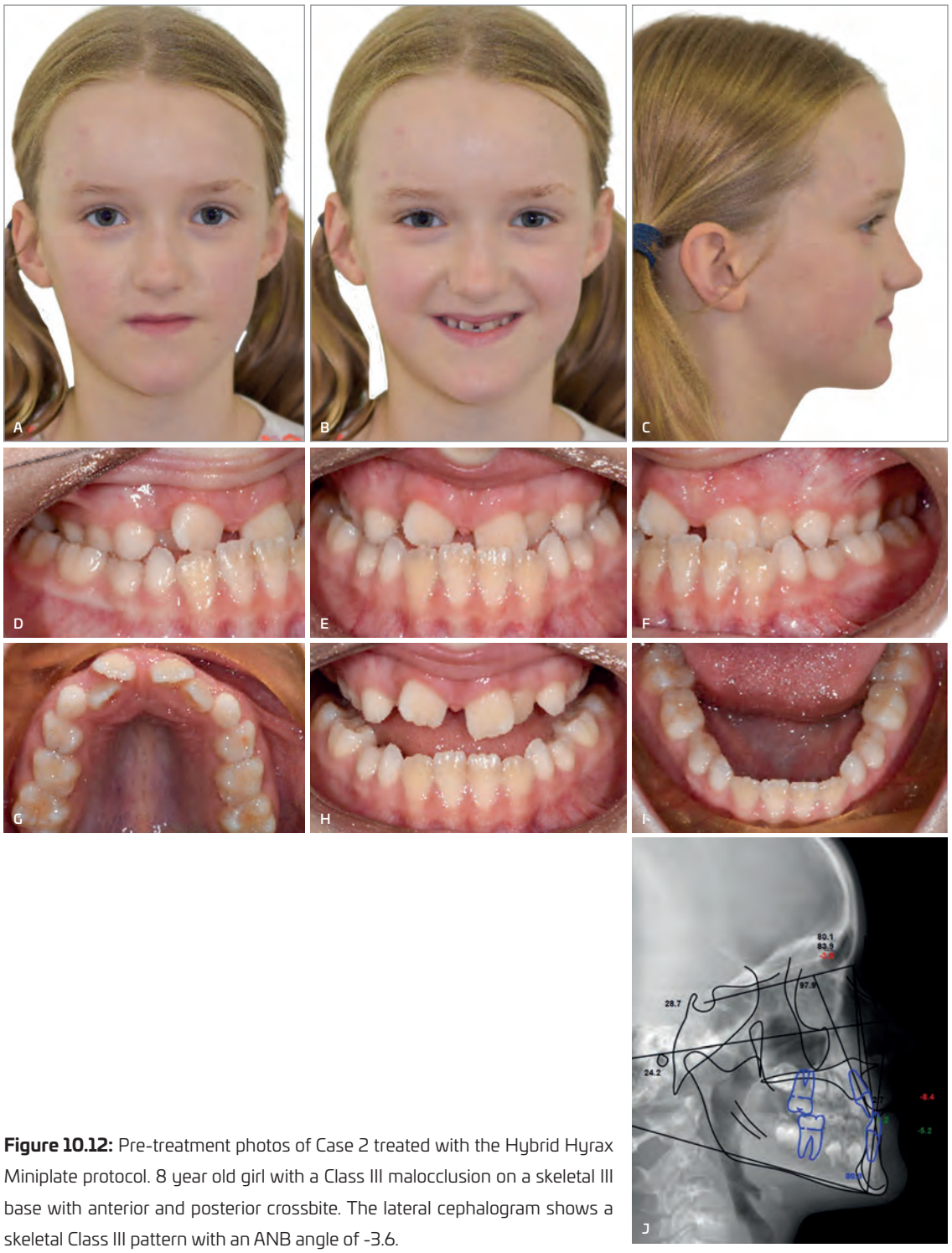

Figure 10.12: Pre-treatment photos of Case 2 treated with the Hybrid Hyrax Miniplate protocol. 8 year old girl with a Class III malocclusion on a skeletal III base with anterior and posterior crossbite. The lateral cephalogram shows a skeletal Class III pattern with an ANB angle of -3.6.

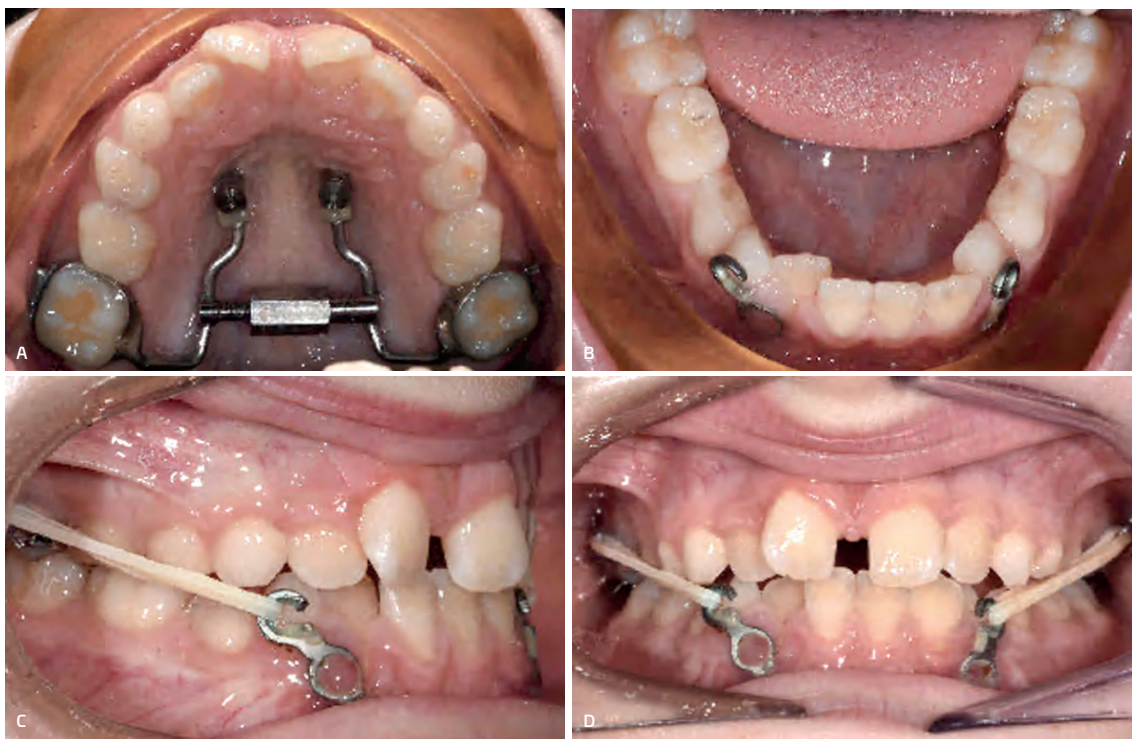

Figure 10.13: Intra oral views of Hybrid Hyrax Miniplate protocol used in Case 2.

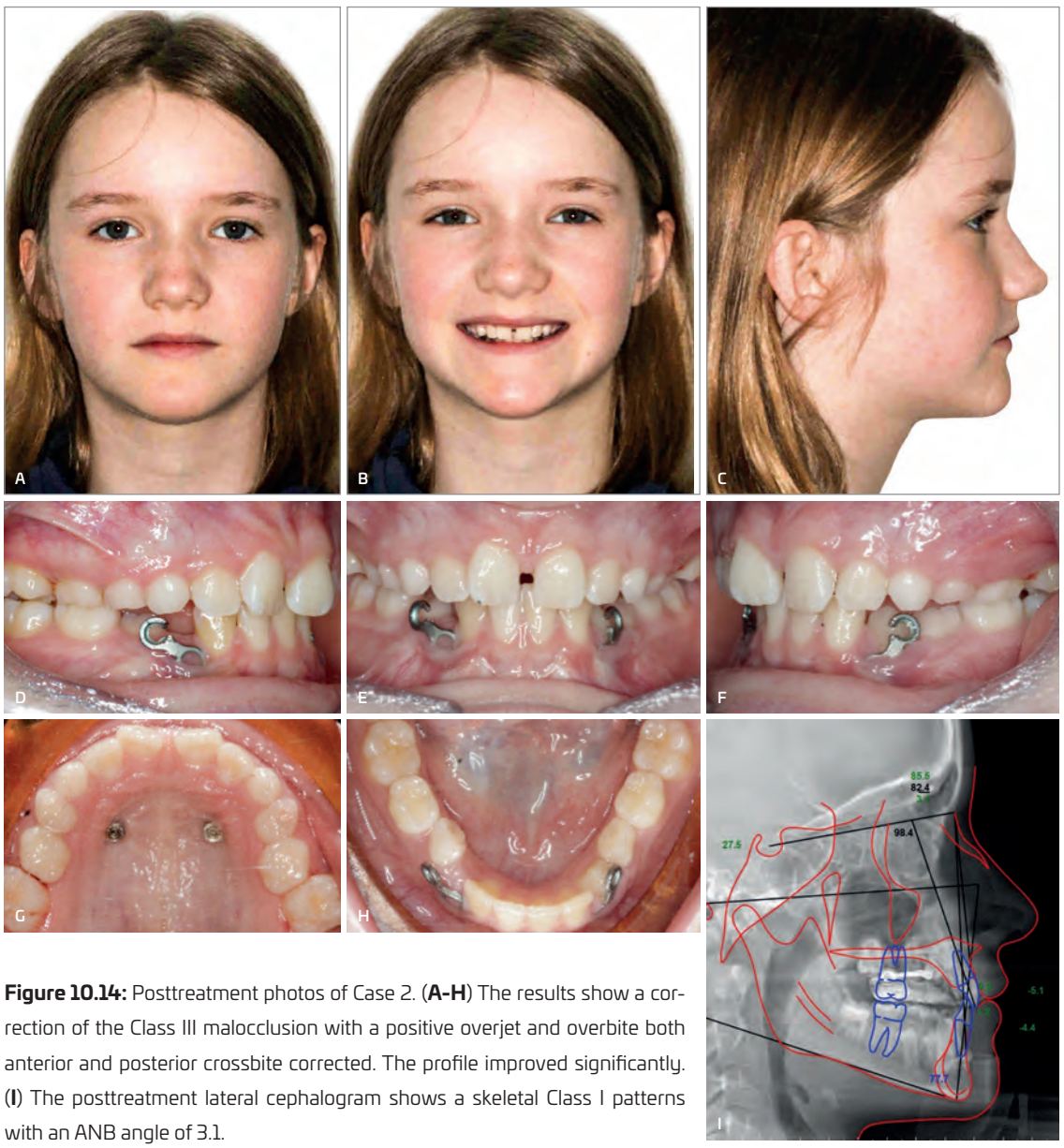

Figure 10.14: Posttreatment photos of Case 2. (**A-H**) The results show a correction of the Class III malocclusion with a positive overjet and overbite both anterior and posterior crossbite corrected. The profile improved significantly. (**I**) The posttreatment lateral cephalogram shows a skeletal Class I patterns with an ANB angle of 3.1.

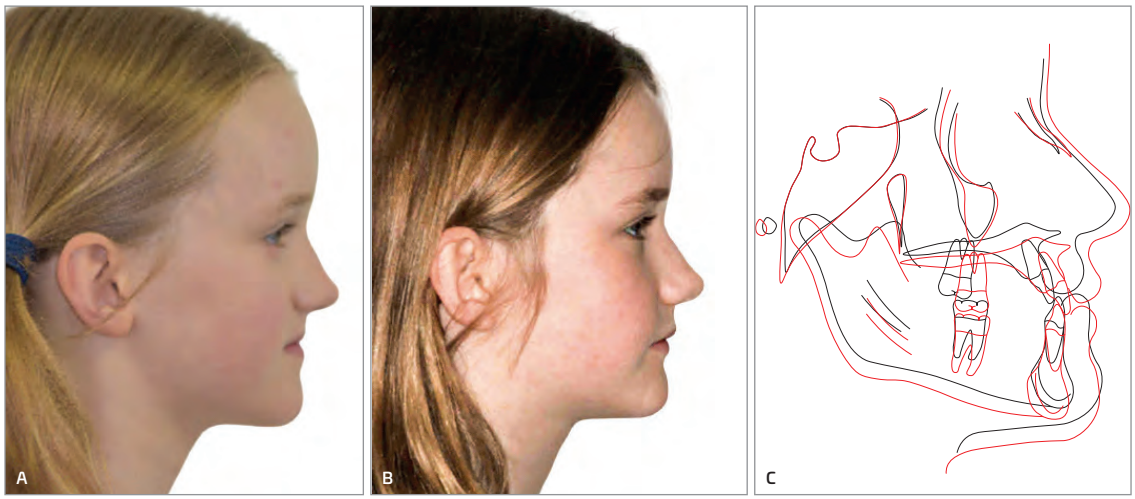

Figure 10.15: (**A**) Pre-treatment profile showing maxillary deficiency. (**B**) Posttreatment profile view showing significant improvement in the Class III pattern. (**C**) Cephalometric superimpositions pre-treatment black and posttreatment red showing significant maxillary advancement and redirection of mandibular growth.

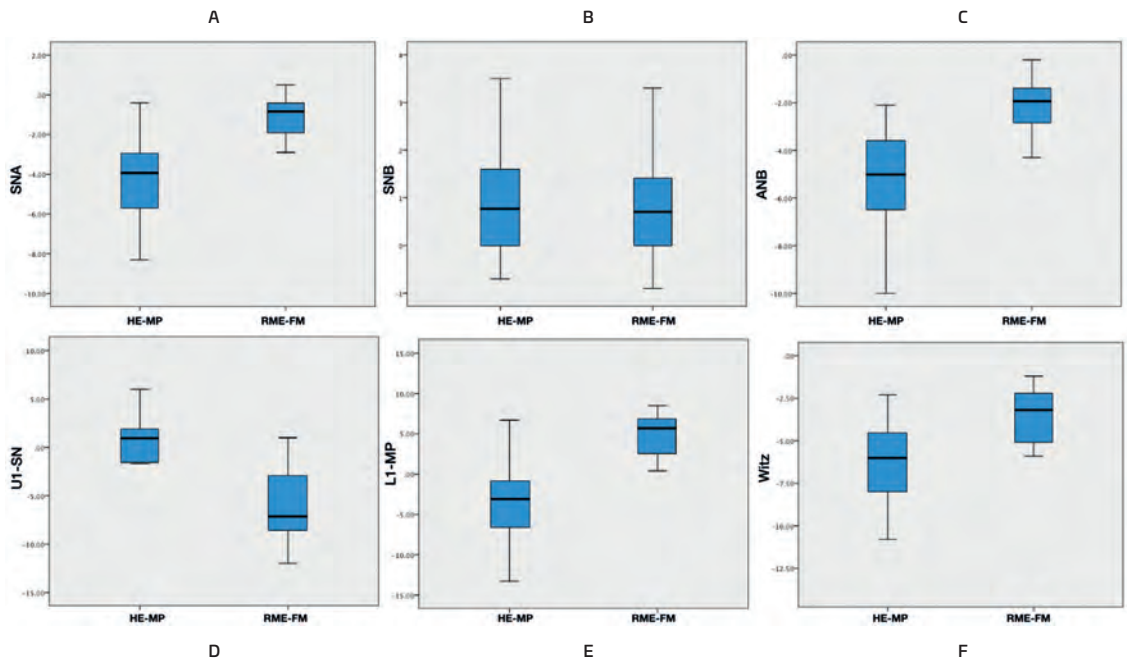

Figure 10.16: Box plots of the results of Tarraf et al. (**A**) changes in the SNA angle were greater with the Hybrid Expander and Miniplate combination HE-MP when compared to the tooth borne RME facemask (RME-FM). (**B**) similar effect on the mandible as shown by the SNB angle. (**C**) Overall greater skeletal change with the HE-MP as shown by the ANB angle and (**D**) showing greater linear skeletal change in the Witz appraisal. (**E**) Upper incisor to SN (U1-SN) showing no dental change in the upper with the HE-MP and significant proclination with RME-FM. (**F**) The lower incisors show advancement with the HE-MP as opposed to the retroclination seen with the RME-FM.

10.6.4 Hybrid Hyrax Miniplate combination versus Hybrid Hyrax Facemask

Only one study so far compared the two. Willmann et al.[38] compared the Hybrid Hyrax Mentoplate protocol with the Hybrid Hyrax facemask. They looked at the pre- and post-treatment lateral cephalograms of 34 cases, with 17 in each group. The results showed that the effect on the maxilla was almost identical, with both groups showing a 2.23 degree increase in the SNA angle. Nevertheless, the facemask group showed a greater reduction in the SNB, which was attributed to the greater backward rotation of the mandible in the facemask group. The mandibular plane angle did not significantly change in the Mentoplate group, while it increased by 1.2 degrees in the facemask group. The authors concluded that the effects of the two protocols were very similar, but that the Mentoplate protocol may be a better choice in cases where greater vertical control is required.[38]

Nevertheless, the average age of both groups was under 10 years old and it may be argued that with older children the results may be in favour of the Hybrid Hyrax and miniplates combination. Older children are less likely to be accepting of the extraoral facemask. In addition, they will not sleep enough hours to make bedtime wear effective.

10.6.5 Elastic wear protocol for intraoral maxillary protraction

While some authors[73] started with 200 g elastics from the outset it may be prudent to follow the protocol used by DeClerck et al[88] which advocated gradually increasing the elastic strength. By progressively increasing the elastic force the bone density[95] around the miniplates will gradually increase and thus increase miniplate stability.

The loading can be started with elastic forces of 100 g per side and the patients are instructed to wear the elastics full time, replacing them at least once a day. The elastic force can then be progressively increased up to 200 g per side after 6-8 weeks and maintained for twelve months or more.

Elastic wear can be started within two weeks of the placement of the plates according to De Clerck88 while others[77] suggested a 6-8 week healing period. There is currently little literature to support either method and both seem to have good success rates.

10.6.6 Why treatment with skeletal anchorage takes longer

Tarraf et al. found that in order to achieve the same overjet treatment with the Hybrid Expander miniplate combination took on average two to three months longer than for conventional RME facemask.[77] In fact, despite the longer treatment time and the significantly greater skeletal correction, the Hybrid Expander miniplate group showed slightly less improvement in overjet. Similar findings were also reported by De Clerck et al. in their study comparing the BAMP protocol with RME facemask.[92] The treatment was approximately two months longer with the BAMP method.[92] This can be explained by the lack of dental compensation when skeletal anchorage is used in the mandible. When tooth borne Class III correction is used, 40-60% of the correction comes from mesial movement of the maxillary molars, proclination of the maxillary incisors and retroclination of the mandibular incisors.[21] This occurs concomitantly with the skeletal correction and thus serves to correct the overjet in a shorter period of time. When skeletal anchorage is being used, the dental compensation is eliminated, and thus the entire overjet correction is achieved through skeletal changes only, which explains the longer duration of such treatment. Additionally, in the skeletal anchorage groups the lower incisors advanced slightly during treatment, detracting more from the overjet correction, as opposed to the retroclination of the lower incisors seen with the RME facemask.

The second factor that may play a role in slower correction with Hybrid Expander miniplate treatment is the lack of backward rotation of the mandible. There was no significant reduction in the SNB angle, nor was there an increase in the mandibular

plane angle reported in the in the Hybrid Hyrax miniplate[38,77] and BAMP groups.[92] On the other hand, with the facemask, a reduction in the SNB by 1 degree on average contributed significantly to the overall skeletal correction and would have also facilitated overjet correction.[38,77 92] This was mainly attributed to the increase in the mandibular plane angle which was caused by backward rotation of the mandible.

10.7 Variations of the Hybrid Hyrax

10.7.1 Combination of maxillary expansion and distalization with maxillary protraction in crowded Class III cases

Class III malocclusion can often be associated with maxillary transverse deficiency and dental crowding. In addition, ectopic eruption of the maxillary first molars is often observed in cases with maxillary deficiency, which can lead premature loss of the deciduous second molar and reduced arch length.[96] Maxillary expansion alone may not be enough to relieve such crowding and extractions in the maxillary arch in Class III cases are usually undesirable. Molar distalization can be very helpful in such cases to relieve the crowding. Appliances such as head gear would not be desirable for molar distalization as it may negatively influence maxillary growth while tooth borne distalizers would lead flaring of the maxillary anterior segment which is also undesirable.[97] Wilmes et al. proposed combining the Hybrid Hyrax and maxillary protraction with mini-implant supported distalization using the Hybrid Hyrax Distalizer.[98] The appliance can be used for maxillary protraction with facemask (Fig. 10.17 to Fig. 10.22)[98] or in combination with miniplates in the mandible (Fig. 10.23 to Fig. 10.26).[99] This unique approach allows maxillary skeletal development in the antero-posterior and transverse dimension while increasing the maxillary arch depth and length through molar distalization thus addressing maxillary crowding.

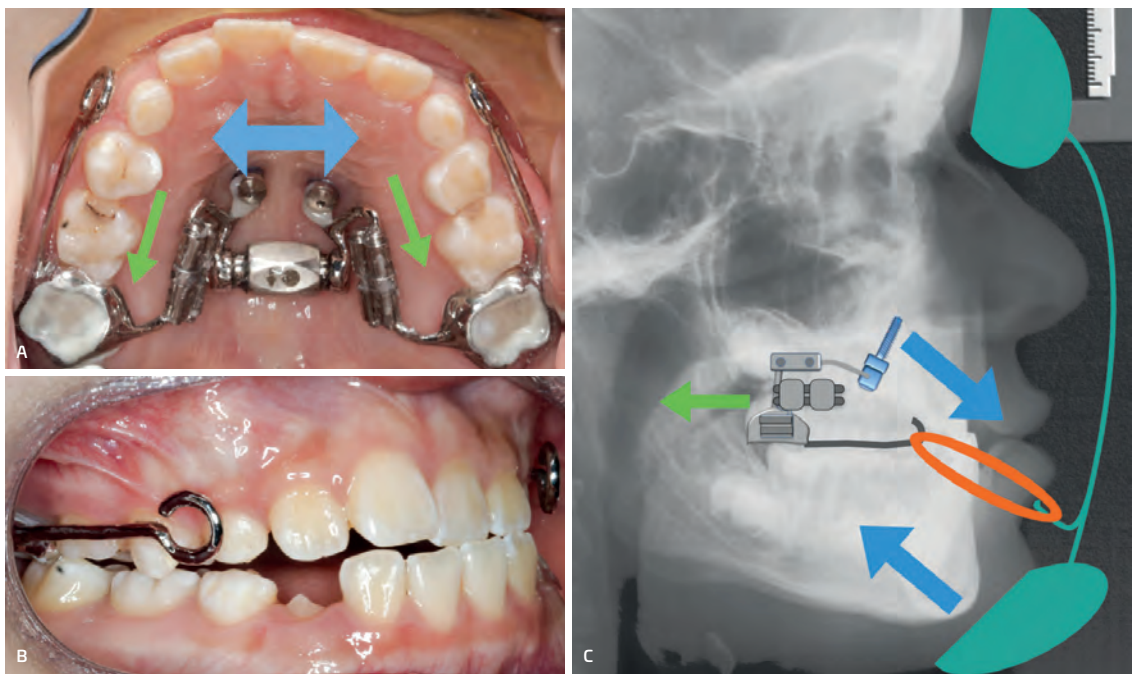

Figure 10.17: Hybrid Hyrax Distalizer with facemask. (**A**) Occlusal view of the appliance the blue arrow shows the vector for the orthopaedic expansion force and the green arrow. (**B**) buccal view with facemask hook. (**C**) Diagrammatic representation of the orthopaedic forces acting on the maxilla and mandible with the protraction facemask blue arrows and green arrow for the dental distalization.

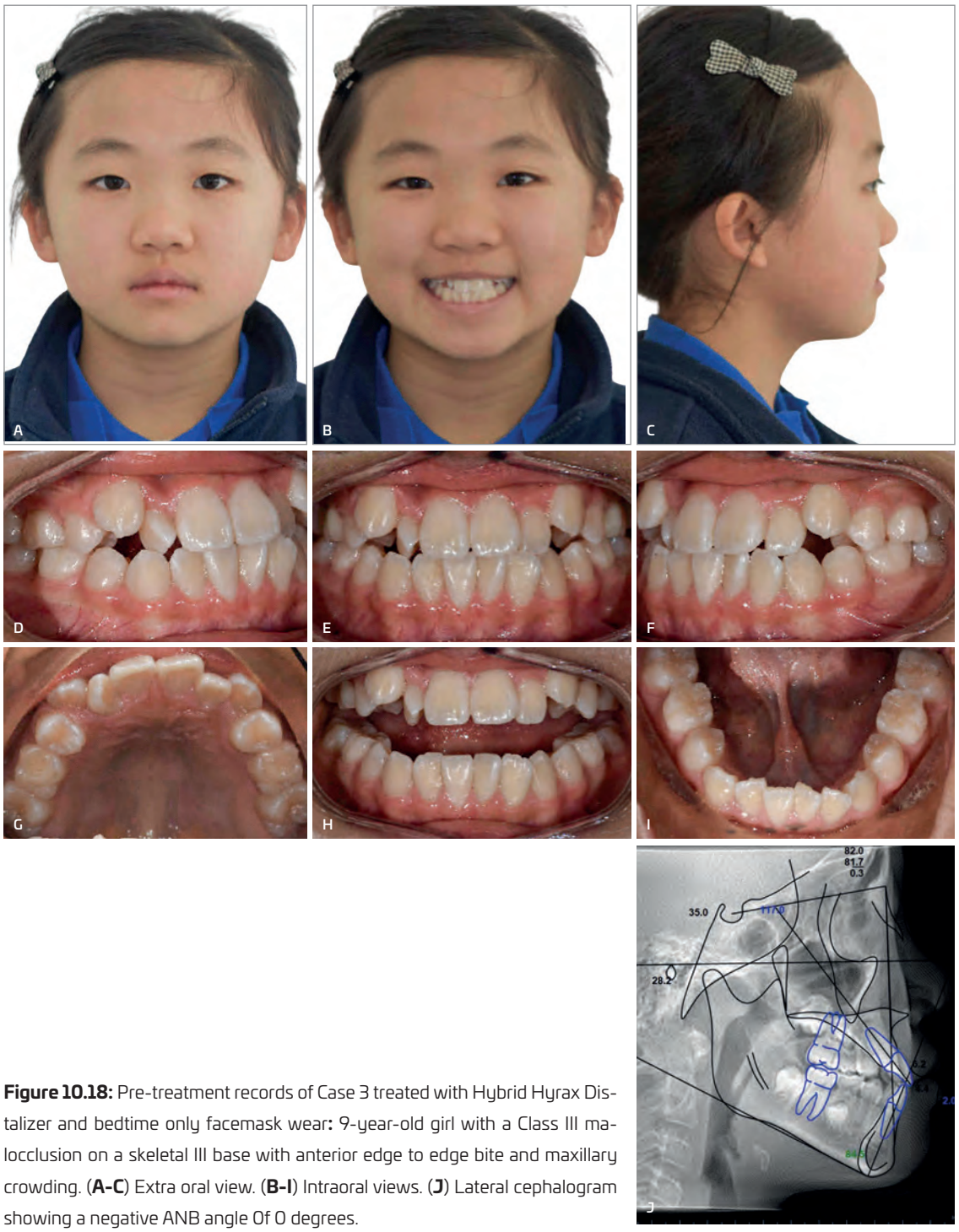

Figure 10.18: Pre-treatment records of Case 3 treated with Hybrid Hyrax Distalizer and bedtime only facemask wear**:** 9-year-old girl with a Class III malocclusion on a skeletal III base with anterior edge to edge bite and maxillary crowding. (**A-C**) Extra oral view. (**B-I**) Intraoral views. (**J**) Lateral cephalogram showing a negative ANB angle Of 0 degrees.

Figure 10.19: Case progression photos Case 3. (**A,B**) Treatment start. (**C,D**) Expansion and distalization progressing with space opening for the canines. (**E,F**) End of active treatment with positive overjet and distalization created enough space for alignment of the canines.

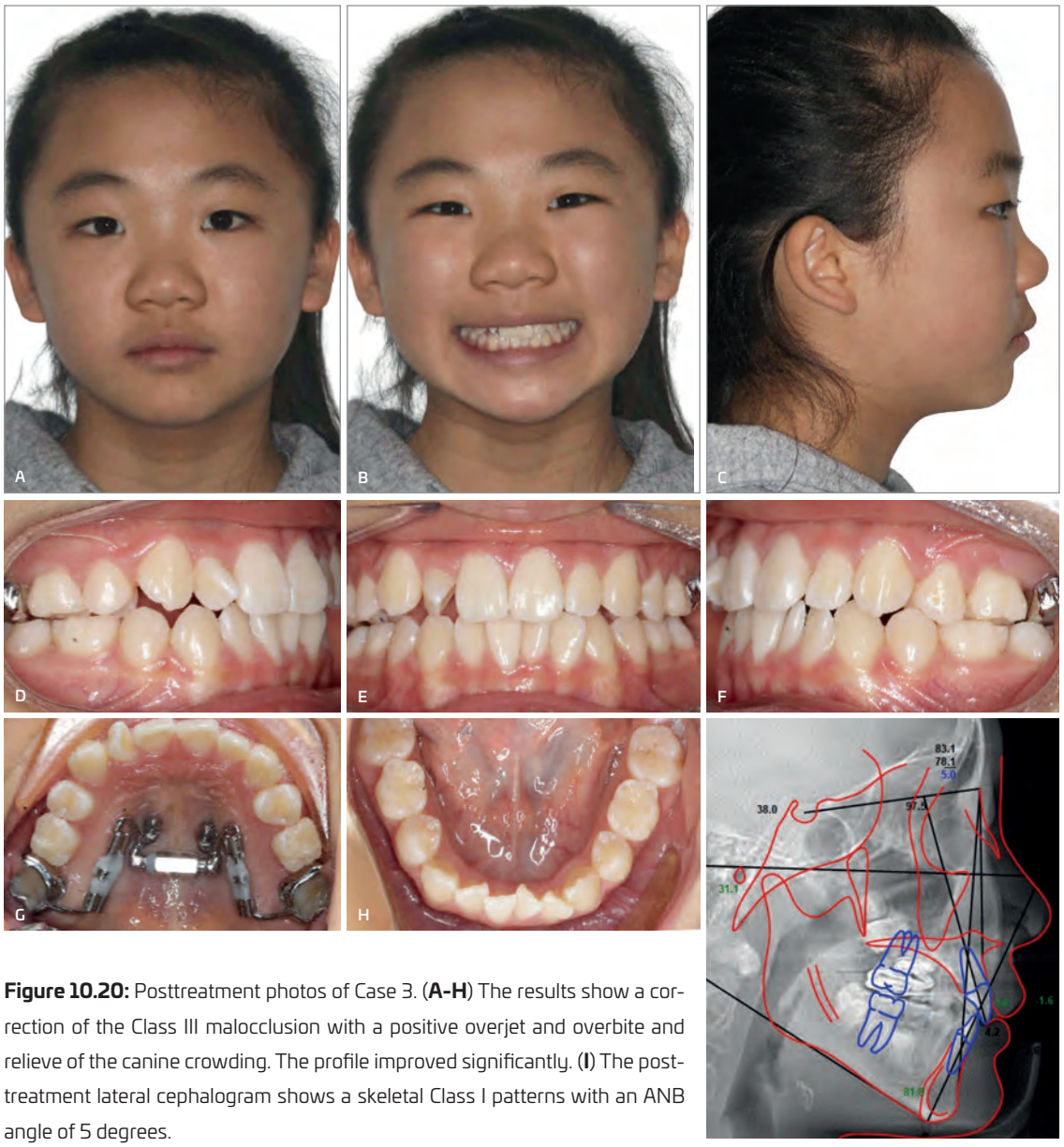

Figure 10.20: Posttreatment photos of Case 3. (**A-H**) The results show a correction of the Class III malocclusion with a positive overjet and overbite and relieve of the canine crowding. The profile improved significantly. (**I**) The posttreatment lateral cephalogram shows a skeletal Class I patterns with an ANB angle of 5 degrees.

Figure 10.21: (**A**) Pre-treatment profile with maxillary deficiency evident. (**B**) Posttreatment profile with improvement in upper lip position and profile convexity. (**C**) Cephalometric superimpositions pre-treatment black and posttreatment red showing significant maxillary advancement and redirection of mandibular growth. The maxillary anterior teeth slightly retroclined because of the distalization.

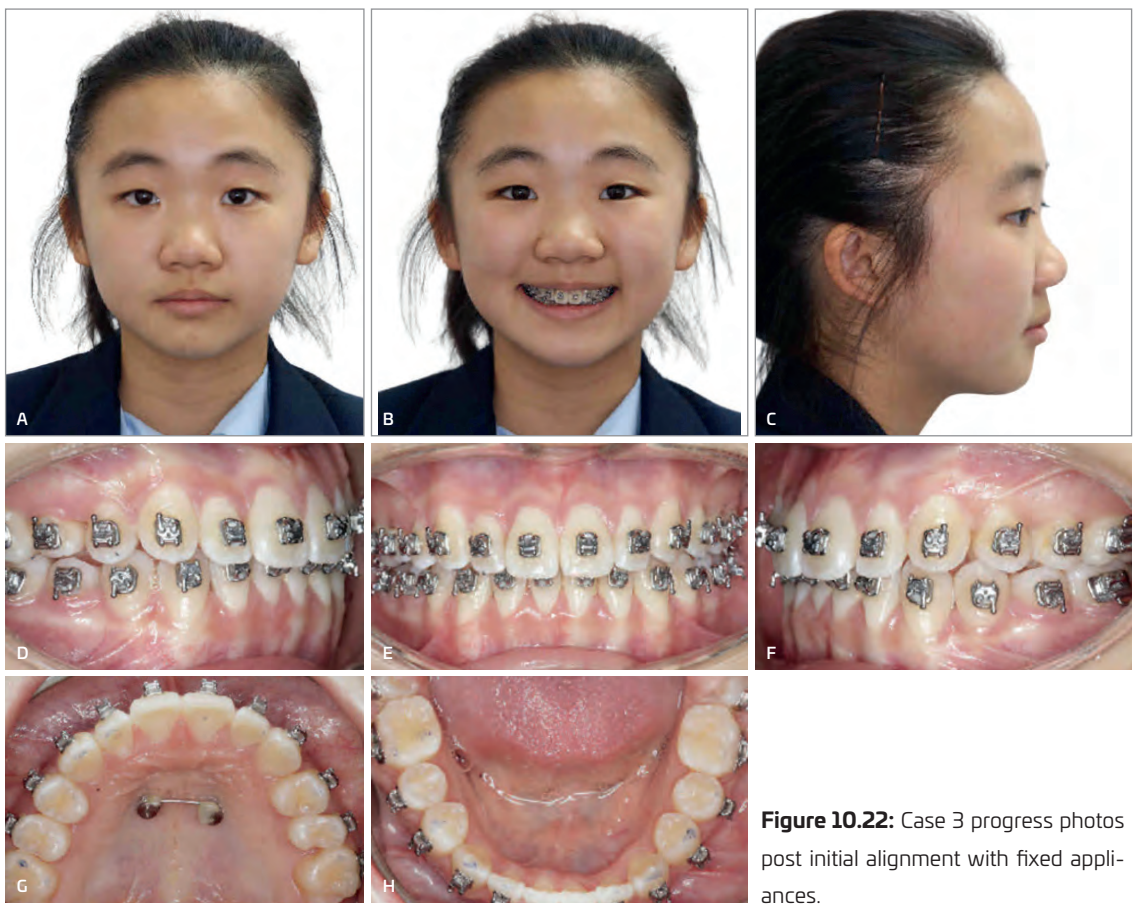

Figure 10.22: Case 3 progress photos post initial alignment with fixed appliances.

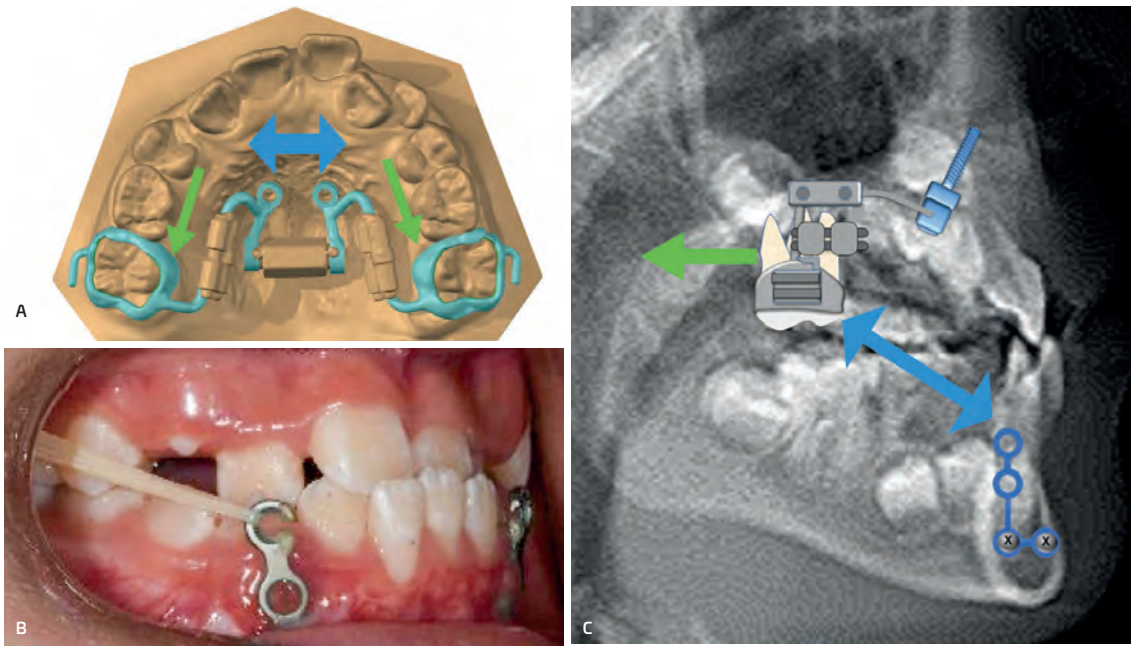

Figure 10.23: Hybrid Hyrax Distalizer with Miniplates. (**A**) Occlusal view of the appliance the blue arrow shows the vector for the orthopaedic expansion force and the green arrow. (**B**) Buccal view with elastics running from the hook on the molar band to mandibular miniplate. (**C**) Diagrammatic representation of the orthopaedic forces acting on the maxilla and mandible with the elastics to the miniplate blue arrows and green arrow for the dental distalization.

Figure 10.24: (**A-I**) Pre-treatment photos of Case 4 treated with the Hybrid Hyrax Distalizer and Miniplate protocol. 9-year-old girl with a Class III malocclusion on a skeletal III base with anterior crossbite and crowding. (**J**) The lateral cephalogram shows a skeletal Class III pattern with an ANB angle of -1 degrees.

Figure 10.25: Case progression photos Case 4. (**A,B**) Treatment start. (**C,D**) Expansion and distalization progressing with space opening for the canines. (**E,F**) Case progression with space opening for the maxillary canines. (**G,H**) End of active treatment with positive overjet and distalization created enough space for alignment of the canines.

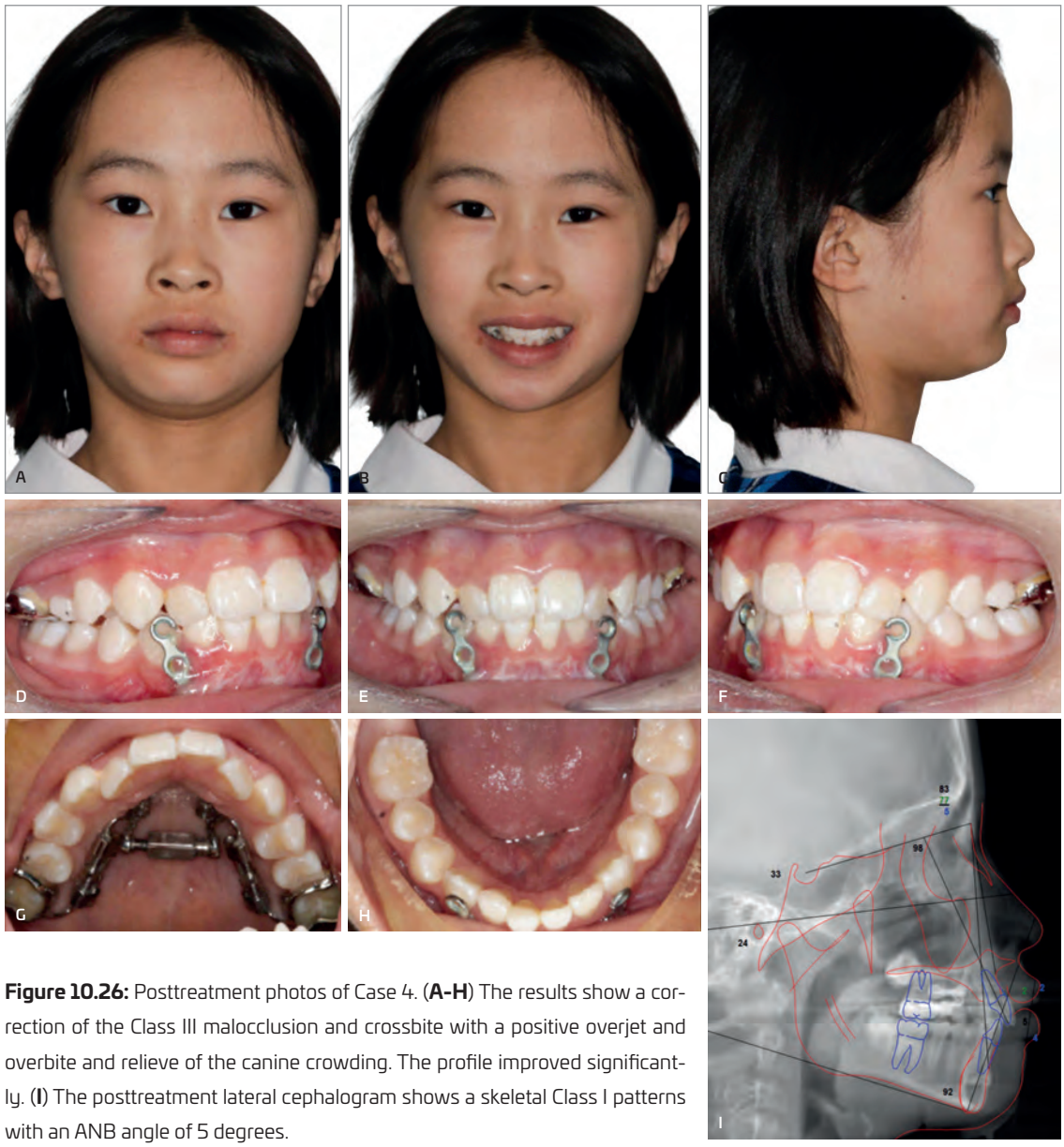

Figure 10.26: Posttreatment photos of Case 4. (**A-H**) The results show a correction of the Class III malocclusion and crossbite with a positive overjet and overbite and relieve of the canine crowding. The profile improved significantly. (**I**) The posttreatment lateral cephalogram shows a skeletal Class I patterns with an ANB angle of 5 degrees.

10.7.1.1 Maxillary expansion and distalization protocol

After an initial period of 2-3 weeks of expansion maxillary protraction is started with either a facemask[98] or with Class III elastics to mandibular miniplates.[99] After a period of 3-6 months of protraction and once a positive overjet is achieved the distalization can be started by asking the patient to activate the distalization screws 0.2 mm once a week while continuing the maxillary protraction.

10.7.2. Compliance free Tooth-Bone Borne corrector NET-3

Despite the use of skeletal anchorage with the Hybrid Hyrax facemask enhancing the results and the BAMP88 and HH-MP protocols increasing patient acceptance by eliminating the extraoral component, both methods are still 100% reliant on the patient adhering to the prescribed wear regimen. This can make the treatment unpredictable. The introduction of the NET3 corrector aimed to address this problem (Fig. 10.27). It consisted of a Hybrid Expander anchored on two palatal miniscrews and two maxillary first molars with a cantilever bite jumper design, like a reversed Herbst appliance. The intermaxillary force was provided through a modified PowerScope spring (American Orthodontics, Sheboygen, WI, USA) with 260 g of force, which was placed after expansion. The lower appliance was a modified lingual arch. The appliance was tested in

Figure 10.27: The NET3 corrector setup. (**A**) Maxillary appliance with SuperScrew (The SuperScrew-SuperSpring Co. Los Angeles, CA, USA) and cantilever arms. (**B**) Active appliance with shims or split stops added to activate the spring further; (**C**) Lower lingual arch with Herbst attachment on the buccal surface of the molar crowns. (**D**) Diagrammatic illustration of the biomechanics of the NET3 corrector.

prospective clinical trial and compared with conventional RME facemask.[77]

By using a completely intraoral approach that does not require patient compliance, the NET3 corrector enhances the operator's control over the treatment. The results in terms of skeletal correction and patient tolerance were encouraging. However, there are still some limitations to this approach. Firstly, the lower component is only tooth-borne, and there were significant dental side effects in the mandible. Although this may be acceptable in mild and moderate cases, this may be quite undesirable in more severe cases. A future improvement and direction for future research could be to consider the use of a compliance-free design in conjunction with mandibular skeletal anchorage.

10.7.3. Class III treatment in late adolescence

With advanced age the maxillary growth slows down and sutural interdigitation increases reducing the response to protraction forces. The resistance to transverse maxillary expansion also increases.

There are two approaches to help increase the response the maxillary growth modification in such cases.

The Alt-RAMEC protocol[78] or one of its variations is recommended in more mature adolescents. Alternating rapid maxillary expansion and contraction (Alt-RAMEC) of 7 mm per week for nine weeks has been found to disarticulate the circummaxillary sutures and increase the responsiveness to maxillary protraction especially in late Class III treatment.[100,101] With the increase in the resistance to maxillary expansion and the heavy loading involved in Alt-RAMEC there is concern that anchorage teeth can suffer negative side-effects such as root resorption, alveolar bone fenestrations and dehiscence.[102,103] It is recommended that a modified Hybrid Hyrax namely the Hybrid Quadexpander be adopted in such cases (Fig. 10.28). Instead of only two miniscrews in the anterior palate the Hybrid Quadexpander uses 4 miniscrews, two in the anterior palate and two in the palatal alveolar process between the first molar and the second premolar, which is an area of the greatest root separation,[104] thin keratinized mucosa[71] and good bone density.[71] The second modification is instead of the Hyrax screw the Hybrid Quadexpander uses the Power-Screw (Tiger Dental, Bregenz, Austria) or the Super-Screw (The SuperScrew-SuperSpring Co. Los Angeles, CA, USA). The hex-nut design makes it easier for patients to activate the expander themselves. Furthermore, the wrench activation allows for greater leverage to overcome the increased resistance to expansion in more mature patients where the activation pin of the Hyrax screw has been found to bend. In addition, laboratory testing showed that both the Power-Screw and the Super-Screw outperformed the Hyrax screws in the ability to sustain the mechanical demands of expansion in more mature patients.[105]

Figure 10.28: The Hybrid Quadexpander with two miniscrews in the anterior palate and two miniscrews in the palatal alveolar process between the second premolar and first molar and a molar band.

After an initial period 7-9 week of Alt-RAMEC elastic wear can be started following a similar protocol as with the Hybrid Hyrax Miniplate described above.

10.8 Long Term retention after Class III growth modification

The long-term stability of Class III growth modification treatment remains a challenge. Class III cases are known to resume their original growth pattern once treatment is discontinued[106] and so close follow-up is required. Additionally, studies on the growth of Class III individuals show that their mandibles grow more and for longer than those of Class I individuals.[107]

At this stage there is insufficient data regarding long-term outcomes for Class III treatment using skeletal anchorage. Treatment with conventional tooth borne RME and facemask shows long-term stability in approximately 65-75% of cases.[28,86] With

the skeletal correction being greater in bone borne methods we can expect, that long-term, the results will be at least as stable if not better than previously reported.

Additionally, with tooth borne methods treatment must be discontinued after a certain period to avoid tooth damage and excessive dental side-effects. On the other hand, with bone borne methods treatment can go on for longer and even long-term retention using the bone borne Class III elastics can be considered, especially for more severe cases, without the risk of tooth damage.

In general, for long term stability the treatment should aim for an overcorrection and to achieve a good overlap between the maxillary and mandibular anterior teeth. The transverse retention is reasonably simple with the placement of a rigid stainless steel Beneplate (Fig. 10.29). We recommend leaving the miniscrews in place for 12-24 months after the initial treatment. Miniplates should also be left in place until follow-up indicates a stable result.

If after 12-24 months follow up there are signs of relapse that may outgrow the correction, then consideration can be made for a second phase of treatment. If the initial treatment was performed with the Hybrid Hyrax and facemask it may be prudent to consider the second treatment to be done using miniplates in the mandible combined with an appliance constructed on the palatal miniscrews. This can be either a new Hybrid Hyrax or a rigid transpalatal bar (TPA) anchored to the miniscrews (Fig. 10.30). If initial treatment already used miniplates they can then be used again.

The same protocol using a rigid TPA can also be considered when treating a severe

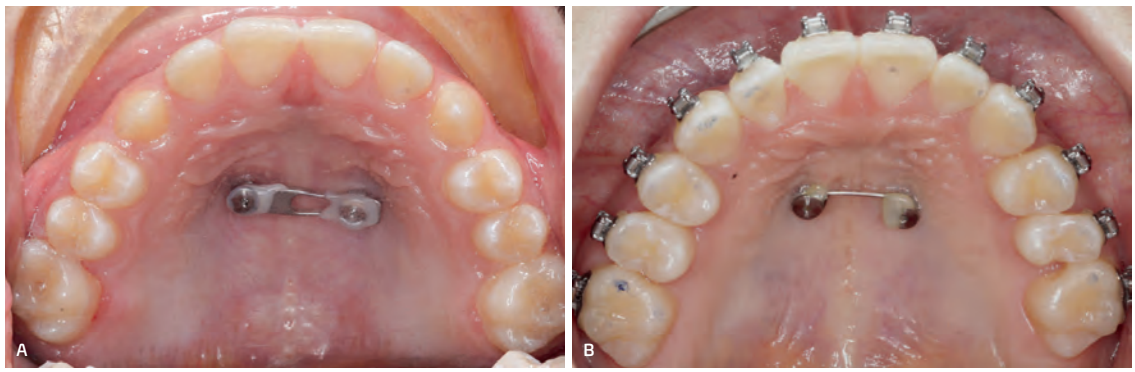

Figure 10.29: Skeletal retention protocol post Hybrid Hyrax to maintain skeletal expansion. (**A**) Beneplate (Benefit PSM Medical Solutions, Gunningen, Germany). (**B**) 0.8 stainless steel wire bend with two loops and fixed between the miniscrews.

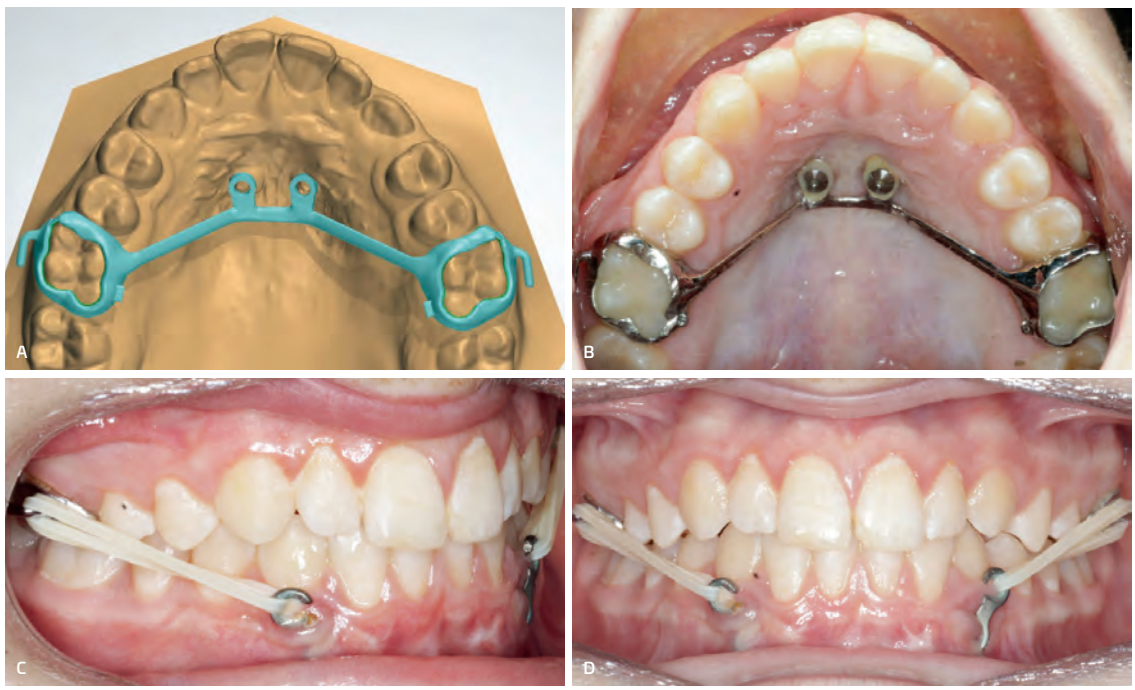

Figure 10.30: Start of active retention phase after Class III correction. (**A**) Digital design of rigid TPA, with buccal hooks and rings to fit the miniscrews. (**B**) CAD/CAM TPA cemented and fixed to miniscrews. (**C,D**) Continuation of Class III elastic traction from the mandibular miniplate to the hooks on the TPA for active retention.

Class III skeletal pattern with family history of a severe skeletal problem. In such cases it may be prudent to continue elastic wear, even if only part-time, during and after puberty to control the skeletal changes.

Success in the long-term management of severe Class III malocclusion using the presented methods requires patient commitment and motivation and such a long treatment can be considered burdensome for some patients and their families. A thorough discussion would be required before initiating treatment to weigh up the costs and benefits of this approach versus a potentially shorter intervention followed by a break, which could then be followed by orthodontic camouflage or a combined orthodontic and orthognathic surgical approach.

When it comes to long-term retention, the use of the BAMP method may be simpler. There will be no need for any components to be left on the teeth or for a rigid TPA to be constructed, adding cost, and also increasing the potential for tooth damage from cement leakages and decay on the anchorage teeth

10.9 Airway benefits from the Hybrid Hyrax

It has long been known that maxillary expansion has a positive influence on the nasal airway.[108] Maxillary expansion has been shown to increase the nasal patency, increase nasal airflow and reduce resistance to nasal beathing.[108-110] Furthermore, maxillary expansion has been successfully used in treating childhood sleep apnea (OSA) and sleep disordered breathing (SDB) in the absence of adeno-tonsillar hypertrophy.[111,112] It has also been shown that the best results in children with OSA and upper airway obstruction are achieved when adenotonsillectomy is complimented with maxillary expansion.[113]

The Hybrid Hyrax has been shown to have a greater effect on the nasal airway than conventional tooth borne maxillary expansion.[114,115] In a recent randomized clinical trial,

where rhinometry was performed to assess nasal airflow before and after expansion, children who were treated with the Hybrid Hyrax had a significantly greater increase in nasal airflow likened to the use of a nasal decongestant spray.[114] This is likely due to the use of miniscrews in the palate allowing a greater skeletal expansion at the maxillary base and the base of the nose. Using computational fluid dynamics it was also shown that all aspects of nasal ventilation improved with maxillary expansion, however, it was significantly greater with the Hybrid Hyrax than with two other tooth borne maxillary expansion appliances.[115] Thus, it can be concluded that in case where there is a history of upper airway obstruction and/or OSA it is recommended to use the Hybrid Hyrax appliance over a tooth borne appliance.

10.10 Summary and conclusions

The use of miniscrews in the anterior palate to support maxillary expansion and protraction with the Hybrid Hyrax overcomes many of the limitations of tooth borne appliances. The use of skeletal anchorage eliminates the unwanted dental side-effects of mesial migration of the buccal segments, incisor proclination and increased crowding. Secondly, the skeletal effects are greatly enhanced. Thirdly, the Hybrid Hyrax makes the treatment independent of the dentition. This allows effective anchorage in the late mixed dentition stage when the teeth offer poor anchorage.

Compared to miniplates in the maxilla weather for facemask or intraoral elastics the Hybrid Hyrax offers a simpler and much less invasive alternative. The miniscrews are safe, have a higher success rate and can be placed under local analgesia.

Additionally, maxillary expansion can be done with the same appliance using the same miniscrews. The Hybrid Hyrax is also versatile and Molar distalization can also be incorporated to manage Class III cases with maxillary crowding. The appliance can be

used in conjunction with facemask or mandibular miniplates for maxillary protraction depending on the age and needs of the patient.

Table 10.1: Recommendation for management of Class III malocclusion in growing children.

TREATMENT PROTOCOL	CASE SEVERITY	AGE GROUP	CLINICAL CONSIDERATIONS	ADVANTAGES	DISADVANTAGES
Tooth-borne RME-facemask combination (RME-FM)	Mild and mild to moderate	6-9 years *Good root support on the maxillary deciduous molars	• Expansion needed • Acceptance of facemask wear 13-16 hours a day	• Minimally invasive	• Extraoral facemask needed • Demanding wear regimen • Compliance-dependent • Undesirable dental side effects • Small total correction • Not effective in older children
Hybrid Hyrax expander-facemask combination (HE-FM; bedtime wear) *Consider adding distalizer in cases with crowding*	Mild, moderate and severe	7-10 years *younger than seven if safe placement of palatal miniscrews possible	• Expansion needed • Family rejected miniplates placement • Acceptance of wearing facemask to bed. **For more severe cases: can be used as a phase 1 treatment, and mandibular miniplates can later be inserted when safe placement is possible.*	• Expansion and protraction both using skeletal anchorage • No need for GA • Procedure completable in the orthodontic office; minimally invasive with few complications • Bedtime wear routine achievable for most young children	• Extraoral facemask needed • Compliance-dependent • Safe placement of the palatal miniscrews may be difficult before the eruption of the maxillary lateral incisors and in very narrow arches • Retroclines the lower incisors • Some backward rotation of the mandible

Table 10.1: (continuation) Recommendation for management of Class III malocclusion in growing children.

TREATMENT PROTOCOL	CASE SEVERITY	AGE GROUP	CLINICAL CONSIDERATIONS	ADVANTAGES	DISADVANTAGES
Hybrid Hyrax expander-miniplate combination (HE-MP) *Consider adding distalizer in cases with crowding*	Moderate and severe cases **Milder cases that reject the facemask*	7-14 years **Younger cases only when all lower incisors erupted*	• Expansion needed • Rejected/ not accepting of facemask/failed to comply with facemask • Active lifestyle • Long-term retention needed (family history of Class III)	• No need for extraoral devices • Expansion and protraction both using skeletal anchorage • Appliances are almost invisible • No dental side effects • Possibility to decompensate the lower incisors • Treatment maintainable long-term without difficulty; good option for severe cases • Full fixed upper and lower appliances usable in parallel • Well tolerated and accepted by older and active children • High success rate of maxillary anchorage unit	• Need for surgery adds cost, inconvenience and risk • Flap surgery required • More discomfort in early stages • Higher percentage of complications than palatal miniscrews • Compliance-dependent
Maxillary and mandibular miniplates (BAMP)	Moderate and severe cases	11-14 years old **lower canines erupted and maxillary bone dense enough for zygomatic miniplates*	• No expansion needed • Active lifestyle • Possible option for cases with a previous treatment that included expansion • Reasonably well aligned dentition • Long-term retention needed (family history of Class III)	• No need for extraoral devices • Appliances almost invisible • No dental side effects • Possibility of decompensating the lower incisors • Treatment maintainable long-term without difficulty; good option for severe cases • Full fixed upper and lower appliances usable in parallel • Well tolerated and accepted by older and active children	• GA needed • Four flap surgeries to place devices • Only after eruption of the lower canines • Higher failure rate of maxillary miniplates • More discomfort early on • Compliance-dependent

TREATMENT PROTOCOL	CASE SEVERITY	AGE GROUP	CLINICAL CONSIDERATIONS	ADVANTAGES	DISADVANTAGES
NET3 corrector	Mild and moderate cases	7-14 years old	• Expansion needed • Family or young patient who rejected wearing a facemask • Family rejected miniplates placement • Poor compliance with elastics or facemask recorded or expected • Ideally patient local to the clinic for adjustment and repairs.	• Compliance-free • Expansion and protraction both using skeletal anchorage • No need for GA • Procedure completable in the orthodontic office; minimally invasive with few complications.	• Skeletal correction slightly less than other bone-borne methods • Dental compensation in the lower arch • Higher frequency of breakages

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