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9-Year Follow-Up on Maxillofacial Implant-Supported Framework Designed to Accommodate Childhood Growth

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Abstract

This clinical report focuses on the challenges and solutions for a child subjected to craniofacial trauma from a wild hyena biting off his nose and anterior maxilla. Unique considerations in prosthodontics and biomedical engineering were required based on future craniofacial growth and development of the child. The physical requirement of a maximum retentive prosthesis for an active, athletic child required unique engineering designs and executions. The sequence of treatment and prosthesis fabrication are detailed. The patient has been followed for 9 years without physiologic complications and only minor prosthodontic complications.

KEYWORDS

Glabella, magnets, CAD-CAM, SFI-bar, craniofacial implants, maxillofacial prosthesis, nasal prosthesis

Maxillofacial prosthodontic treatment protocols for adult rehabilitation are well documented in the prosthodontic literature,[1–14] especially noted in a systemic review of classification of maxillectomy defects by Bidra et al.[15] Replacement of facial tissues and organs with prosthodontic materials, including the use of osseointegrated implants for improved retention, has provided patients afflicted with surgical and traumatic loss with rehabilitation permitting them to return to reasonable function and social acceptance.

Facial prosthodontic rehabilitation of children presents an entirely different set of challenges.[16–18] The prosthodontic team must consider the future cranial facial changes as the unaffected parts of the cranium and face mature. Changes in the osseous structures, as well as soft tissue changes, must be considered and long-term treatment plans established.[19–22] Additionally, children and adolescent youth are often active in sporting and energetic physical activities that require added retentive mechanisms with safety releases built into the prosthesis.

CLINICAL REPORT

History

A 6-year-old male was attacked by a wild hyena in Ethiopia where he sustained severe soft tissue loss to his orofacial region (Figs 1A-C). He sustained avulsion of the nose, upper lip, and part of the maxilla. There was a loss of the middle third of the upper lip. There was scarring of the right and left commissures of the lips. Surviving exsanguination with emergency first aid, a year later he was transported to the United States where a team of plastic surgeons successfully placed bilateral tissue expanders in the cheeks and reconstructed his upper lip (Fig 2A). A provisional silicon prosthetic nose was also constructed and retained with adhesive paste (Fig 2B). At 8 years old, the patient was fully engaged in school and related sporting activities. The adhesive retention of the initial nose proved inadequate and alternative biomechanics needed to be considered.

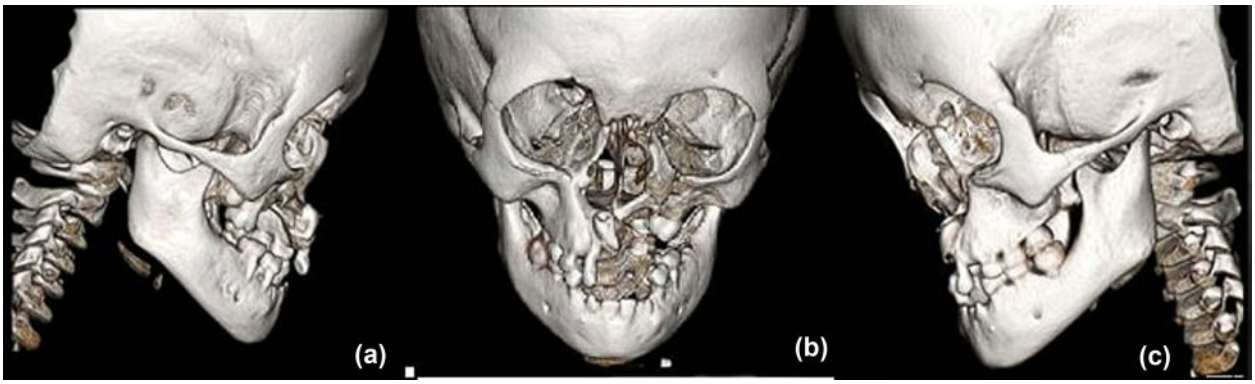

FIGURE 1 Three-dimensional reconstruction in (a) right lateral view, (b) frontal view, and (c) left lateral view, illustrating the degree of destruction created by the hyena bite

Treatment

The patient was transferred for reconstruction at the OMFS department at Geisinger Medical Center, Danville, PA. Following careful draping and isolation of the nasal complex region and under general endotracheal anesthesia, attention was drawn to two areas in preparation for placement of craniofacial implants. Utilizing the incision made by the plastic surgeon, in preparation for advancement of the upper lip, access was gained to the anterior maxilla in the area of the alar region of the nose and maxilla. Appropriate bone depth was clinically and radiographically evident. Two titanium implants were surgically implanted under copious irrigation. One extra-cranial style implant (4 mm Vistafix; Cochlear, Centennial, CO) was placed in the glabella region where 8 mm of bone was available,[2,23,24] and one implant (4 mm Vistafix; Cochlear) was placed in the left paranasal region. The implants were found to be stable upon placement and were permitted to osseointegrate without loading for 5 months. At this junction, the reconstruction commenced with a plastic surgeon in preparation for tissue expansion. Five months later, the two implants were found to be osseointegrated. In order to achieve a tripod form of retention for the future prosthesis, one implant (4.3 × 8 mm NobelActive; NobelBiocare, Yorba Linda, CA) was placed in the right paranasal area and found to be stable. Healing abutments were installed on the 3 implants and the incision was closed.

The patient was then referred to a private prosthodontic practice (Pi Dental Center, Fort Washington, PA) where board certified prosthodontists and a biomedical engineer used diagnostic tools, including CBCT data, to develop a treatment plan to enable the creation of a prosthesis that would meet the requirements of continued growth with maximum, yet safe, retention of the nasal prosthesis. When the treatment plan was completed, additional collaboration with a university (Temple University, Philadelphia, PA) maxillofacial prosthodontist and anaplastologist was necessary before the reconstructive process commenced.

The treatment plan required the construction of a rigid implant-retained framework capable of both magnetic retention of the removable nasal prosthesis and expansion to accommodate the future cranial facial growth of the patient.[6,10,16,19–22,25,23,24]

Preliminary impression

During the initial treatment visit and prior to removal of the healing abutments, a preliminary facial moulage was made to facilitate the construction of a primary stone cast and fabrication of a custom acrylic impression tray. The facial tissues, skin around the abutments, the eyelashes, eyebrows, and eyelids were coated with healing ointment (Aquaphor; Eucerin, Wilton, CT). Saline-soaked sterile gauze was then gently placed in the remaining nasal cavities to block out the impression material (Fig 2C). Alginate impression material (Jeltrate Plus; Dentsply Caulk, Milford, DE) was carefully applied to the face up to the corner of the eyes. Then, quick setting impression plaster (Cloverleaf; Healey Co, Bronx, NY) was gently layered on top of the alginate to create a stable base for removal of the impression (Fig 2D). Following removal of the preliminary impression and creation of a preliminary stone cast, an acrylic impression tray was constructed.

Definitive impression process

At the next treatment visit, the 3 implants were exposed under local anesthesia (Marcaine; Carestream Health, Palatine, IL) and a transdermal anesthetic salve (LidoCream 5; Golden Touch, Benton, KY) was applied to remove the healing abutments comfortably. Transmucosal abutments (Multi-Unit; NobelBiocare) were successfully installed. A 1 mm straight abutment was used in the glabella region while 17° 2 mm abutments were selected bilaterally for the implants in the maxilla. Immediately following abutment connection, prosthetic impression copings were secured with 10 mm guide pins.

Steel rods were then custom cut to a length extending approximately 10 mm beyond the impression copings in three directions creating a tripod of stability. The rods were

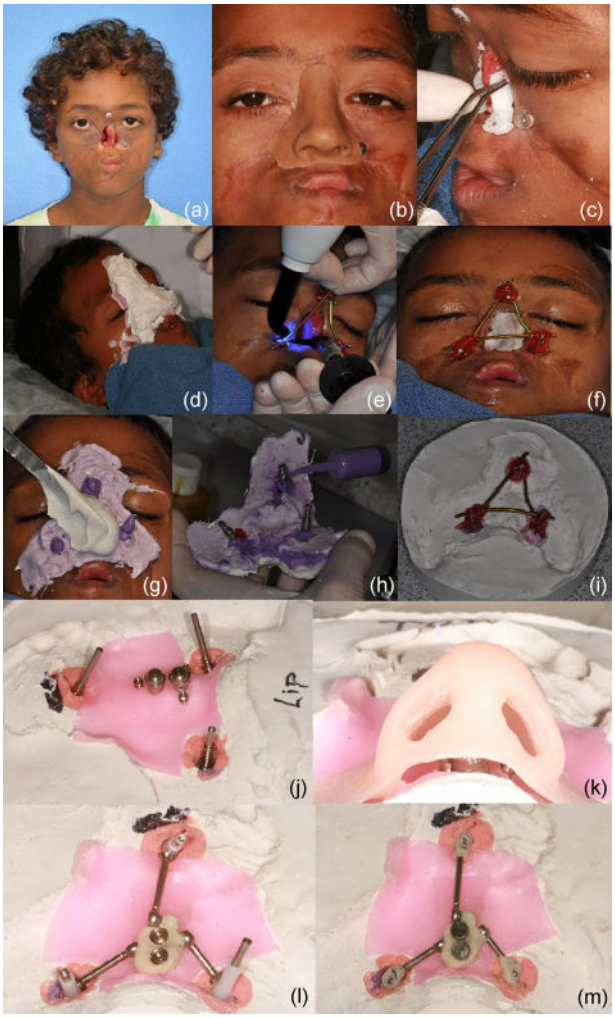

FIGURE 2 (a) Frontal view post-implant placement with healing cap visible on the implant installed in the glabella region. (b) Provisional silicone nasal prosthesis secured with medical adhesive. The retention of this prosthesis was inadequate for an active, athletic child. (c) Nasal passages were closed over with moistened gauze in preparation for the preliminary impression. (d) Quick set impression plaster was used over the alginate impression to develop a preliminary cast on which a custom tray and a diagnostic wax nose could be constructed. (e) Steel rods were connected with light-cured Triad gel. (f) Interlocking steel rods were connected with Triad to the impression copings in preparation for the master impression. (g) Silicone impression with Regisil bite registration material was used to cap off the guide pins securing the impression coping to the abutments. (h) The intaglio surface of the impression was refined by adding additional silicone material into voids creating a smooth surface for (i) the resulting master cast. (j) Two rare earth magnets and three Brånemark System abutment screw tops were positioned on baseplate wax in a location that will accommodate the (k) overlying prosthesis. (l) The initial construction of the "mother ship" design connected the platform holding the magnets to the three Brånemark System abutment stops that were repositioned to angle towards the three implants. Modified SFI-bars were screw-retained to the mother ship in approximation to the castable multiunit abutment cylinders. (m) Cold cure acrylic resin secured the ends of the SFI-bars to the castable multiunit abutment cylinders. The facial height of the cylinders was reduced to create a low profile in an effort to accommodate the overlaying silicone prosthesis

securely fastened to the impression copings with a light activated material (Triad Gel; Dentsply, York, PA) as illustrated in Figure 2E. The entire system was then carefully unscrewed and removed to ensure passive removal at the time of the impression.

Then the steel rod impression splint was retightened to the transmucosal abutments. The nasal passages were again blocked with moist gauze (Fig 2F) and a master impression was made with silicone (FX-302-1 Clone –A and Clone- B 1:1; Factor 2, Lakeside, AZ) around the bars and impression copings to provide a stone cast with the position of the implant abutments. Vinyl polysiloxane registration material (Regisil 2x; Dentsply Caulk) was applied to the tops of the guide pins prior to the application of quick set plaster (Fig 2G). With the plaster set, a thin area was reinforced with the light activated material (Triad Gel; Dentsply). Abutment replicas (Multi-unit; Nobel Biocare) were installed in the impression copings (Fig 2H) and a master cast was poured using a Type IV gypsum (Silky-Rock White; Whip-Mix Corp, Louisville, KY) (Fig 2I). Abutment healing caps were placed on the transmucosal abutments, and the adhesive-retained prosthetic nose was modified for maximum retention. The patient was dismissed.

Construction of the expanding framework pattern

The center of the fixed prosthetic nasal/facial reconstruction, termed the "Mother Ship", was designed to contain 2 rare earth magnet keepers (MAGNA-CAP; Factor II, Inc., Lakeside, AZ) and magnets (Midi Lip Magnet; Factor II) compatible with the original Brånemark System standard abutment. One thickness of base plate wax was used to cover the center of the stone cast to block out and provide cleansing space between the fixed framework and the nasal mucosa. The first step was to cut the coronal aspects of the abutment analogs (Abutment Replica Standard; Nobel Biocare) and connect the magnets and magnet keepers to assess the vertical height requirement. Then, the coronal aspects of three Brånemark System Standard Abutment Screws were cut off and positioned peripherally near the magnet system (Figs 2J and K). The bodies of the three Standard Abutments were not used.

Three castable prosthetic cylinders for the transmucosal abutments were installed on the abutment analogs in the area of the glabella and the maxilla. Afterwards, three "tube-in-tube" style bars (SFI-Bar-2 implants; Sterngold Dental, Attleboro, MA) designed for stress-free loading[26] were positioned near the castable prosthetic cylinders to help determine the position of the modified Brånemark System Abutment Screws in the mother ship. Auto-polymerizing resin (Jet; Lang Dental, Wheeling, IL) was then used to secure two magnet assemblies in the center of the mother ship and the three modified abutment screws in the proper direction to receive the rounded end of the stress-free bars. With the mother ship completely assembled, the stress-free bars were cut to the desired length, set into the proper orientation (Fig 2L), and

connected to the three castable prosthetic cylinders with additional auto-polymerizing resin (Jet; Lang Dental) (Fig 2M).

The acrylic resin retained to the implant/abutment connections was reduced as close to the cast without compromising the strength of the connection. The acrylic resin in the mother ship was also reduced to create as much space as possible for the new prosthetic nose. To allow for expansion of the "tube-in-tube" stress-free bars as the patient grows, a rubber wheel was used to slightly decrease the diameter of the inner tube ends to reduce friction.

Prior to dismissing the patient, custom healing prosthetic cylinders were constructed with the same dimensions as the end of the stress-free bars that will be casted and secured to each implant. This was accomplished to maintain the soft tissue profile during construction of the framework.

Framework fabrication

The three acrylic resin patterns that connect the stress-free bars to the implants were cast, finished, and polished. They were screwed onto the master cast and reassembled to the mother ship pattern. Each of the three extensions and the accompanying components were numbered (labeled with dots) to assure proper reassembly when the mother ship is milled in titanium. The master cast was also marked with corresponding dots.

The master cast and the entire framework assembly was packaged and shipped to a custom milling center (Nobel-Procera Innovation Centre; Quebec City, Canada) for copy-milling of the mother ship in a solid piece of titanium. The master cast and the resin pattern of the mother ship was optically scanned and the necessary standard tessellation language (STL) file was created for milling (Figs 3A and B). With the completion of the milled titanium mother ship, all the components were reassembled on the master cast (Fig 3C).

Fabrication of nasal prosthesis

The stone cast prepared from the initial facial moulage was used to sculpt a preliminary wax nasal prosthesis. The original adhesive retained nasal prosthesis, and photographs of family members were used as a guide in shaping the new nose. This wax nose was used during the design of the mother ship and the attachment to the implants to be sure they would fit into the confines of the proposed nasal prosthesis. The two magnets were installed on to the magnet keepers which were screw-retained on the mother ship. The magnets were joined together with auto-polymerizing resin (Jet; Lang Dental) and surrounded by two rubber tubes to maintain the access inside the nostrils of the silicone nose (Fig 3D). The wax pattern for the nose was then connected to the acrylic/magnet system. To prevent distortion of the fragile wax pattern a special two-pronged tool was constructed for easy removal of the wax pattern by lifting the acrylic/magnet complex (Fig 3E). Once the framework (including the mother ship) was fabricated and assembled to the master cast, it was confirmed that a new cast with more soft tissue coverage would be necessary for the final nasal prosthesis to cover the implants and produce the fine tissue margins.

Two magnets were connected with cold cure acrylic resin (Jet; Lang Dental), installed on the keepers attached to the cast. Wax relief was provided, and a custom tray (Fig 3F) was fabricated using light activated material (Triad Gel; Dentsply, York, PA). This tray incorporated the magnets and provided accurate positioning of the assembly (Figs 3F and H). The patient returned for delivery of the framework (Fig 3G) and the final impression was made that accurately captured: (1) the location of magnets in the mother ship, (2) the relevant soft tissue areas, and (3) the areas of the skin where the borders of the silicone nose would rest. The impression was accomplished in two stages: first, the custom tray was lined with light body impression (Imprint 4 Light; 3M ESPE, Germany) to capture the details for the borders of the silicone nose (Fig 4A); then, following the appropriate block-out of the framework, a second application of the same light body impression material is added to voids around the acrylic/magnet complex and replaced on the face aligning the magnets to the keepers (Figs 4B and C).

Brånemark System standard abutments analogs were installed on the magnet keepers in the impression. A new working cast was poured with Type IV gypsum (Silky-Rock; Whip-Mix Corp). A duplicate set of magnets connected with cold cure acrylic, keeping as low a profile as possible, were picked up inside the wax up of the nasal prosthesis. The wax up was tried on the patient (Fig 4D) and the sculpture was completed including any necessary adjustments to the fine wax margins on his face and the master cast. Clinical photos were taken of the patient and a base shade was mixed (Figs 4E and F) and recorded for the silicone to be used in the casting of the final prosthesis. The wax pattern was flasked with Type IV gypsum (Silky-Rock; Whip-Mix Corp). After the wax boiled out, the acrylic holding the magnets was cleaned with Acetone (Humco; Texarkana, TX), primed with a violet condensing primer (A-335; Factor II), and then allowed to bench cure for 30 minutes. The base silicone (Medical Adhesive Silicone Type A; Dow Corning Corp., Midland, MI) was then mixed and tinted to the previously selected base shade with Functional Intrinsic II Silicone Color (Factor II). The digital photographs taken of the patient were referenced while the mold was intrinsically painted with Type A Adhesive, thinned with an odorless turpentine substitute (Turpenoid; Weber, Philadelphia, PA), and tinted with a combination of The Functional Intrinsic II silicone and oil colors (Grumbacher, Inc., Bloomsbury, NJ). Then, the base shade was mixed, and the mold was filled and closed under pressure in a dental flask. The silicone was allowed to cure overnight and then deflasked and trimmed. With the patient present, the final prosthesis was tried on, the fit was confirmed, and extrinsic painting using Type A Adhesive thinned with Turpenoid and tinted with a combination of The Functional Intrinsic II silicone colors and oil Colors (Fig 4G).

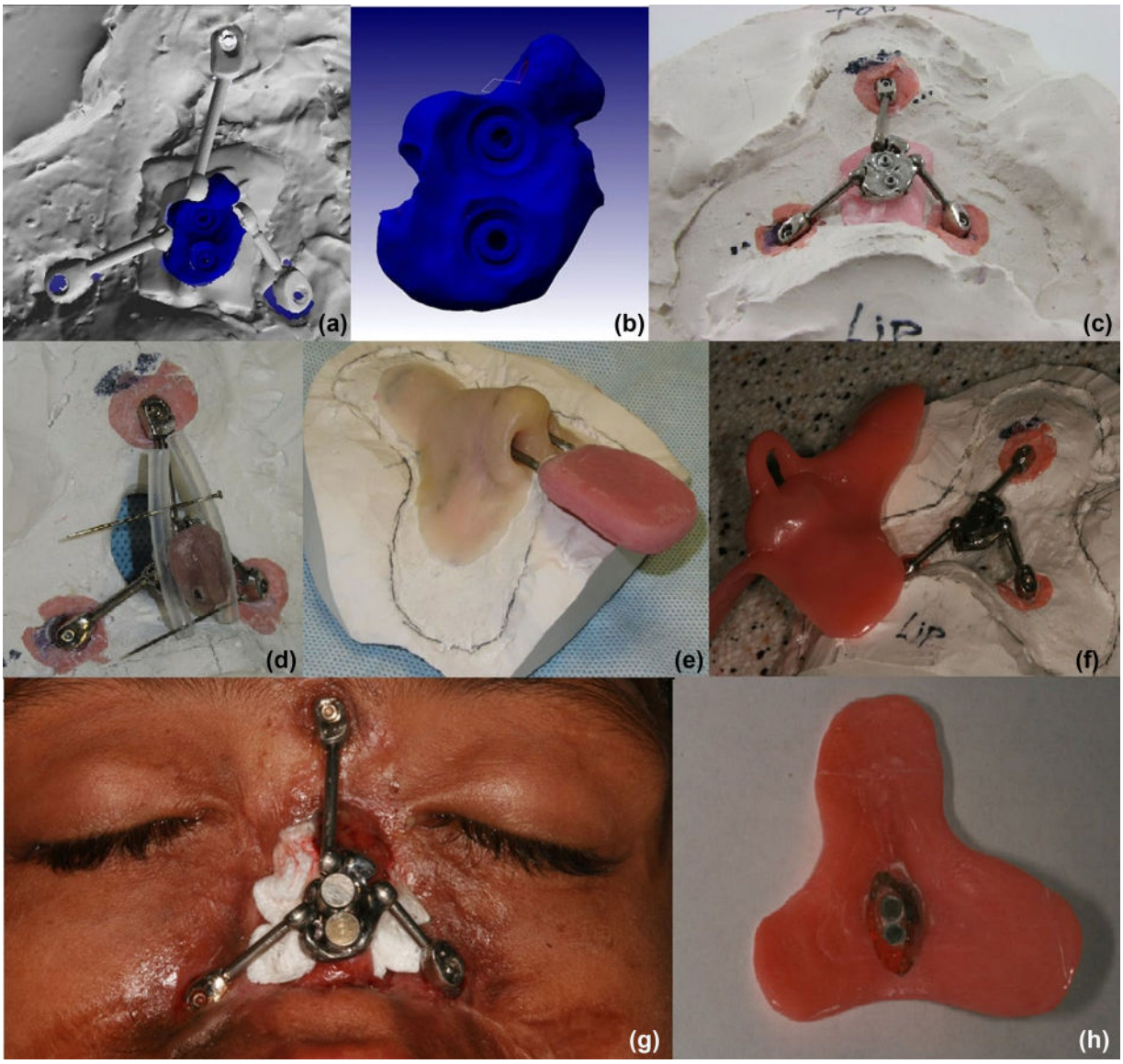

FIGURE 3 Standard tessellation language (STL) files were generated for the precision milling of the mother ship in titanium. (a) The entire master cast and SFI-bars were scanned as well as the (b) mother ship independently. (c) The robotically milled titanium mother ship was positioned on the master cast and connected to the transdermal implant anchorage units via the SFI-bars. (d) Rubber tubes were positioned to maintain air passage to the prosthesis nostrils. (e) The "nose picker" tool was developed to remove the prosthesis by lifting the magnets off the keepers. (f) Custom tray was designed to incorporate a spare set of magnets for repeatable reposition over the mother ship. (g) After delivery of the framework, the nasal passages were blocked and the surrounding skin, eyelashes, and eyebrows were lubricated prior to the final impression. (h) Intaglio side of custom tray illustrating the magnet position

A final clear coat of Type A Adhesive was placed to seal the paint coat and the prosthesis was dulled to remove the shiny surface. The prosthesis was delivered to the patient (Figs 4H and I). A post-operative cone beam computed tomography (CBCT) scan was taken to verify proper seating of all hardware (Figs 5A-C). Instructions on care and use of the prosthesis were reviewed with the patient and his family.

The supporting framework became loose on two separate instances in the course of the first year of follow-up. The first instance resulted from a direct hit from a soccer ball to the nose. The second instance was from a backpack full of books during a scuffle at school. After both instances, the patient returned to have the framework checked and retightened. Figure 6 illustrates a space in the SFI bar, indicating a small measure of expansion in the tube-in-tube assembly that connects to the implant placed in the glabella region. No evidence of space in the tube-in-tube assemblies that connect to the maxillary implants has been identified.

At the 9-year follow-up visit, the nasal prosthesis was removed, and the screws of the mother ship were checked. All screws were tight, and the mother ship was firm and stable. There was inflammation around the glabellar implant, as seen in Figure 7. A small amount of Chlorhexidine Gluconate was applied using a cotton-tipped applicator and cleaned around the implant connections. Prosthesis margins are well adapted to the tissues (Fig 8).

FIGURE 4 (a) Peripheral silicone border impression is followed by a (b) secondary impression over the mother ship and magnet keepers. (c) The completed definitive impression. (d) Wax try-in of sculpted nasal prosthesis approved by the patient and his family. (e) Pigment mixing to establish the base color for the silicone mixture was (f) tested on the patient's forehead. (g) Surface coloring in natural light was the last artistic touch in completing the coloration of the prosthesis. (h) The patient had his first look at his new prosthesis and then (i) tested the retentive capabilities with his natural athletic abilities

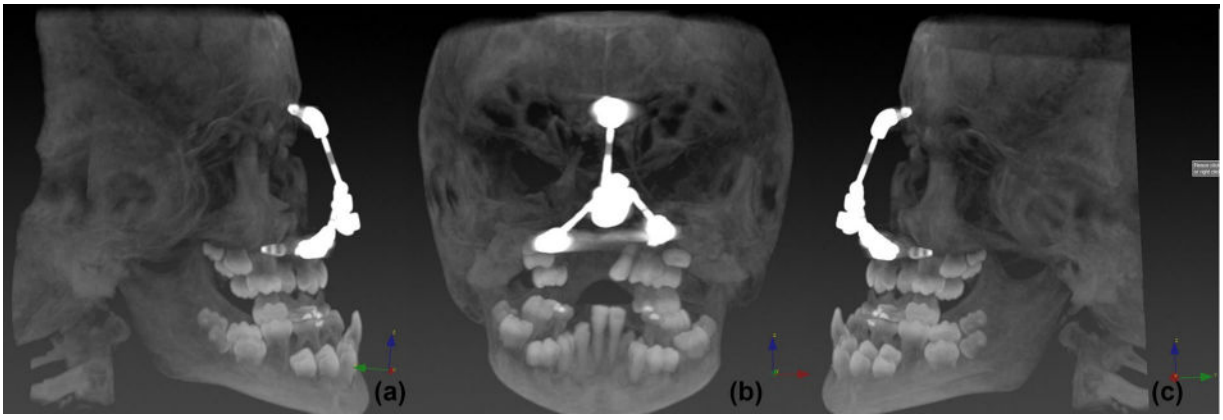

FIGURE 5 (a) Right lateral, (b) frontal, and (c) left lateral views generated from post-delivery CBCT scan, illustrated complete position of mother ship, SFI-bars, and craniofacial bone implant anchorage

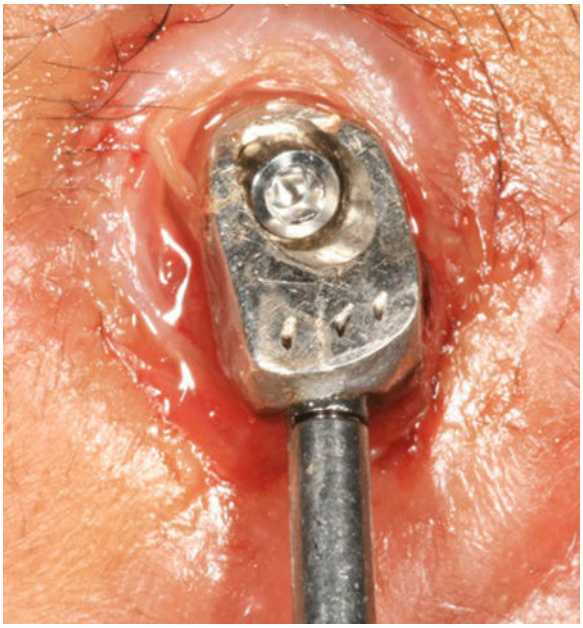

FIGURE 6 Expansion of the SFI-bar connected to the glabella after 1 year of follow-up

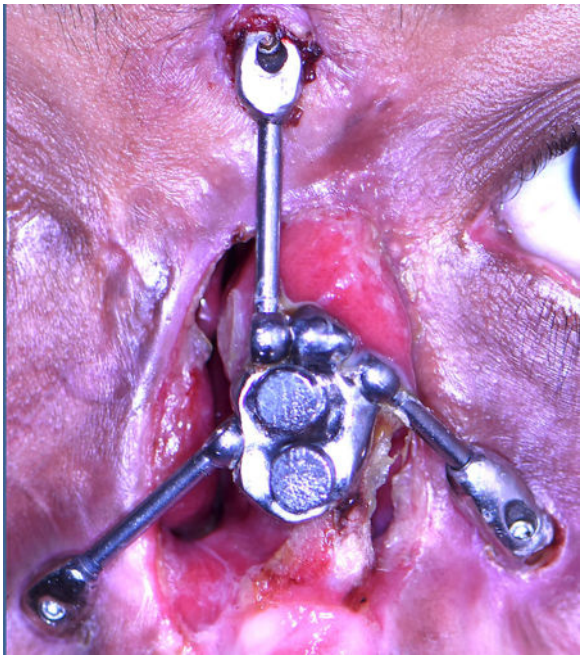

FIGURE 7 Framework at 9 years post maxillofacial treatment

Radiographic examination reveals implants remain osseointegrated (Figs 9A-C).

DISCUSSION

Cobein et al reviewed the retention systems for extraoral maxillofacial prosthetic implants.[27] In the nasal regions, bar-clips or magnets were most commonly selected by practitioners.[27] According to Cobein et al, selection is "primarily governed by indication and the practitioner's ability".[27] In the nasal region, Visser et al used a bar-clip in all of their auricular (60 patients) and nasal prostheses (9 patients),[28] while Karakoca et al chose the bar-clip for 7 of the 9 patients and magnets in 2 patients.[29] Karayazgan-Saracoglu et al preferred retention by magnets, as a result of the implants' angled orientations, for all ocular, nasal, and midface prostheses, and bars for auricular protheses.[30] Curi et al used magnet-retained nasal prostheses.[31] In complex midface craniofacial cases, Curi et al used magnetic retention in 71.4% (40/56 patients) of maxillofacial prostheses.[31] Curi et al used bar-clip retention in 28.6% of maxillofacial protheses (16/56 patients) when the patients were physically active to avoid accidental dislocation and embarrassment.[31] Curi et al also found the type of retention system had no significant impact on implant survival rate.[31]

FIGURE 8 Patient at 9 years post maxillofacial treatment

Use of craniofacial implants in adults is widely published in the dental literature; however, there are limited reports of treatment of children with nasal or midfacial defects requiring implant placement and subsequent prosthetic reconstructions. In retrospect, the use of Bone-Anchored Hearing implants (BAHIs) in children is documented in the literature.[32–39] One hundred eighty-two children under the age of 16 years at The Birmingham Children's Hospital received Bone-Anchored Hearing Aid (BAHA).[36] Implant failure rate was reported to be 40% in children <3 years old, 38% in children 3 to 5 years old, 8% in children 5 to 10 years old, and 1% in children >10 years old.[36] One hundred seven (59%) children had a significant medical history including syndromes.[36] Nineteen implants were lost due to significant skin reaction and five children suffered

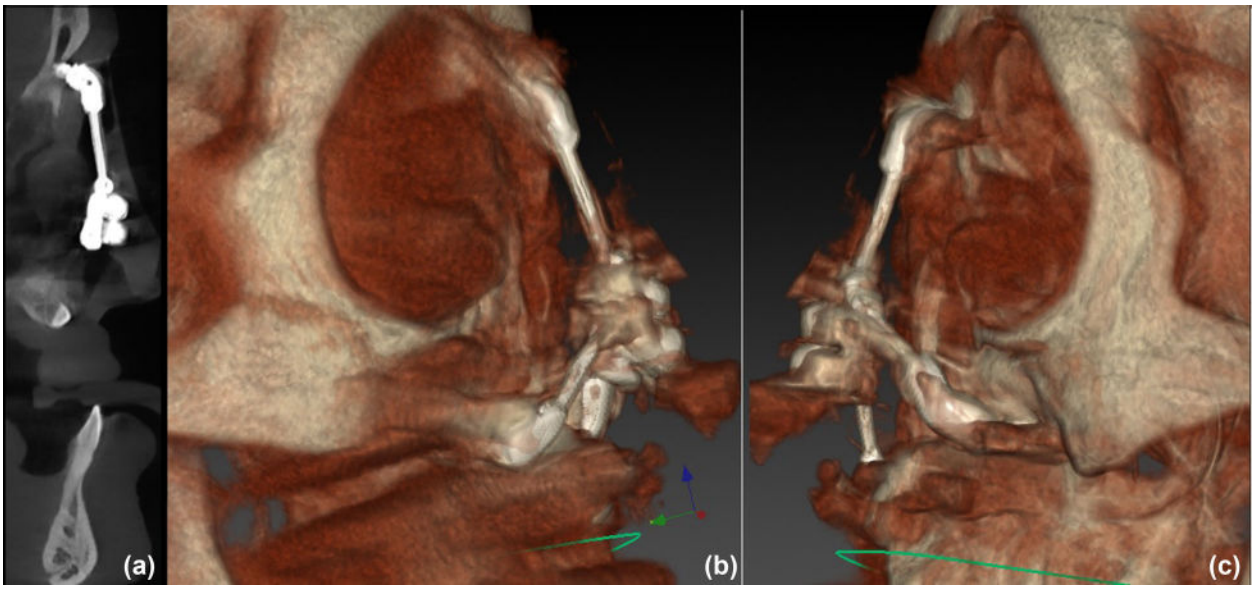

FIGURE 9 9-year follow-up radiographic views (a), (b), and (c)

implant loss due to trauma.[36] Implant failure rate was 14% of 230 loaded implants (32 implants lost in total, 18 of which happened in 7 patients).[36] According to McDermott et al, older children have an increased number of active hypertrophied sebaceous glands, increasing their risk for acne and for skin complications.[36]

A systematic review on Bone-Anchored Hearing implants (BAHIs) in children by Kruyt et al found adverse soft tissue reactions in 26.4% of implants (251 of the 952 implants), revision surgery was performed in 16.8% of implants (142 of the 845 implants), and bone loss to be 13.3% of the implants (127 out of 952 implants).[37] Kyurt et al found that the studies available in the literature have a small sample size and have a high level of heterogeneity.[37] Faber et al excluded pediatric patients from his study, and observed skin reactions in 130 adult patients (52.4%).[38] Faber et al attributes the cause of the higher implant failure rate in the pediatric population to be the following three factors: a child's skull is thinner, has a lower mineral content, and higher water compared to an adult skull.[38] Skull thickness is affected by age and syndromes. A significant number of pediatric patients receiving craniofacial implants have a diagnosis of a craniofacial syndromes, such as Oculoauriculartervebral (Goldenhar) syndrome and Mandibulofacial dysostosis (Treacher-Collins syndrome).[36,38,39]

In adults, Abu-Serriah et al found skin complications at 20% and Holgers et al found it at 21%.[40,41] Nishimura et al monitored a sample of 23 implants placed in 11 nasal defects monitored every 6 months for 7 years.[25] With the unit of measure being visit/sites for a total of 76 visit/sites, Nishimura et al found 85.5% (65/76) of visit/sites showed an absence of inflammation, 10.5% (8/76) of visit/sites demonstrated slight redness, and one visit/site demonstrated red and moist tissue.[25] Vitomir et al found the overall nasal implant survival rate in adults of 28 implants monitored over 12 years in the nasal region to be 93.3%.[42]

The placement of dental implants is usually restricted to patients with completed craniofacial growth. Risks associated with placing implants in children, as discussed by Lekholm,[22] points out that implants act like an ankylotic tooth and will not move together with growing surrounding structures. Additionally, an osseointegration fixed reconstruction could be anticipated to have a negative influence on the local and general growth and development.[22] Nonetheless, there are certain clinical and social justifications that warrant implant placement in children, the least of which may be the improvement in quality of life. Clinicians, biomedical engineers, and other researchers need to carefully monitor and document the ongoing outcome of such treatments.

The primary goal in this patient's treatment was to provide him with a fixed maxillofacial prosthesis without restricting the craniofacial growth and development. A rigid framework that is commonly used in adult patients[43] would not be a consideration for this young child; however, fixation of the prosthesis is a primary goal as pointed out by Henry during the 1985 Congress on Tissue Integration in Oral and Maxillo-Facial Reconstruction in Brussels, Belgium.[44] Henry stated, "Repair of the facial defects is planned on the basis of uniquely individual case requirements, and fixtures are placed where bone is available because the prime requirement is fixation. Resultant abnormalities of contour can often be compensated by prosthodontic artwork. In the final analysis, the overall benefits of treatment often grossly overshadow the minor defects in form."[44]

Last, but of great magnitude, when the initial treatment is completed, the team has engaged in the life-long responsibility for maintaining this unique bone anchored prosthesis.[45] The long-term clinical success rates for osseointegrated

implant-retained prostheses that penetrate the skin are dependent on the continuity of functional anchorage, which is directly dependent on healthy osseointegration and marginal bone maintenance.[46] The patient hygiene requirement for this prosthesis is critically important and some burden for hygiene maintenance may fall on the shoulders of a responsible family member or other caregiver so the abutment/framework interface can be maintained in good health. Initially, the patient should be checked professionally with great emphasis on hygiene around the skin penetrating areas, every 3 to 4 months, in a lifetime of follow up.[46] The patient was informed of the risk of adverse skin reactions during the treatment planning phase.

It is imperative that the team analyze the treatment plan and agree that the anticipated result of treatment for this patient will ensure that the patient will be at least as well off after the treatment as he was before. The planned treatment must also be designed to preserve that which is left rather than meticulous artistic replacement of that which has been lost due to the initial trauma. This treatment is based on decades of scientific data related to osseointegration. It is also highly dependent on a multidisciplinary approach and interaction of various experienced and skilled specialists with variable backgrounds.

At the 1-year follow-up visit, observation of the framework and the space (approximately 1 mm) that had developed between the transdermal implant anchorage unit and the SFI-bar appeared to indicate that some craniofacial growth had occurred in a vertical direction beneath the glabella. No separation or expansion has yet been observed for the bars anchored to the implants in the maxillary buttresses. Additional silicone noses were required from time to time reflective of seasonal changes impacting skin tones, as well as changes required to accommodate craniofacial growth and development. The need for additional framework structures has not been necessary.

CBCT and CAD-CAM technology are being increasingly used and incorporated into the workflows of maxillofacial reconstruction.[47] Dominigue et al used a 3D-printed prosthetic ear and 3D-printed surgical guides using implant software and CBCT to place 8 implants in the right temporal bone.[48] The digital approach allowed a prosthetically driven approach of placing implants at the desired depth and angle.[48] They were also able to avoid complications such as bleeding or inner cortical perforations of the heavily pneumatized mastoid part of the temporal bone.[48]

CONCLUSION

The treatment of children with maxillofacial defects presents unique challenges not experienced with adult patients having similar requirements. The growth and development of the craniofacial anatomy puts limitations and demands on the reconstructive process. In this report, the aspects of anatomical growth and associated biomedical engineering are addressed.

The key elements to the success of a reconstruction for a young child rely on the biomedical engineering concepts on physical expansion of the retentive mechanism used to stabilize the prosthesis. Bone anchored prosthetics in children has been scrutinized with valid concerns about the ankylotic nature of osseointegrated implants, which weighed heavily in the decision to move forward in this patient's treatment. The long-term success of this endeavor will require meticulous follow-up care by the prosthodontic team.

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DISCLOSURE

The authors report no conflicts of interest.

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