Low-profile reconstruction plates for mandibular reconstruction. Is it a practical alternative?

Original Article

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ABSTRACT

Objective: The purpose of this study was to to outline the performance of low profile 2.4-mm reconstruction plate in bridging segmental mandibular defects.

Materials and methods: The study is a randomized clinical trial with a one-year follow up period. Patients requiring segmental resection was divided into Group I, managed with a low-profile 2.4-mm reconstruction plate, and Group II, managed with a regular 2.7-mm reconstruction plate. A long-term follow-up session was performed to outline plate related complications.

Results: Twelve patients were included in this study and divided into two groups, and at the end of the follow up period one patient failed to recall. None of the cases in the study group suffered from plate related complications, while two cases reported major and minor Plate related complications in the control group.

Conclusion: a 2.4-mm reconstruction plate utilized in the fixation and reconstruction of a segmental mandibular defect offers a more convenient fixation device with a comparable favorable clinical and radiographic outcomes as the conventional reconstruction plate.

Key Words: mandibular reconstruction, reconstruction plate, low-profile

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INTRODUCTION

Segmental mandibular defects reconstruction is one of the most demanding topics in the maxillofacial field with a continuous state of evolution and update to meet the contemporary parameters. Resection of affected segments of the mandible is usually manifested with morphological and functional morbidity. Mandibular reconstructive surgeries are performed with a initial mindset of bridging the defect to maintain morphological form and functional performance of the lower third of the face. [1- 3]

Initial defect bridging is commonly performed with an alloplastic internal fixation device to maintain the three-dimensional spatial relation between the remaining parts of the mandible [4]. A mandibular reconstruction plate is leading option for segmental defect bridging [5,6]. The conventional mindset for the utilized fixation device is of increased plate profile thickness and bi-cortical large bore plates [7]. Dotey et al. (2005) states that a higher plate profile owes greater fatigue durability [8].

Despite that, the use of a thicker profile plate has several drawbacks to the mandibular reconstruction procedure [9]. The shaping and bending processes for a higher plate profile to fit the symmetrical curvilinear horse-shoe configuration of the mandible is a time consuming, arduous, and flawed procedure [9].

A great residual stress would accumulate in areas of abrupt bending the plate configuration to match the mandible curve [10]. Martola et al. (2007) reports that this accumulated stress will eventually lessens the fatigue strain gained by increasing the plate profile [10].

Furthermore; the use of a thicker plate profile with primary reconstructive procedure comes with great shaping and matching complications [11]. Zhang et al. (2015) reported the use of functionally stabilized fixation in the form of miniplates to fix mandibular defects reconstructed

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with fibular flap with multiple osteotomies [12] .

Pereira et al. (2012) reported the use of a low-profile reconstruction plate system in the management of segmental mandibular defects. They reported long term follow up with optimal clinical performance and much improved intraoperative performance [13].

Moreover; the use of a thicker plate profile will propagate the modulus of elasticity of the fixation device, being much higher than that of the cortical bone [14]. This will be manifested as stress shielding phenomenon with great impact and resorption load on the grafted bone [15].

Hence, this study was conducted to delineate the performance of the 2.4-mm reconstruction plate in bridging segmental defects. Furthermore; a long-term follow-up was performed to observe the rate of plate related complications that may be encountered with different profiles of the reconstruction plate.

MATERIALS AND METHODS

A randomized controlled clinical trial study design was implemented to evaluation the performance of the implanted reconstruction plate. A total of 12 Cases eligible for segmental mandibular resection and reconstruction were recruited in this study based on sample size calculation using a one-sample t-test.

All of the included patients were selected from those admitted to the Outpatient Clinic of the Oral and Maxillofacial department, Alexandria University. Cases that require condylar prosthetic device attached to the plate were excluded from this study. The study was conducted after receiving the permission from the local research ethics committee (IRB No: 0010556-IORG: 0008839), and all patients signed an informed consent.

Cases were managed with tumor resection and fixation of the defect using a reconstruction plate. The total sample of the study were divided into 2 groups:

• Group A: Fixation was achieved with a low-profile 2.4-mm reconstruction plate system (JEIL Medical Corporation Company: Seoul, Korea). This reconstruction plate system consists of a 2.4-mm screws, with a 2.4-mm plate profile (Figure 1).

• Group B: Fixation was achieved with the conventional 2.7-mm reconstruction plate system (JEIL Medical Corporation Company: Seoul, Korea) (Figure 2).

All patients were acquired to perform a preoperative radiographic examination in the form of MSCT-scan, for proper lesion visualization and to perform virtual planning by mirroring the unaffected side to obtain a harmonious final appearance. The patients mid-sagittal plan was used to act as a reference plan to the mirroring tool to create a Neo-Mandible Model. Mandible Model was performed using Fused Deposition Modelling (FDM) printing 3D printing technology. Pre-adaptation of the reconstruction plate was performed, ensuring at least three screw holes in each bone stump.

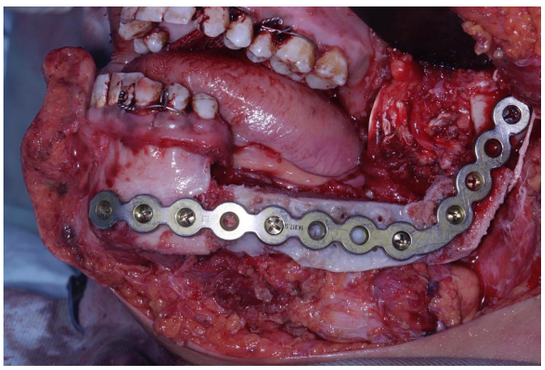

Figure 1. Patient managed with a low-profile 2.4-mm reconstruction plate as a fixation device.

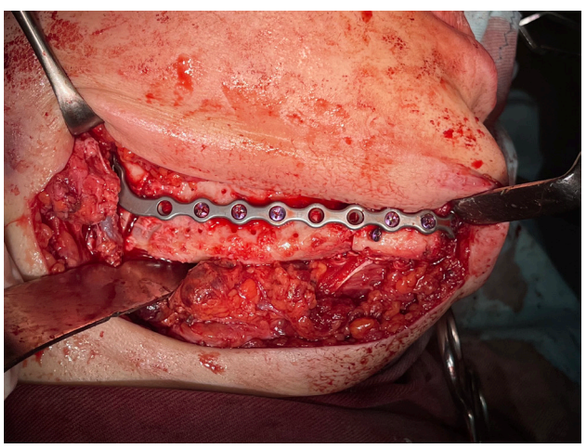

Figure 2. Patient managed with a low-profile 2.4-mm reconstruction plate as a fixation device

Surgical procedure

The lesion was approached through an extraoral second neck crease incision. Following lesion exposure, resection was performed using reciprocating saw with respect to the preoperatively determined safety margin. The chosen fixation device was then placed to bridge the defect using the preoperatively adapted plate, each according to the enrolled group. In both groups 3 screws are placed in the proximal and distal stumps. A bony reconstruction of the defect was not performed in all of the cases.

Clinical Follow up

An early clinical follow-up was maintained for 6 weeks. All patients were recalled 1 year after the operation for a clinical examination and panoramic radiographic examination.

The selected patients were categorized as either:

• Successful reconstruction; where the utilized reconstruction plate is in place or osseous gap bridging is achieved in the last follow up session.
• Minor plate related complications are those complications that could be managed without reoperation.
• Major plate related complications are those complications that need reoperation to manage, such as screw lessening, Intraoral plate exposure or infection.
• Failed reconstruction; where plate fracture occurred, and a major operation was required to replace the fixative device.

Statistical Analysis

Data were analyzed using IBM SPSS for windows version 23.0. (IBM Corp, NY, USA). The study opted for a descriptive analysis to differentiate between the two groups.

RESULTS

Table 1 documents the diagnosis, characteristics and demographic data of all 12 enrolled patients.
The study reported a 0.71:1 male to female ration, with a mean age of 36±11.36 years.The most prevalent etiological factor was ameloblastoma, which was encountered in 6 cases. On the other hand, 2 cases were presented with fibromyoma and other two with fracture non-union. Ameloblastic fibroma and Ameloblastic carcinoma was encountered only once.

Brown class I defect was encountered in 4 cases, with a lateral defect not passing the ipsilateral canine. Whilst 8 cases were presented with Brown class II defect, where the ipsilateral canine is resected in the defect. Accordingly, the 4 cases with Brown Class I defect are presented with intact contra lateral and central dental occlusion, while the remaining eight cases are presented with only contra lateral occlusion.

Bony reconstruction was performed in ten cases, with anterior iliac crest graft in 6 patients, costochondral rib graft in 2 patients, and calvarial graft in 1 patient. In only 3 cases the defect bridging was achieved, and no osseous reconstruction was performed, 2 cases in the study group and 1 cases in the control group.

Only one patient in the control group (II) failed to report at the one year follow up session. In the 1-year panoramic examination, osseous healing and regain of lower border continuity was noted in six patients. Dental rehabilitation was performed in seven cases at various periods during the long year follow-up (Table 2).

A total of nine cases reported a successful reconstruction procedure, all of the study group and 3 in the control group. Two case in the control group, where a 2,7-mm reconstruction plate was utilized, reported Plate Related Complications. None of the 11 cases that reported at the one year follow up period encountered a failed reconstruction procedure.

Table 1: Patients Characteristics and demographic Data.

N	Group (Plate)	Age/ Sex	Resection Etiology	Defect Classification (Brown)	Bony Reconstructi	Prescence of Dental Occlusion
1	I (2.4)	28/F	Ameloblastoma	I	AICG	1L+1C
2	I (2.4)	39/M	Ameloblastoma	II	AICG	1L
3	I (2.4)	20/F	Ameloblastic Fibroma	II	Calvarial Graft	1L
4	I (2.4)	20/F	Fracture non-union	II	✕	1L
5	I (2.4)	29/F	Fibro-myxoma	I	AICG	1L+1C
6	I (2.4)	38/M	Fracture non-union	II	✕	1L
1	II (2.7)	35/M	Ameloblastoma	II	AICG	1L
2	II (2.7)	47/F	Ameloblastoma	I	AICG	1L+1C
3	II (2.7)	28/F	Ameloblastoma	II	CCG	1L
4	II (2.7)	51/M	Ameloblastic Carcinoma	II	✕	1L
5	II (2.7)	54/F	Fibro-myxoma	II	AICG	1L
6	II (2.7)	43/M	Ameloblastoma	I	CCG	1L+1C

n, Number; yr, Year; M, Male; F, Female; M:F, Male: Female Ratio; AICG, Anterior Iliac Crest Graft; CCG, Costochondral Graft;

Table 2: Plate Related Complications (PRC).

N	Group (Plate)	1-year follow up	Description	Dental	Osseous Healing
1	I (2.4)	Success		✓	✓
2	I (2.4)	Success		✓	✓
3	I (2.4)	Success		✗	✗
4	I (2.4)	Success		✗	✗
5	I (2.4)	Success		✓	✓
6	I (2.4)	Success		✗	✗
1	II (2.7)	Success		✓	✓
2	II (2.7)	Minor PRC	Extra-oral Plate Exposure	✓	✓
3	II (2.7)	Major PRC	Intraoral Plate Exposure, infection	✗	✗
4	II (2.7)	Success		✓	✓
5	II (2.7)	Success		✓	✓
6	II (2.7)	Drop-out		✗	✗

n, Number; PRC, Plate Related Complications.

One patient was presented with an extraoral plate exposure (Figure 3).

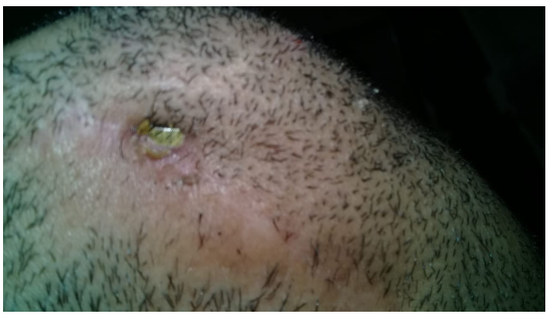

Figure 3. Minor postoperative Plate Related Complication in one of the cases in the control group managed with 2.7-mm reconstruction plate.

This minor PRC was presented 2 months from the operation. External wound care instructions were prescribed to the patient and wound debridement was performed, however the exposed plate persisted. Fortunately, this complication didn't affect the normal osseous procedure of the grafted AICG, and the patient was reoperated to remove the 2.7-mm reconstruction plate eight months from the initial operation. Another case was presented with a rather drastic major complication. This patient was presented with an extraoral swelling 2 weeks from the operation. Empirical antibiotic was prescribed however with no improvement. On the third postoperative week, an intraoral pus started oozing and intraoral wound dehiscence and exposure of the plate was evident in the angle area at the end of the first postoperative month. Several wound debridement attempts were performed with no improvement. The patient was reoperated 6 weeks from the initial surgery, with the removal of the plate and the previously grafted bone. The new stumps after refreshment were fixed with a 2.4-mm reconstruction plate with no osseous reconstruction. In the one-year follow-up, the patient showed uneventful healing and he is scheduled for an osseous grafting surgery.

DISCUSSION

A steady and stable mandibular unit after the segmental resection of the affected part of the mandible is the main intention to be achieved in any mandibular reconstructive surgery, with a grater mindset of improving the patient quality of life [3]. Over the most recent publications in the indexed literature, the alloplastic fixation device to bridge the mandibular defect gap has gain several modifications [16]. Hence this study was conducted to outline the performance of a low profile 2.4-mm reconstruction plate in the fixation of a segmentally resected mandible.

The most prevalent etiological factor was ameloblastoma, which was encountered in 6 cases. On the other hand, 2 cases were presented with fibromyoma and other two with fracture non-union. Ameloblastic fibroma and Ameloblastic carcinoma was encountered only once.

In this study, the most encountered etiological factor was ameloblastoma (n=6). A similar outcome was reached by Ayoub et al. (2014) and Marschall et al. (202) [17,18]. Ameloblast is the most prevalent developmental odontogenic tumor in the mandible [19]. Its developmental nature results in it late discovery and its locally invasive nature results in the use of a safety margin in order to prevent tumor recurrence [20-21].

The inclusion of locally aggressive but benign lesion allowed for primary reconstruction to be performed with no emphasis on the drawbacks of chemotherapy or radiotherapy. In this study nine received primary reconstruction in contrast to only three cases where only defect fixation was attained, and reconstruction was performed in a secondary fashion. Two of the cases where

fracture non-union cases with history of infected fracture lines, thus the choice for a staged reconstruction was opted. Kadam (2019) states that primary reconstruction is not always available in developing countries owing to recourses scarcity [22,23]. As opted in this study, Perez and Ellis (2020) reported that secondary reconstruction to posttraumatic mandibular segmental defects should be performed [24].

Ameloblastomas are typically thought of as benign tumours, but there have been reports of metastasizing ameloblastomas showing typically benign morphological features in both primary and metastatic lesions. This is likely due to the ameloblastomas' propensity for recurrence and locally aggressive behaviour similar to malignant tumors [25]. In this study, none of the cases showed signs of recurrence at the one year follow up session. The findings of this study suggested that a high recurrence rate caused by poor management may increase the likelihood of metastasis, and it appeared to be very challenging to predict the propensity of recurrence and even metastasis from the gross characteristics, including radiological and histopathological findings.

The majority of the cases in this study were of Brown class II classification, with defects that span from the angle to the ipsilateral canine. This may be correlated to the predominantly being nature of the included patients in this study, where nine cases were resected for a benign cause, 2 posttraumatic defect malformation, and only one presented with malignant variant of ameloblastoma, Ameloblastic carcinoma. Dowgierd et al. (2022) reported a predominant prevalence of Brown Class II defect in their study [26].

Anterior iliac crest was the main utilized donor site in six patients. In all of the cases where osseous reconstruction was performed, a non-vascularized graft was utilized. In mandibular reconstruction, vascularized fibular osteo-myo-cutaneous free flaps are the gold standard modality of choice. However, it is shown to have a number of serious flaws making it not always the best option for ideal outcomes. Along with donor site morbidity, availability, and operation length, microsurgeries, and vascularized free transfer place a significant cost burden on the patient and stain hospital resources [27].

An alternative method for reconstructing medium-sized mandibular lesions, Brown class I-II, is non-vascularized bone grafts [27-29]. As stated by Bradely et al. (2000), the anterior iliac crest is a reliable and accessible harvesting site with sufficient osseous mass and contour for three-dimensional defect restoration [30-32].

Concerning the Plate Related Complications (PRC), all of the cases managed with 2.4-mm low profile plate reported uneventful long-term complication-free successful reconstruction, while two cases fixed with the thicker plate profile reported PRC. Regarding the 2.4-mm plate, Pereira et al. (2012) reported uneventful reconstruction with exemplary morphological and functional outcomes [13] In this study a one-year follow up session was performed in order to assess long term PRC. This choice was based on the literature, as there is a scientific consensus in the literature that plate fatigue fracture happens within the first six months post-implantation [33, 34]. According to Arias-Gallo et al. (2004), the majority of hardware issues appeared at locations subjected to greater moment and shear stresses. Mechanical stress is a major contributor to problems and is created by mandibular functional movements including mastication. forces brought on by the masticatory muscles contracting [35]. In both groups of this study, no patients are presented with screw loosening.

In one case managed with 2.7-mm reconstruction plate, wound dehiscence and intraoral infection occurred, which was resolved with reoperation for plate explanation and replacement. Incidences of wound infection were reported by Osborn et al. (2017) in nine patients where a 2.7-mm reconstruction plate was utilized [36]. The literature lists a number of factors that can predispose to wound infection, but poor oral mucosal seal and the complication of intraoral dehiscence are the main factors that contribute to wound infection and graft failure. The oral flora and saliva enter relatively sterile tissues through a wound dehiscence, starting the inoculation phase of the illness. with a double layer watertight suture, the oral wound seal is carefully achieved.

Seol et al. (2014) states that the pre-bending procedure of a thicker plate is more arduous and with more complications [16]. From the experience gained in this study, the utilization of a lower-profile 2.4-mm reconstruction plate offers a predictable outcome in moderate-sized mandibular defects, with fewer complications. Further studies should be conducted to correlate their performance in Brown class IV defects. The use of lower plate profile may act to place the plate in a more coinvent subapical position, and not directly on the lower border of the mandible. One of the limitations in this study is the lack of assessment to the effect of coronoidectomy and masticatory forces on the long-term performance of various types of reconstruction plate. Kimura et al. [11] states that masticatory pressure can cause vertical stress on the plate, which will be manifested as screw loosening and bone resorption around the screw. According to Seol et al. (2014), coronoidectomy should be considered in any Brown Class I defect, involving the angle [16].

CONCLUSION

The utilization of a lower-profile reconstruction plate showed a comparable clinical and radiographic performance as the conventional thicker plates. 2.4-mm reconstruction plates are easier to adapt to the bony morphology of the mandible with similar rigidity as the thicker plates. The superb outcome reached in this study may outdate the use of the 2.7-mm plates in favour to the lower-profile 2.4-mm reconstruction plates in moderate-sized defects.

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CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest. The authors declare that they received no funding to perform this study.

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