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Stability and complications of miniplates for mandibular reconstruction with a fibular graft: outcomes for 544 patients

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Abstract

Fibular flaps are usually used for the reconstruction of the mandible, but the use of plate systems, including miniplates and reconstruction plates, has recently been debated. We have made a retrospective study of 544 consecutive patients who had fibular grafts with miniplates used for fixation, and also made retrospective measurements of orthopantomographs from 37 patients to assess the stability of the miniplates used in the fibular flaps. When miniplates were used with fibular flaps there were 10.3% (56/544) complications, of which 4.8% (26/544) were loosening of the screws, 2.6% (14/544) fracture of the plate, 1.5% (8/544) exposure of the plate, and 6.4% (35/544) infection. The median **(IQR)** time at which the complications occurred was 24 (7–48) months. We conclude that loosening of screws is common at the binding interface near the condyle and in the molar region; plates are more likely to fracture near the binding interface in proximity to the molar region; and plates at the chin are the most likely to be exposed. Diabetes and the use of radiotherapy were associated with complications. Our data suggest that miniplates used for mandibular reconstruction are relatively reliable.

Keywords: Mandibular defect; Reconstruction; Miniplate; Complication; Stability

Introduction

Microvascular free flaps are commonly used to reconstruct oromandibular defects, and fibular flaps are the most reliable way to reconstruct a long defect in the mandible. They have the advantage of providing sufficient blood supply and a stock of bone large enough to be shaped to repair a serious defect in the mandible. Plating systems are critical to guarantee the stability of grafted bones, and the most commonly used are reconstruction plates and miniplates.

Single large plates used to stabilise fibular free flaps are difficult to manipulate during the operation and may interfere with the vascular pedicle. They can be prebent, however, which can save operating time and maximise geometrical accuracy. However, a "stress-shielding" phenomenon has been described, which may lead to resorption of bone.[1] Stress shielding happens when the normal forces exerted on the mandible are eliminated by the rigid plate, and bone is resorbed because it is no longer needed to maintain the same load. This decreases the bone mineral content of the neomandible and lessens overall bony strength, so osteonecrosis is common in a neomandible with a reconstruction plate.[2]

Miniplates are fixation plates with a diameter less than or equal to 2.0 mm.[3] They have several advantages including ease of application, short fixation time, little risk of disruption of the vascular pedicle, and ease of removal if necessary.[4] In contrast, because they are smaller, they are

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Table 1
Types of defect according to the classification of Jewer et al,[6]

Type of defect	Number (%)
L	239 (44)
H	141 (26)
HC	7 (1)
HCL	6 (1)
LC	72 (13)
LCL	79 (15)

more likely to fracture and result in malunion or non-union of the neomandible.[5]

Some surgeons prefer to use large plates because they doubt the stability of miniplates for fixation of grafted bone and think that they have a higher chance of complications. However, after radiotherapy thick reconstruction plates can often dehisce through the skin, and that is why we use miniplates. We have retrospectively reviewed the reliability and stability of miniplates used for fibular flap reconstruction.

Material and methods

We reviewed the records of 544 consecutive patients who had fibular reconstruction with miniplates (diameter 2.0 mm) during a 10-year period (January 1999-December 2010).

We recorded personal and clinical details, diagnosis, sites and types of defects, smoking history, radiotherapy, duration of follow up, and complications related to the plates. We defined these as: loosening of the screws, fracture of the plate, exposure of the plate, and infection.

We used the standard international HCL classification suggested by Jewer et al,[6] to assess defects: defect C encompasses the central mandibular segment between teeth 33 and 43; defect L extends from the canine tooth to the base of the articular process leaving out the condyle; and defect H encompasses the mandible from the symphysis up to and including the condyle (Table 1). We recorded factors that could be related to the survival of the plate, which included age (less than 65 and 65 or more), sex, smoking, diabetes, radiotherapy, and defects of the mandible (anterolateral or lateral).

We used the following inclusion criteria to study the stability: patients with single defects of the condyle (H and HC); follow up of at least 1 year; and all panoramic radiographs complete. The exclusion criteria were the use of radiotherapy and complications that developed during follow up. A total of 37 patients were included. We measured the mandibular angles of the normal side and the angles on the grafted side, which were formed by fibular bones. Angle A refers to the normal mandibular angle, while angle B refers to the angle formed by the fibular bones. To measure these angles we drew four lines on the panoramic radiographs: line one and line two formed the external margin of the two grafted fibulas; line three was drawn across the tangent of the lowest edge of the mandibular body that crosses the bottom point of

Figure 1. The measurements of Angle A and angle B on orthopantomography.

the mandibular angle; line four was drawn across the most lateral point of the condyle and the most lateral point of the mandibular angle. We defined angle A as the angle formed by lines one and two, while angle B was formed by lines three and four (Figures 1 and 2). The difference between the values of angle A and angle B was recorded as angle C. Serial data for angle C were taken during each follow up and changes in this angle were evaluated, which avoided bias caused by any distortion in the orthopantomographs. Data were entered into IBM SPSS software (version 17.0 IBM Corporation, Armonk, NY, USA) and analysed using Kaplan-Meier analysis, Cox's regression analyses, and a paired sample *t* test ($\alpha = 0.05$).

Results

In all, 544 patients were reviewed, which included 206 women (38%) and 338 men (62%). The mean (SD) age of the patients was 43 (SD = 16.362) years and the mean (SD) duration of follow up 36 (SD = 36.037) months. The most common causes for defects of the mandible were ameloblastoma (n = 168, 31%) and squamous cell carcinoma (n = 148, 27%).

Table 1 shows the type of defects studied, of which 23 (4.2%) had problems with the venous return, and of these, 14 survived. Plates were removed from 52 (9.5%) because of recurrent tumour with metastases, 14 (2.5%) had locally recurrent tumour alone, and 26 (4.7%) had complications

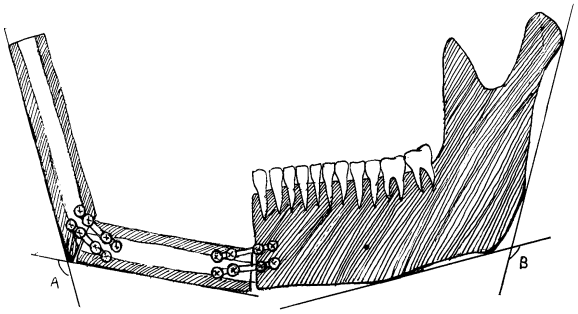

Figure 2. Diagram of the measurements of angle A and angle B.

Table 2A
Complications in 544 patients. Data are number (%) unless otherwise stated.

Variable	No (%)
Total complications	56 (10.3)
Loosening of screws	26 (4.8)
Fractured plate	14 (2.6)
Exposed plate	8 (1.5)
Infection	35 (6.4)
Median (IQR) time before complication developed (months)	24 (??-??)

Table 2B
Sites of loosening of screws (21 sites in 14 patients).

Site	No
Binding interface near the condyle	7
Interface of 2 fibulas near the molars	6
Binding interface near the molars	4
Binding interface near the incisors	3
Binding interface of 2 fibulas near the incisors	1

Table 2C
Sites of fracture of plates (12 sites in 14 patients).

Site	No
Binding interface near the condyle	4
Chin	3
Body of mandible	2
Incisor region	1
Intraoral	1
Not stated	1

with the plates. A further 133 (24.4%) had no symptoms, but the plates were removed 1-2 years later.

Table 2 (A-C) shows the overall complications involved and the sites affected. For five patients "loosening of screws" was recorded in the operating notes and medical records, but there were no orthopantomographic images. In one case "fracture of the plate" was recorded in the operating notes and medical records, but there were no orthopantomographic images, and in one case "exposure" was noted in the medical records without mention of where it was.

The Cox regression analysis showed that only diabetes and radiotherapy were associated with complications of the plates (Table 3). The Kaplan-Meier analysis showed that patients with diabetes had more complications than patients who did not (Table 4, $p = 0.002$). Similarly, radiotherapy was

Table 3
Cox analysis for survival of the plate.

Factors	B	Wald	p value
Age (years):	-3.22	0.480	0.502
Less than 65			
65 or more			
Sex:	0.067	0.044	0.834
Male			
Female			
Defect:	-0.231	0.639	0.424
Anterolateral			
Lateral			
Smoking	0.439	2.491	1.551
Diabetes	1.245	9.473	0.002*
Radiotherapy	0.977	12.475	0.000*

* $p < 0.005$.

associated with significantly poorer survival of the plates ($p = 0.000$). Patients with diabetes were at higher risk of loosening of the screws, fractures of the plate, and infection ($p = 0.002$). Diabetes had no significant effect on exposure of the plate ($p = 0.200$). Radiotherapy increased the rates of loosening screws, exposure of the plates, and infection ($p = 0.000$), but fractures of the plates were not significantly affected by whether a patient had had radiotherapy or not.

In 37 patients, orthopantomographic images were measured between 1 and 8 years later at the following times: immediately after the operation, at 3, 6, 9, 12, 15, 18, 21, 24, 27, and 30 months, as well as at 3, 4, 5, 6, 7, and 8 years. Orthopantomographic images were measured and the mean values of angle C ($\bar{c}_n$) were recorded each time (Table 5). The mean value of angle C ($\bar{c}_0$) after the operation was 8.5°. A paired sample t test was used to compare $\bar{c}_n$ and $\bar{c}_0$. Angle B significantly changed at 1 year ($p = 0.091$), but remained stable thereafter.

Discussion

The fibular free flap has become a standard and often preferred method for mandibular reconstruction. The large amount of vascularised bone it yields allows it to support an osseointegrated implant in the repaired defect. In general, plating systems are critical to guarantee the stability of grafted bones. This involves the use of a range of different plates from miniplates to large reconstructive plates, and

Table 4
Complication rates and Kaplan-Meier analysis for different factors. Data are number (%).

	Diabetes			Radiotherapy		
	Yes (n = 24)	No (n = 520)	p value#	Yes (n = 107)	No (n = 437)	p value#
Loosening of screw	5 (20.8)	21 (4.0)	0.000**	11 (10.3)	15 (3.4)	0.002*
Fracture of plate	2 (8.3)	12 (2.3)	0.047*	4 (3.7)	10 (2.3)	0.309
Exposure of plate	1 (4.2)	7 (1.3)	0.200	4 (3.7)	4 (0.9)	0.020*
Infection	4 (16.7)	31 (6.0)	0.039*	16 (15)	19 (4.4)	0.000**
Overall	7 (29.2)	49 (9.4)	0.002*	21 (19.6)	35 (8.0)	0.000**

Kaplan-Meier analysis for each complication: *$p < 0.05$; **$p < 0.000$.

Table 5
Number of patients, $\bar{c}_n$ value, and p-value at different times of follow-up.

Time	Cases	$\bar{c}_n$ (°)	p value
Month postoperatively:	37	-8.5500	
3	20	-5.8050	0.009
6	17	-0.7000	0.001
9	12	-6.6917	0.012
12	14	-2.9714	0.000
15	3	-8.7000	0.091
18	7	-1.8000	0.060
21	3	-13.9000	0.326
24	7	2.8000	0.044
27	6	-1.1833	0.063
30	2	-9.6000	0.328
33	3	-5.5667	0.130
Year postoperatively:			
3	4	5.4500	0.408
4	5	-6.6800	0.076
5	3	-5.100	0.181
6	0	0	-
7	1	-10.0000	-
8	1	-10.0000	-

the latter theoretically withstand more stress than the smaller ones.

Miniplates were associated with fewer plate-related complications (56/544, 10.3%) than reported in other publications,[2,3] where they were between 20% and 30%.[2,7–9] Maurer et al.[10] Robey et al.[2] and Shaw et al.[3] reported no significant difference in complication rates between reconstruction plates and miniplates. This may be explained by our large sample and improvement in techniques over recent years, together with the large number of our patients who did not have cancer or radiotherapy. Different definitions of complications of the plate may also lead to different results. Postoperative complications are not sufficient reason to avoid the use of miniplates in mandibular reconstruction.

Sites where screws loosened were primarily at the binding interface near the condyle and the molar region, and the binding interface near the molar region was prone to fractures. Tie et al,[11] calculated the Von Mises stresses on grafted fibular bones using 3-dimensional finite-element analysis. They concluded that the maximum Von Mises stress on grafted bone was higher than on normal bone, which indicates it's concentrating and shielding effects. The location of maximal Von Mises stresses varied by the pattern of the defect; the maximum on the reconstructed mandible with a RBS^H defect occurred at the right binding interface near the molar region with the maximum stress on the reconstructed mandible, as did a B defect. However, the maximum stress on the reconstructed mandible with a BS^HS^H defect occurred at the left binding interface near the incisor region. Our results agree with those put forward by Tie et al.[11] The chin has less soft tissue than other regions, which may explain the greater exposure of the plate.

Factors that influenced complications of the plate were diabetes and radiotherapy. We showed a significantly decreased survival of plates after radiation, which has also been shown by others.[3,10] We focused only on miniplates, while other studies looked at both miniplates and reconstruction plates.

We found that diabetes and radiotherapy had no correlation with fracture of the plate, nor did age, smoking, or the mandibular defect. Maurer et al[10] showed that smoking and age over 60 may reduce the success of mandibular reconstruction.

Because they are small and malleable, miniplates have been associated with instability,[5] but Huh et al,[12] confirmed their stability experimentally in dogs. Analysis of our 37 patients showed that the angle of the reconstructed mandible changed at around one year. However, as there were no complications associated with the plate, this result can be explained by reattachment of the muscle and self-rehabilitation of the occlusion. After this, the angle of the reconstructed mandible remained relatively constant. This suggests that miniplates are capable of keeping grafted bones stable after reconstruction. We had a small sample, and so more cases are required to prove this definitively.

Conflict of interest

We have no conflict of interest.

Ethics statement/confirmation of patients' permission

Not required.

Acknowledgments

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