A Novel Application of Calcium Phosphate-Based Bone Cement as an Adjunct Procedure in Adult Craniofacial Reconstruction

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ABSTRACT

Secondary corrective osteotomy of malunited craniofacial fractures can be a challenging proposition. The exposure, extrusion, and palpability of the titanium implants used become a genuine concern especially in areas of relatively thin skin, such as the periorbital region. Restoring a satisfactory contour to the midface is another major task for the plastic surgeon. Bone cement used to reconstruct craniofacial defects has existed for many years. However, most applications have been as a substitute for autogenous bone grafts for defects less than 25 cm^2. In this article, we present two cases of malunited facial fractures that underwent corrective osteotomy, during which we felt that despite the conventional osteotomy and reduction techniques, there was still either a small remnant step deformity or suboptimal contour smoothness due to prominence of the implants used. We thus used bone cement as a resurfacing medium over titanium implants to restore good malar contour and reduce the palpability and exposure rate of the titanium implants. We report good patient satisfaction with contour correction with no increase in wound infection rates or any delay in wound healing. There was initial chemosis associated with the use of the bone cement, which resolved in both patients within 3 to 4 weeks. Postoperative computed tomography showed some degree of osteointegration but no fraction of the bone cement. Calcium phosphate bone cement thus presents an attractive adjunctive method for midfacial contour resurfacing, when used in conjunction with conventional osteotomy procedures and as an onlay over prominent titanium implants.

KEYWORDS: Norian, craniofacial resurfacing, corrective osteotomy, camouflage procedure

Reconstruction of complex craniofacial bony injuries can be a challenging proposition especially when undertaken as a secondary corrective procedure, requiring osteotomies. Often, these patients present in a polytrauma scenario, with a multitude of other life-threatening injuries that may have precluded reduction and fixation of the comparatively less urgent facial injuries. Common associated injuries that may delay fracture fixation to a later date include cerebral injuries, cervical spine injuries, and thoracoabdominal visceral/

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soft tissue injuries. These patients would have had a complex course including multiple operations. By the time the patient is suitable for intervention for the facial bony injuries, some degree of malunion would have occurred, necessitating the need for secondary osteotomies and placement of a significant amount of titanium plates for fixation. Quite frequently, there is some amount of bony defect as well after reduction of the initial fracture fragments.

As the skin over the periorbital region is fairly thin without bulky underlying soft tissue cover, coupled with the greater amount of hardware that is placed for fixation, implant extrusion or exposure or the palpability to the patient becomes a real concern. Moreover, with a secondary corrective procedure, completely accurate bony reduction can be a very difficult endeavor, bony defects notwithstanding. Although bony defects can be bridged quite simply with an autogenous bone graft either from rib or iliac crest, the contour deformities, the palpability of the implants, and the relative lack of bulk of soft tissue cover in the periorbital region necessitate a more optimal solution.

We present two cases of previously fixed orbitozygomaticomaxillary complex fractures that have gone into malunion, resulting in contour deformities and enophthalmos that required a secondary corrective procedure involving osteotomies and realignment of the fracture fragments. In both cases, conventional zygomaticomaxillary osteotomies, autogenous bone grafting, and titanium implants were used for primary correction and fixation of the bony deformities. Norian Craniofacial Repair System (CRS) (Norian CRS, Synthes Singapore Pte, Ltd, Singapore) was then used as a secondary adjunctive procedure to resurface the titanium plates used for fixation to achieve a smooth natural contour as well as reduce palpability of the implants and the risk of implant extrusion.

Figure 1 Intraoperative photo showing Norian CRS being used to smooth the contour over the maxilla and inferior orbital rim as well as cover the titanium implants.

METHODS

Both patients were involved in road traffic accidents with multiple traumatic injuries. Both fractures were fixed initially with titanium implants but unfortunately resulted in malunion of the fracture fragments with consequent contour deformity of the midface and enophthalmos. Preoperative computed tomography (CT) scans and clinical photos are as shown in Figs. 1–10.

Both patients underwent corrective osteotomy and replating of the fracture fragments and reconstruction of the orbital floor defects with a precontoured orbital reconstruction plate as well as SynPOR mesh (Synthes Singapore Pte, Ltd, Singapore) (Figs. 8 and 9). Figure 1 shows Norian CRS over the orbital rim and floor plates. In the first case, a short 4-cm segment of iliac crest bone graft was used to bridge the malar bony defect. In each case, 3 mL of Norian CRS was used. It

Figure 2 Anteroposterior computed tomography 3-D reconstructed image showing Norian CRS and the iliac crest bone graft.

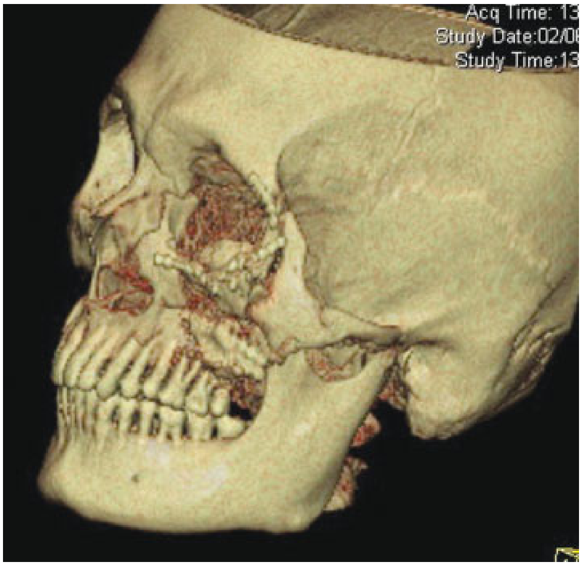

Figure 3 Oblique view 3-D reconstruction image showing Norian CRS forming a smooth malar contour.

was applied over the implants and then shaped to ensure a smooth natural contour (Figs. 11 and 12). The wound was then closed as per the usual fashion.

RESULTS

The follow-up periods of the two cases were 6 months and 3 months, respectively. 3-D reconstructed images show good restoration of the bony contour over the orbital rim and zygomaticomaxillary complex (Figs. 2 and 3). Postoperative CT scans of the face were performed at 1 month postoperatively and showed minimal resorption of the bone cement (Figs. 4 and 5). In the first patient, a repeat CT scan at 2 months postoperatively showed some degree of osteointegration of the bone cement (Figs. 6 and 7). In addition, pre- and postoperative photographs (6 months) of the first patient are shown in Figs. 8 and 9.

Figure 5 Coronal computed tomography image at 1 month postoperatively showing Norian CRS in situ and the iliac crest bone graft with minimal resorption.

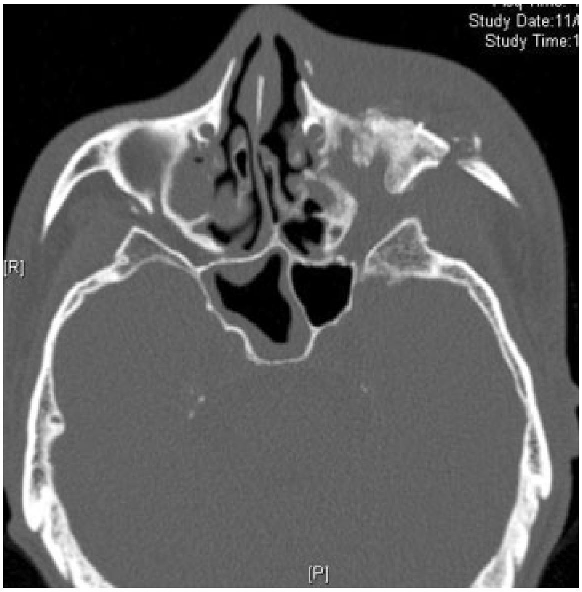

Figure 4 Axial computed tomography image at 1 month postoperatively showing Norian CRS in situ with minimal resorption.

Figure 6 Axial computed tomography image at 2 months postoperatively showing minimal resorption of Norian CRS with some amount of bony ingrowth.

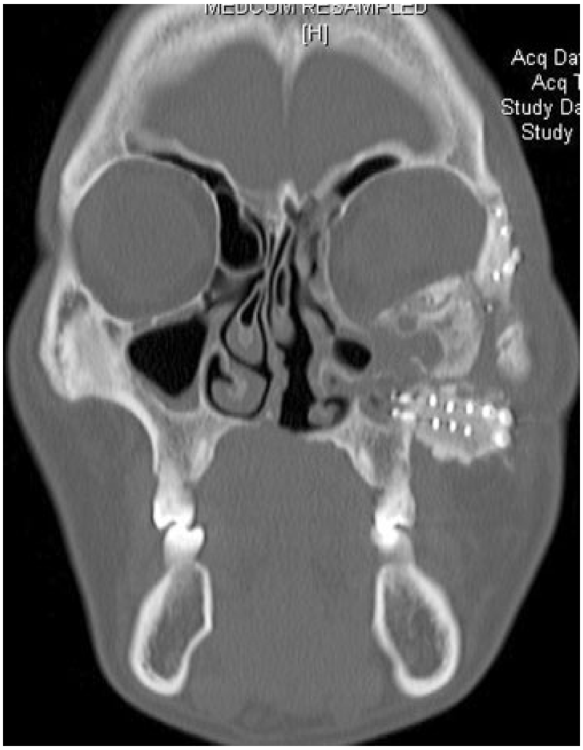

Figure 7 Coronal computed tomography image at 2 months postoperatively showing minimal resorption of Norian CRS with some amount of bony ingrowth.

Figure 9 Four months postoperative photo showing good left malar contour with correction of depression as well as resolution of left eye chemosis.

Both patients reported good satisfaction of the aesthetic outcome of the procedure, with regards to the restoration of midface contour and reduction in degree of enophthalmos. In both patients, mild chemosis was noted that could have been attributable to both the surgery and Norian CRS. This resolved for both patients within 3 to 4 weeks postoperatively. Complete wound healing was noted in both patients.

Figure 8 Preoperative photo showing left-sided malar depression.

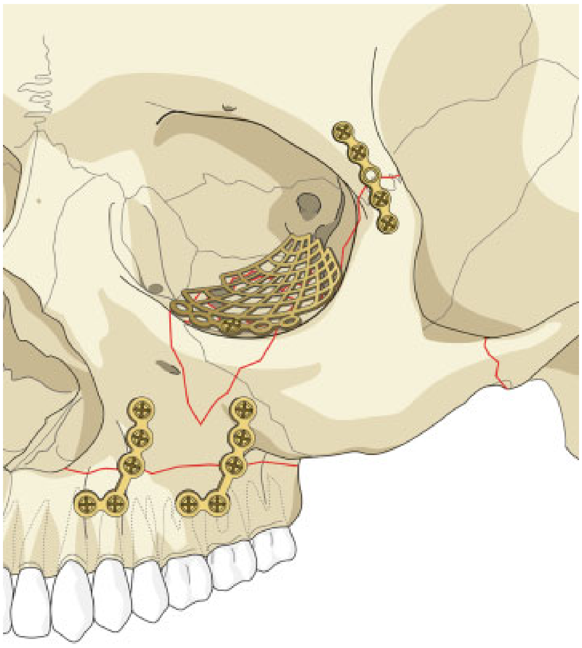

Figure 10 Previously malunited left zygomaticomaxillary complex fracture with large left orbital floor and anterior maxillary floor defects (shaded).

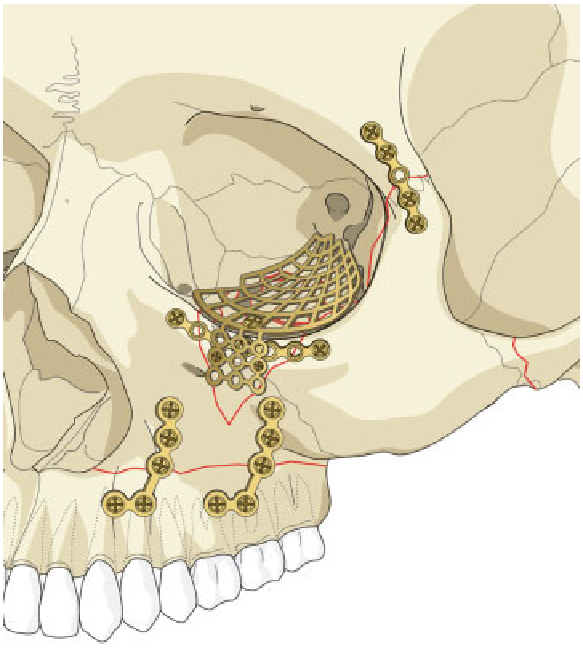

Figure 11 Diagram showing postosteotomy and reduction of fracture fragments with fixation at the left frontozygomatic suture, inferior orbital rim, and medial and lateral maxillary buttresses with titanium plates and screw. Reconstruction of orbital floor with preformed orbital titanium plate and maxillary wall defect with titanium mesh (checked portion).

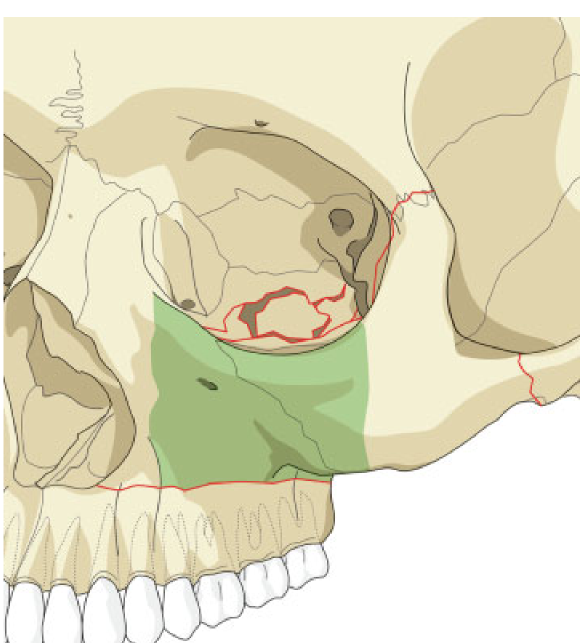

Figure 12 Onlay application of Norian CRS over inferior orbital rim and anterior maxillary wall/titanium mesh (green portion).

DISCUSSION

Secondary corrective procedures to improve the contour deformity due to malunited facial fractures can be fraught with challenges. If the patient experiences little functional deficit from this bony malunion, such as malocclusion or pain, then the procedure is essentially a cosmetic one, which seeks to improve the aesthetic outcome for the patient. This can be especially difficult if the original fracture lines are not be apparent, making placement of the osteotomy cuts very testing. In addition to this, putting multiple implants in the periorbital area, which is necessary in a significant number of cases where soft tissue cover is thin, presents another problem. Thus, the two major problems confronting craniofacial surgeons would be the palpability of implants or even implant extrusion in the periorbital area, as well as smoothing out contour irregularities in anatomically imperfectly reduced facial fractures after corrective osteotomy.

Several techniques have been tried as camouflage procedures without good cosmetic success. These include the use of hyaluronic acid fillers and free fat transfer. These are either only temporary measures or they lack the ability to be molded to a contour that is similar to the normal side. Furthermore, they do not solve any functional issues unlike an osteotomy and refixation.

Bone cement used to reconstruct craniofacial defects has existed for many years. However, most applications have been as a substitute for autogenous bone grafts for defects less than 25 cm^2.[1] Several calcium phosphate cements are now in use worldwide, which are biocompatible and osteoconductive.[2,3] Materials such as the calcium-based bone cements are an attractive proposition to us and are thought to have potential for bone replacement (up to 60 to 70% in some series). Furthermore, reports have shown that calcium-based bone cements have high tissue tolerance and few complications.[4,5] The U.S. Food and Drug Administration has approved calcium-based cements for bony defects up to 25 cm^2. The complications rates in these studies vary widely.[6] Some recent publications allude to a high complication rate in large defects, whereas others question the biomechanical strength of these constructs.[7] These issues related to the use of calcium-phosphate bone cement are relatively insignificant to us as we use it mainly for contour resurfacing and covering the titanium implants, thus negating the biomechanical strength issue; only a small area is resurfaced, thus reducing potential complications.

A recent study showed good bone formation when titanium mesh was used to stabilize monocalcium phosphate bone cement (Norian CRS) in the defect. Histologically, there was evidence of invasion of the calcium phosphate by bone, which peaked at 6 months.[8] Norian CRS has also been used successfully in several studies for the reconstruction of small to moderate-sized craniofacial defects, particularly in the pediatric population, with good evidence of bony ingrowth into the bone cement and relatively little resorption of the cement in long-term follow-up.[2,9] This follows the previous widespread use of calcium hydroxyapatite cement for the secondary reconstruction of craniofacial defects, particularly orbitocranial reconstruction.[10,11]

Using this knowledge, we proceeded to use 3 mL of Norian CRS over the titanium mesh and plates used for fixation and reconstruction of the orbital floor defects in the corrective osteotomies performed for both patients. The reason for surgery for both patients was contour deformity and enophthalmos, although the second patient also had persistent pain on biting hard, which indicated fibrous union with mobile fracture fragments. The Norian cement was smoothed to cover the titanium implants and also correct the slight contour irregularities from the slight imperfect reduction of the fragments postosteotomy. An iliac crest bone graft was used in lieu of Norian CRS to bridge the large bony defect in the first patient as we had doubts about the fracture rate of Norian in such a large defect.

Replacing tried and tested reconstructive principles of bony osteotomies, autogenous bone grafting, and titanium implants with the use of onlay ceramic paste in these challenging patients is certainly fraught with danger. Therefore, it is not our aim to use onlay calcium phosphate as a replacement but rather an adjunct tool that may be employed should the primary osteotomy and reduction procedure not yield the optimal cosmetic result or if the surgeon wants added insurance against palpability and extrusion of the hardware used. Foreign body reaction to the cement has also been described by some authors[10,11] and might be of concern in the periorbital region, although both our patients demonstrated complete resolution of their eye irritation symptoms.

Wound infection was suggested to be higher when Norian CRS was used in conjunction with large-scale osteotomies in one study, although the authors noted that it may well be due to the scale of the surgery rather than the use of the bone cement.[8] We have not noticed any increased rates of wound infection in our short follow-up so far.

A longer follow-up and the recruitment of more patients would be the next step to further investigate the long-term feasibility of this technique and the elucidation of any long-term complications.

CONCLUSION

Corrective osteotomies for malunited facial fractures are a challenge. In some cases, perfect anatomic reduction of the bone fragments is not possible even after the osteotomy is done. Norian CRS bone cement has been used extensively for the reconstruction of small pediatric craniofacial defects. We present a novel application and believe it affords the plastic or craniofacial surgeon a viable adjunctive procedure to quickly and easily smooth out these contour irregularities at the same sitting. Furthermore, it also potentially forms a barrier over the implants, thus reducing the palpability and rate of exposure of the implants. There does not appear to be any effect on wound healing or infection rates in the short postoperative period. However, we would exercise caution in using it to bridge large bony defects more than 25 cm^2 or in lieu of corrective osteotomy procedures when the latter is indicated. A longer follow-up period with a larger patient pool is needed to track long-term benefit and any delayed complications.

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