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CASE REPORT

Pediatric/Craniofacial

Zygomatico-maxillary Reconstruction with Computer-aided Manufacturing of a Free DCIA Osseous Flap and Intraoral Anastomoses

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Summary: Craniomaxillofacial reconstruction using virtual surgical planning, computer-aided manufacturing, and new microsurgical techniques optimizes patient-specific and defect-directed reconstruction. A 3D customized free deep circumflex iliac artery (DCIA) flap with intraoral anastomoses was performed on a 23-year-old man with a posttraumatic right zygomatico-maxillary defect with failure of alloplastic implant reconstruction. An osseous iliac crest flap was sculpted based on a customized 3D model of the mirror image of the patient's unaffected side to allow for perfect fit to the zygomatico-maxillary defect. An intraoral dissection of the facial artery and vein was performed within the right cheek mucosa and allowed for end-to-end microvascular anastomoses. 3D preoperative planning and customized free DCIA osseous flap combined with an intraoral microsurgical technique provided restoration of facial esthetics and function without visible scars. In cases where zygomatico-malar reconstruction by alloplastic material fails, a customized free DCIA osseous flap can be designed by virtual surgical planning to restore facial appearance and function. *(Plast Reconstr Surg Glob Open 2017;5:e1226; doi: 10.1097/GOX.0000000000001226; Published online 3 February 2017.)*

The face is the only part of the body that cannot be hidden. Facial asymmetry, loss of contour definition, and scarring are quickly noticeable and can lead to stigmatization.[1] Major facial defects may sometimes require free flap reconstruction. Intraoral anastomosis of free flaps has been introduced by Gaggl et al[2] to avoid facial skin incision. In addition, advances in computer-aided design and manufacturing, have greatly facilitated flap reconstruction,[3–9] especially for complex cases of craniomaxillofacial defects.

We have combined the use of intraoral free flap anastomosis with a patient-specific computer-designed free deep circumflex iliac artery (DCIA) osseous flap to restore bony architecture of a latent zygomatico-maxillary complex (ZMC) defect without the addition of a facial scar. A case report describing the pathology, preoperative virtual surgery, and surgical procedure is outlined below.

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Received for publication September 24, 2016; accepted December 16, 2016.

This study conformed to the Declaration of Helsinki.

DOI: 10.1097/GOX.0000000000001226

CASE

A 23-year-old man with a history of a traumatic comminuted fracture of the right ZMC presented to our clinic 4 years after primary reconstruction at an outside hospital center. The patient had had a secondary alloplastic implant reconstruction, which was complicated by a chronic infection with draining cutaneous fistula that then necessitated implant removal. Upon presentation, the patient complained of severe right cheek pain, secondary lower eyelid ectropion with conjunctival irritation, and most significantly, psychological stress due to his facial asymmetry (Fig. 1).

METHODS

A virtual plan was performed with Materialise (Leuven, Belgium) and a mirror image of the patient's unaffected

Disclosure: *The authors have no financial interest to declare in relation to the content of this article. The Article Processing Charge was paid for by the authors.*

Fig. 1. Preoperative view of right-sided posttraumatic zygomatico-maxillary defect.

side was created. Stereolithographic models of the patient's face and defect were printed. The model of the defect represented the exact bony shape required to restore the facial contour and served as a guide for flap shaping (Fig. 2).

With the patient in a supine position, the contralateral iliac crest ridge was incised to facilitate a 2-team approach. External and internal oblique muscles were dissected and the DCIA pedicle was followed along the inner cortex of the iliac crest until appropriate height and length were exposed. The inner table of the iliac crest flap was harvested according to the preoperative virtual plan. The iliac bone flap was sculpted to achieve identical replication of the personalized maxillary 3D model while maintaining perfusion by its pedicle. The bone flap was inset onto the facial model until perfect contour was achieved (Fig. 3).

Recipient vessel position was confirmed and marked intraorally with a Doppler probe. The buccal mucosae followed by the buccinator muscle were incised anterior to Stensen's duct.[10] The facial artery and vein were dissected along 4 cm to facilitate intraoral anastomoses and to allow adequate vessel caliber. The maxillary defect was exposed through a superior gingivobuccal sulcus incision. Bone edges were debrided and an infraorbital nerve neurolysis was performed.

The customized bone flap was transferred to the right ZMC defect and was fixated using 2 monocortical bone screws. End-to-end intraoral arterial and venous microanastomoses were completed. The patient was discharged

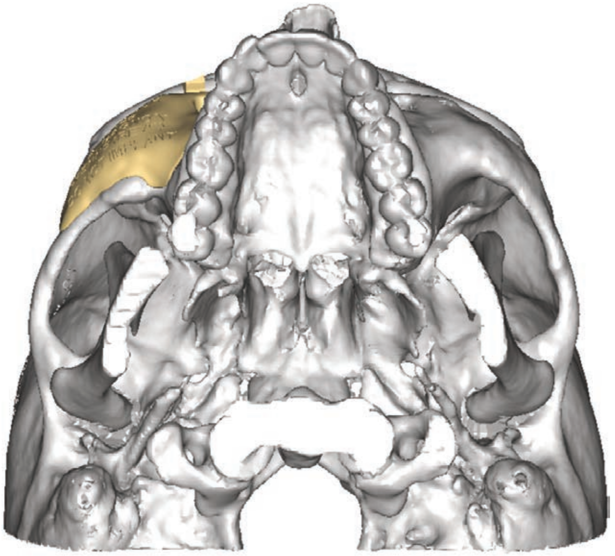

Fig. 2. Virtual surgical planning of 3D model of patient's skull with zygomatico-maxillary defect reconstruction by mirror image of contralateral intact ZMC.

at 2 days postoperative and was followed on a bimonthly basis without any complications.

RESULTS

Postoperatively, the patient showed facial symmetry and a restored midfacial contour (Fig. 4). There was a complete resolution of his initial presenting complaints, including cheek pain.

DISCUSSION

Reconstructive options to midfacial defects include autogenous tissue transfers or alloplastic implants. Our patient had already experienced several complications from an alloplastic implant; therefore, he was not a candidate for its reuse. Moreover, our patient had already suffered significant psychological distress from his facial deformity and was hoping to have a reconstruction that precluded

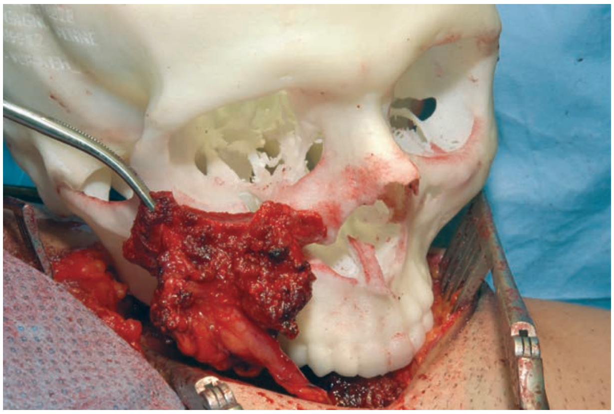

Fig. 3. Confirmation of DCIA flap insetting on 3D model of patient skull with maxillary defect while maintaining perfusion through its pedicle.

the addition of any facial scars. Combining the patient's requests with his past medical history confirmed our decision to use a vascularized bone flap with intraoral anastomosis.

Low level of donor-site morbidity and high esthetic demands were the criteria used during the decision making process. The iliac crest flap, DCIA, was the flap of choice for this type of reconstruction. Its large amount of available bone combined with acceptable donor site morbidity justified this choice.[11,12] In the presented case, the cortex was split to allow reconstruction of the defect. This technique allows for thinner bone harvesting, thus decreasing the risk of hernia compared with bicortical iliac crest harvest.[13,14] Moreover, the natural curvature of the iliac crest is a great fit for contouring of the maxilla.[15,16] The overlying muscle has been described to treat alveolar ridge fistulas, to close nasal cavities or, in this case, to fill soft-tissue deficit of the malar region.[17,18] The optimal vascular pedicle length and diameter of the flap[19] facilitated intraoral anastomosis in this case. Rarely, donor-site morbidity can cause gait disturbances,[20] which did not occur in this case. The discreetly hidden donor-site scar constitutes a definite advantage of the DCIA flap.[21,22]

Intraoral anastomosis was elaborated by Gaggl et al[2] to avoid the need for any facial skin incisions. This technique also facilitates identification of the facial nerve branches, preventing injury and paralysis.[23] Several reports of intraoral free flap anastomosis for a wide range of surgical indications and with a large variety of flaps followed and demonstrated favorable outcomes.[1,2,23–26]

Fig. 4. Three-month postoperative view of right-sided zygomatico-maxillary defect restoration.

The field of 3D virtual surgery has been shown to reduce operative time, to be cost effective[27] and to enhance surgical efficiency, accuracy, creativity, and reproducibility.[28–32] 3D reconstruction from 2D computed tomography scan images of our patient's donor iliac crest and recipient maxilla provided preoperative contour deformity of the ZMC defect and parameters of the unaffected side. Theses virtual images allowed the creation of a 3D model of a bony segment that interdigitated with the maxillary defect while presenting outside contours of the intact contralateral maxilla. The sterile models allowed for intraoperative adjustments and confirmation. Virtual imaging also displayed the DCIA flap vascularization, allowing appropriate mapping of arterial course through the flap and sites of required osteotomies according to defect size.

CONCLUSION

This case study demonstrates that careful 3D preoperative planning and customized free DCIA osseous flap combined with an intraoral microsurgical technique restored facial esthetics and function while minimizing recovery time and eliminating visible scars, in a patient where zygomatico-malar reconstruction by alloplastic material had failed.

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PATIENT CONSENT

The patient provided written consent for the use of his image.

REFERENCES

1. Nkenke E, Agaimy A, von Wilmowsky C, et al. Mandibular reconstruction using intraoral microvascular anastomosis following removal of an ameloblastoma. *J Oral Maxillofac Surg.* 2013;71:1983–1992.
2. Gaggl A, Bürger H, Virnik SA, et al. An intraoral anastomosing technique for microvascular bone flaps in alveolar ridge reconstruction: first clinical results. *Int J Oral Maxillofac Surg.* 2009;38:921–927.
3. Bill JS, Reuther JF, Dittmann W, et al. Stereolithography in oral and maxillofacial operation planning. *Int J Oral Maxillofac Surg.* 1995;24(1 Pt 2):98–103.
4. Klein HM, Schneider W, Alzen G, et al. Pediatric craniofacial surgery: comparison of milling and stereolithography for 3D model manufacturing. *Pediatric Radiol.* 1992;22(6):458–60.
5. Sailer HF, Haers PE, Zollikofer CP, et al. The value of stereolithographic models for preoperative diagnosis of craniofacial deformities and planning of surgical corrections. *Int J Oral Maxillofac Surg.* 1998;27:327–333.
6. Altobelli DE, Kikinis R, Mulliken JB, et al. Computer-assisted three-dimensional planning in craniofacial surgery. *Plast Reconstr Surg.* 1993;92:576–85; discussion 586.
7. Lo LJ, Marsh JL, Vannier MW, et al. Craniofacial computer-assisted surgical planning and simulation. *Clin Plast Surg.* 1994;21:501–516.
8. Gateno J, Teichgraeber JF, Xia JJ. Three-dimensional surgical planning for maxillary and midface distraction osteogenesis. *J Craniofac Surg.* 2003;14:833–839.

9. Westermark A, Zachow S, Eppley BL. Three-dimensional osteotomy planning in maxillofacial surgery including soft tissue prediction. *J Craniofac Surg.* 2005;16:100–104.
10. Calva D, Chopra KK, Sosin M, et al. Manson's point: a facial landmark to identify the facial artery. *Journal of plastic, reconstructive & aesthetic surgery: JPRAS.* 2015;68(9):1221–7.
11. Taylor GI, Townsend P, Corlett R. Superiority of the deep circumflex iliac vessels as the supply for free groin flaps. Clinical work. *Plast Reconstr Surg.* 1979;64:745–759.
12. Taylor GI, Townsend P, Corlett R. Superiority of the deep circumflex iliac vessels as the supply for free groin flaps. *Plast Reconstr Surg.* 1979;64:595–604.
13. Taylor GI. Reconstruction of the mandible with free composite iliac bone grafts. *Ann Plast Surg.* 1982;9:361–376.
14. Shenaq SM, Klebuc MJ. The iliac crest microsurgical free flap in mandibular reconstruction. *Clin Plast Surg.* 1994;21:37–44.
15. Baliarsing AS, Kumar VV, Malik NA, et al. Reconstruction of maxillectomy defects using deep circumflex iliac artery-based composite free flap. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2010;109:e8–13.
16. Grinsell D, Catto-Smith HE. Modifications of the deep circumflex iliac artery free flap for reconstruction of the maxilla. *J Plast Reconstr Aesthet Surg.* 2015;68:1044–1053.
17. Brown JS. Deep circumflex iliac artery free flap with internal oblique muscle as a new method of immediate reconstruction of maxillectomy defect. *Head Neck.* 1996;18:412–421.
18. Goh BT, Lee S, Tideman H, et al. Mandibular reconstruction in adults: a review. *Int J Oral Maxillofac Surg.* 2008;37:597–605.
19. Brandtner C, Hachleitner J, Buerger H, et al. Combination of microvascular medial femoral condyle and iliac crest flap for hemimidface reconstruction. *Int J Oral Maxillofac Surg.* 2015;44:692–696.
20. Schultz BD, Sosin M, Nam A, et al. Classification of mandible defects and algorithm for microvascular reconstruction. *Plast Reconstr Surg.* 2015;135:743e–754e.
21. Bitter K, Schlesinger S, Westerman U. The iliac bone or osteocutaneous transplant pedicled to the deep circumflex iliac artery. II. Clinical application. *J Maxillofac Surg.* 1983;11:241–247.
22. Ting JW, Rozen WM, Niumsawatt V, et al. Developments in image-guided deep circumflex iliac artery flap harvest: a step-by-step guide and literature review. *J Oral Maxillofac Surg.* 2014;72:186–197.
23. Sosin M, Sinada GG, Rodriguez ED, et al. Intraoral microvascular anastomosis of an iliac free flap for maxillary fibrous dysplasia. *J Oral Maxillofac Surg.* 2015;73(10):2068 e1–5.
24. Gaggl A, Bürger H, Virnik S, et al. The microvascular corticocancellous femur flap for reconstruction of the anterior maxilla in adult cleft lip, palate, and alveolus patients. *Cleft Palate Craniofac J.* 2012;49:305–313.
25. Nkenke E, Agaimy A, St Pierre M, et al. Intraoral microvascular anastomosis for segmental mandibular reconstruction following removal of an ameloblastoma. *J Craniofac Surg.* 2013;24:e265–e270.
26. Landes C, Cornea P, Teiler A, et al. Intraoral anastomosis of a prelaminated radial forearm flap in reconstruction of a large persistent cleft palate. *Microsurgery.* 2014;34:229–232.
27. Xia JJ, Phillips CV, Gateno J, et al. Cost-effectiveness analysis for computer-aided surgical simulation in complex cranio-maxillofacial surgery. *J Oral Maxillofac Surg.* 2006;64:1780–1784.
28. Steinbacher DM. Three-dimensional analysis and surgical planning in craniomaxillofacial surgery. *J Oral Maxillofac Surg.* 2015;73(12 Suppl):S40–S56.
29. Rohner D, Guijarro-Martínez R, Bucher P, et al. Importance of patient-specific intraoperative guides in complex maxillofacial reconstruction. *J Craniomaxillofac Surg.* 2013;41:382–390.
30. Dérand P, Rännar LE, Hirsch JM. Imaging, virtual planning, design, and production of patient-specific implants and clinical validation in craniomaxillofacial surgery. *Craniomaxillofac Trauma Reconstr.* 2012;5:137–144.
31. Bell RB. Computer planning and intraoperative navigation in orthognathic surgery. *J Oral Maxillofac Surg.* 2011;69:592–605.
32. Gordon CR, Murphy RJ, Coon D, et al. Preliminary development of a workstation for craniomaxillofacial surgical procedures: introducing a computer-assisted planning and execution system. *J Craniofac Surg.* 2014;25:273–283.