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# Managing Oromandibular Hardware Failure after Free Flap Surgery

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## Abstract

Hardware failure after oromandibular reconstruction using free tissue transfer can delay additional therapies directed at cancer treatment and prevent patients from returning to normal oral function. Understanding and strict adherence to principles of rigid fixation is critical in preventing complications. Early surgical intervention for hardware exposure as well as utilization of locoregional flaps may prevent the need for more extensive revision surgery.

**Keywords**

- hardware failure
- free flap
- free tissue transfer
- surgical complications



Free tissue transfer has expanded the oncologic and reconstructive options available to head and neck surgeons. The ability to replace tissue and bone improves the lives of head and neck cancer patients both functionally and cosmetically. Large, previously unresectable cancers are now ablated with a negative margin as the standard of care. Healing time and prevention of chronic wounds or fistula is optimized with free flap reconstruction which then allows patients to move on to adjuvant therapies. Numerous studies have confirmed that osteocutaneous free flaps can be used reliably in the reconstruction of head and neck defects to help optimize patient function and cosmesis postoperatively. Despite this, hardware exposure after oromandibular free tissue reconstruction occurs frequently, particularly in the setting of multimodality therapy.

Understanding the biomechanics of the mandible under load is essential when placing rigid fixation. The mandible is suspended from the temporomandibular joints and is subject to occlusive forces during mastication. Under load, tension exists along the superior mandibular border with compressive forces along the inferior border. Rigid fixation, in conjunction with virtual surgical planning (VSP) and preplating prior to ablative bone cuts, allows for excellent occlusion with use of a vascularized osseous flap without a period of maxillomandibular fixation.

Rigid fixation of the mandible must be accomplished to allow bony osteosynthesis and stable union. Several basic principles must be followed. First, the rigid fixation must be strong enough to overcome stress forces when the mandible is under load. With this in mind, a properly designed single plate or series of miniplates must be positioned to impart strength to the fractured mandible or vascularized bone containing free flap until healing has occurred. Appropriately sized screws must be placed in bony segments to fixate the bone segments to the rigid plate. Additional fixation points within the native mandible or in vascularized bone containing segments of the flap generally result in a more rigid fixation. Lastly, hardware placed intraorally must be covered by flap or native mucosa to prevent bacterial contamination, which may eventually result in infection and loosening of the screws that maintain stability.

Osteosynthesis consists of the union of two or more bone fragments after their proper alignment has been previously gained. The union is mechanically stabilized by means of screws and plates which are required to remain effective until the biological process of fracture healing has restored the bone segment as a single entity. Healing without callus formation is called primary bone healing. When there is direct apposition of cortical bone surfaces, contact healing occurs. Osteoclasts widen the Haversian canals on either side

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of the fracture and move toward each other. Cortical bridging occurs in 8 weeks and is usually completed in 16 weeks.

Secondary bone healing occurs when there is hematoma formation without direct bony contact. Hematoma creates an environment for angiogenesis of the healing fracture. Inflammatory cells, stem cells, cytokines, and fibroblasts initiate an inflammatory response and enhance angiogenesis. Cytokines which help in bone repair are released in this phase as the hematoma is absorbed. Within 3 days after fracture or surgery, a thin layer of fibrous tissue covers the periosteal surface of fractured bone. Over the next 2 weeks, dense fibrous tissue and fibrocartilage formation occurs due to organization of subperiosteal hematoma. This soft callus is converted to hard callus as chondrocytes are replaced by osteocytes. Three to 4 weeks following the fracture, the entire callus is converted to immature woven bone. Lastly, over the next 9 months, the trabeculae orient themselves in the direction of functional pressures after bone formation.

## Surgical Technique

### Soft Tissue versus Bone Reconstruction

When reconstructing a mandible defect, one of the first considerations is reconstruction with a soft tissue versus osseous free flap with reconstruction plate. Generally, an osseous flap provides better functional and cosmetic outcomes. However, patient factors may preclude the desired flap type and the reconstructive surgeon should have multiple flap options at his or her disposal. Regardless, both flap types are at risk of plate extrusion. A systematic review and meta-analysis of 2,379 patients showed the risk of extrusion after soft tissue and plate reconstruction was 20% compared to a rate of 10% in the osseous reconstruction group.[1] The mean time to plate extrusion was 8.8 and 8.4 months, respectively.

A purely soft tissue free flap coupled with a reconstruction bar is not the optimal choice for reconstruction of a mandible defect, although it is a reasonable option in select patients. Considerations for a soft tissue flap include medical comorbidities, peripheral vascular disease, and body habitus. A retrospective review of a single institution's experience with anterolateral thigh free flaps and a reconstruction plate for mandible defects had a rate of extrusion of 27.7% (49/130).[2] Rates of extrusion have been reported as high as 46.15%.[3] Musculocutaneous flaps had lower rates of plate exposure compared to fasciocutaneous or chimeric anterolateral thigh flaps. The additional muscle likely provides an extra level of protection over the plate as the soft tissue contracts during the postoperative healing period.

There are numerous osseous flaps available for reconstruction, with the fibula free flap typically considered the "workhorse" option for bony reconstruction. A study comparing plate extrusion in osseous flaps found fibula free flaps to have the highest rate of extrusion compared to scapula tip and lateral border scapula flaps. Plate exposure occurred in 21 of 61 fibula, 3 of 49 scapula tip, and 3 of 24 lateral border scapula reconstructions.[4] There is likely some patient selection bias as the fibula provides the best bone stock of those three osseous options. Nonetheless, there was a statistically significant association between fibula free flap plate exposure and younger patients, 2.4 mm plates, anterior defects, and a greater number of osteotomies. Other studies have not found the number of osteotomies to be predictors of plate extrusion.[5,6] There is also no agreement in the literature on the risk of exposure with flap type and anterior defects.[5,7–9]

### Miniplates versus Reconstruction Bar

The hardware options available for mandible reconstruction can be broken down into miniplates and reconstruction plates. The reconstruction plate extends the entire length of the osseous free flap segment while the miniplates only provide support at the points of contact between the free flap and native mandible. Compared to miniplates, the reconstruction plate adds increased strength and continuity without the requirement of intraoperative and postoperative maxillomandibular fixation to maintain occlusion.[10] Locking plates are the standard in mandible reconstruction with advantages of the ability to reconstruct without perfect adaptation of the plate to the bone and improved stability without applying excess force to the underlying bone, as previously discussed.[11,12]

Nonetheless, some groups are reporting success with miniplates. A retrospective review of 205 patients undergoing reconstruction with a fibula and reconstruction plate or fibula with miniplates found plate exposure rates of 15.7 and 4.9%, respectively ($p = 0.0128$).[13] They concluded that fibula reconstructions fixed with miniplates may reduce the rate of exposure. Another retrospective review of 544 consecutive patients who underwent fibula reconstruction reported similar results with miniplates, although only 10.3% of the reconstructions used miniplates.[9] They concluded the data suggests miniplates are reliable.

One study compared miniplates with different types of reconstruction plates. The varying hardware for the fibula reconstructions included 2.0 mm mandible plates, 2.0 mm locking plates, < 2.0 mm miniplates, and 2.4 mm locking plates.[14] Plate exposures did not differ between plate types, nor did the rate of nonunion, infections, or fracture. Locking plates are now the standard practice in mandible reconstruction.

Plate thickness is another consideration for reconstruction. A retrospective study from 2005 compared 185 vascularized osseous reconstructions with 2.0 and 2.4 mm locking plates and found no difference in the rate of plate exposure (10.5% vs. 18.8%, $p = 0.15$).[10] Further, lower profile plates were not found to be associated with other complications, such as fracture, infection, or nonunion. The lower profile plates have also been shown to decrease rates of plate complications, including exposure, for patients treated with adjuvant radiotherapy.[15]

### Virtual Surgical Planning

One of the newer technological advances in mandible reconstruction is VSP. The computer-aided design and manufacturing (CAD/CAM) custom plates from VSP are an addition to the traditional stock plate and preformed plate based on a mandible model. In a study of 152 patients, CAD/CAM plates had a lower rate of perioperative complications compared to prebent/preformed plates (35.9% vs. 20.7%, $p = 0.0556$).[14,16] CAD/CAM models have shown the ability to achieve a mean plate-to-bone gap < 1 mm, which was associated with an 86% reduced odds of plate exposure (odds ratio [OR], 0.12; 95% confidence interval 0.02–0.55).[17] Notably, the risk of developing an intraoral dehiscence was also decreased (OR, 0.29; 95%, 0.11–0.75).

Implementing VSP depends on various factors including the complexity of the defect (i.e., number of osteotomies), surgeon availability outside the operating room, and experience and expertise bending a plate to a model preoperatively or intraoperatively. Studies have demonstrated the importance of plate coaptation as a major factor in morphologic and functional outcomes.[18–20] Furthermore, Tang et al[21] demonstrated that VSP was associated with significantly decreased operative and ischemia time as well as improved orthognathic accuracy in a systematic review and meta-analysis of VSP incorporation for fibula free flap reconstruction. Ultimately, optimizing the contour of the plate may decrease contraction of soft tissue over the plate and lead to less hardware complications.[17] The reconstructive surgeon should consider all available options to offer the best reconstruction for the defect.

## Management of Plate Exposure

Every microvascular reconstructive surgeon will inevitably experience mandible hardware failure and must be comfortable managing this difficult complication. Various types of hardware failure exist including plate exposure (intraoral or extraoral), radiographic loosening of the screws or plate, plate fracture, and hardware infection. Options for conservative treatment include observation, antibiotic therapy, nutrition optimization, debridement and primary closure, and hyperbaric oxygen treatments.[5] Early plate exposure may require more aggressive intervention, particularly if the patient is expected to undergo adjuvant therapies. When plate exposure does not improve with conservative management after a cancer resection, the surgeon must remain vigilant for recurrent disease. Early plate exposure that occurs due to fistula formation is best managed with operative intervention to debride and close the wound. Timely management is often necessary because the flap pedicle is threatened by fistula and salivary contamination.

Early hardware exposure due to partial or total flap loss in the perioperative period can be challenging. Unless the flap is nonviable, plate removal is generally avoided in this early setting because bony union has yet to take place. New soft tissue lining or a new vascular bone-containing flap with skin paddle should be considered if tension-free closure cannot be achieved. Local or locoregional flaps can be used, on occasion, with both early and late hardware exposure, to salvage the reconstruction. Palatal island flaps, nasolabial flaps, facial artery myomucosal flaps, or submental island flaps can provide thin pliable tissue to cover hardware.

Most failures occur later in the follow-up course with an average time to exposure of 8 to 9 months.[2,5] In one study, 8 out of 21 patients were successfully managed conservatively with debridement and local flap or mucosal coverage, with or without hyperbaric oxygen.[5,10] If the exposed plate cannot be salvaged with conservative measures, hardware removal may be indicated. Typically, patients will be managed as long as possible with antibiotics, neck washouts and debridement, and minor procedures for flap coverage if bony union has yet to occur but still appears likely. Once bony union takes place, the hardware can be removed with no need for further hardware placement, often dramatically simplifying management efforts. Patient symptoms should also be considered when determining appropriate management. However, when there is persistent plate exposure and/or a chronic draining fistula despite culture-directed antibiotics, plate removal is indicated. The average time to hardware removal was 16.2 months for 20 out of the 34 cases requiring hardware removal due to plate exposure.[5,6,10] The rate of hardware removal due to all complications ranges from 14 to 27%.[5,6,10,22] Bony union was present in nearly 70% of cases reported in one study, which would allow hardware removal and primary closure.[5] Hardware removal was most commonly related to infection or exposure in the first year and continued tobacco use after mandible reconstruction.[5]

In summary, there is no single solution for management of oromandibular hardware failure. Adhering to the principles of rigid fixation until bony union has occurred cannot be over emphasized. A variety of locoregional flaps may be used to cover exposed hardware in selected cases. Lastly, a second soft tissue or bony flap may be needed when partial or total flap loss occurs.

**Conflict of Interest**
None declared.

## References

1 Bauer E, Mazul A, Zenga J, et al. Complications after soft tissue with plate vs bony mandibular reconstruction: a systematic review and meta-analysis. Otolaryngol Head Neck Surg 2021; 164(03):501–511
2 Fanzio PM, Chang KP, Chen HH, et al. Plate exposure after anterolateral thigh free-flap reconstruction in head and neck cancer patients with composite mandibular defects. Ann Surg Oncol 2015;22(09):3055–3060
3 Wei F-C, Celik N, Yang WG, Chen IH, Chang YM, Chen HC. Complications after reconstruction by plate and soft-tissue free flap in composite mandibular defects and secondary salvage reconstruction with osteocutaneous flap. Plast Reconstr Surg 2003;112(01):37–42
4 Prasad J, Sahovaler A, Theurer J, et al. Predictors of plate extrusion in oromandibular free flap reconstruction. Microsurgery 2018;38 (06):682–689
5 Day KE, Desmond R, Magnuson JS, Carroll WR, Rosenthal EL. Hardware removal after osseous free flap reconstruction. Otolaryngol Head Neck Surg 2014;150(01):40–46
6 Knott PD, Suh JD, Nabili V, et al. Evaluation of hardware-related complications in vascularized bone grafts with locking mandibular reconstruction plate fixation. Arch Otolaryngol Head Neck Surg 2007;133(12):1302–1306

 

7 Nicholson RE, Schuller DE, Forrest LA, Mountain RE, Ali T, Young D. Factors involved in long- and short-term mandibular plate exposure. Arch Otolaryngol Head Neck Surg 1997;123(02):217–222
8 Coletti DP, Ord R, Liu X. Mandibular reconstruction and second generation locking reconstruction plates: outcome of 110 patients. Int J Oral Maxillofac Implants 2009;38(09):960–963
9 Liu S-P, Cai Z-G, Zhang J, Zhang J-G, Zhang Y. Stability and complications of miniplates for mandibular reconstruction with a fibular graft: outcomes for 544 patients. Br J Oral Maxillofac Surg 2016;54(05):496–500
10 Farwell DG, Kezirian EJ, Heydt JL, Yueh B, Futran ND. Efficacy of small reconstruction plates in vascularized bone graft mandibular reconstruction. Head Neck 2006;28(07):573–579
11 Gutwald R, Alpert B, Schmelzeisen R. Principle and stability of locking plates. Keio J Med 2003;52(01):21–24
12 Ellis E III, Graham J. Use of a 2.0-mm locking plate/screw system for mandibular fracture surgery. J Oral Maxillofac Surg 2002;60(06):642–645, discussion 645–646
13 Chang T-Y, Lai YS, Lin CY, et al. Plate-related complication and health-related quality of life after mandibular reconstruction by fibula flap with reconstruction plate or miniplate versus anterolateral thigh flap with reconstruction plate. Microsurgery 2022. Doi: 10.1002/micr.30893
14 Zavattero E, Fasolis M, Garzino-Demo P, Berrone S, Ramieri GA. Evaluation of plate-related complications and efficacy in fibula free flap mandibular reconstruction. J Craniofac Surg 2014;25(02):397–399
15 Shaw RJ, Kanatas AN, Lowe D, Brown JS, Rogers SN, Vaughan ED. Comparison of miniplates and reconstruction plates in mandibular reconstruction. Head Neck 2004;26(05):456–463
16 McCann AC, Shnayder Y, Przylecki WH, et al. Comparison of modern rigid fixation plating outcomes for segmental mandibular microvascular reconstruction. Laryngoscope 2019;129(05):1081–1086
17 Davies JC, Chan HHL, Yao CMKL, et al. Association of plate contouring with hardware complications following mandibular reconstruction. Laryngoscope 2022;132(01):61–66
18 Tarsitano A, Ciocca L, Scotti R, Marchetti C. Morphological results of customized microvascular mandibular reconstruction: a comparative study. J Craniomaxillofac Surg 2016;44(06):697–702
19 Wilde F, Hanken H, Probst F, Schramm A, Heiland M, Cornelius CP. Multicenter study on the use of patient-specific CAD/CAM reconstruction plates for mandibular reconstruction. Int J CARS 2015;10(12):2035–2051
20 Haddock NT, Monaco C, Weimer KA, Hirsch DL, Levine JP, Saadeh PB. Increasing bony contact and overlap with computer-designed offset cuts in free fibula mandible reconstruction. J Craniofac Surg 2012;23(06):1592–1595
21 Tang NSJ, Ahmadi I, Ramakrishnan A. Virtual surgical planning in fibula free flap head and neck reconstruction: a systematic review and meta-analysis. J Plast Reconstr Aesthetic Surg 2019;72(09):1465–1477
22 Wood CB, Shinn JR, Amin SN, Rohde SL, Sinard RJ. Risk of plate removal in free flap reconstruction of the mandible. Oral Oncol 2018;83:91–95

 