Clin Oral Invest (2011) 15:151–156
DOI 10.1007/s00784-009-0375-0

ORIGINAL ARTICLE

Macroplate fixation of fractures of the edentulous atrophic mandible: immediate function and masticatory rehabilitation

Steffen Müller · Ralf Bürgers · Michael Ehrenfeld · Martin Gosau

Received: 6 July 2009 / Accepted: 14 December 2009 / Published online: 12 January 2010

Abstract The present study aimed at evaluating the treatment outcome of fractures of the edentulous atrophic mandible by means of an extraoral approach using open reduction and internal fixation with macroplates. Eighteen patients with 21 fractures of the atrophic mandible, who had been treated between 1997 and 2006, were retrospectively analysed. Mandible height was categorised according to the Luhr classification and the patients' general health (The American Society of Anesthesiologists (ASA) classification). Three types of titanium macroplates were used. Demographic data, treatment outcomes and the pre- and postoperative ability to wear mandible dentures were evaluated. The study population consisted of five men and 13 women with a median age of 78 years. The mean follow-up duration was 28 months. The most common cause of fractures was accidental falls (50%); the mandible was affected in 77.8%. Three fractures occurred in class I (bone height 15–20 mm), seven in class II (10–15 mm), and 11 in class III atrophy (<10 mm). According to the ASA classification, the collective showed a mean value of 3. An overall complication rate of 16.7% was noted, consisting of two minor and one major complication that required a second intervention. Five patients needed removal of the osteosynthesis material for prosthetic reasons. Only 50% of the patients were able to wear their dentures before surgery, and all but one were able to wear their prosthesis postoperatively. Treatment of atrophic mandible fractures with macroplates by means of an extraoral approach showed good results and a low complication rate. This procedure allows elderly patients to instantly load the mandible in the means of prosthetic and masticatory rehabilitation, preventing the necessity for second interventions.

Keywords Edentulous · Mandible · Rigid fixation · Atrophy · Fracture

S. Müller
Department of Oral and Maxillofacial Surgery,
Technical University Munich,
Munich, Germany

R. Bürgers
Department of Prosthetic Dentistry,
University Medical Centre Regensburg,
Regensburg, Germany

M. Ehrenfeld
Department of Oral and Maxillofacial Surgery,
Ludwig Maximilians University Munich,
Munich, Germany

M. Gosau (✉)
Department of Oral and Maxillofacial Surgery,
University Medical Centre Regensburg,
93042 Regensburg, Germany
e-mail: martin.gosau@klinik.uni-regensburg.de

Introduction

Life expectancy in the western world has increased, resulting in a demographic shift towards a progressively older population [1, 2]. As a consequence, the frequency of age-related diseases is higher than ever. With rising age, edentulism and atrophy of the alveolar ridge present common dental problems. Atrophy of the mandible decreases bone mass, making the bone more vulnerable to fracture [2–4]. Treatment of mandibular fractures of edentulous patients differs from that of dentate patients. Bone regeneration and fracture healing are delayed in atrophic mandibles because of a reduced cross-section and a smaller contact area of the fractured ends. Additionally,

dense, sclerotic and poorly vascularised bone structures contribute to extended healing times [2, 5]. The height of the mandible is known to be related to the incidence of complications in fracture healing [5–7]. Luhr et al. [6] defined a mandible measuring 20 mm or less in height at a fracture site as atrophic and proposed a classification. The goal of fracture management is the restoration of form and function. However, treatment strategies for fractures of highly atrophic mandibles in elderly patients remain controversial.

We hypothesise that due to the advanced age of the patients, immediate recovery of function is mandatory, which can only be achieved by the rigid fixation with a strong load-bearing plate. Such fixations will minimise operation times, duration of hospital stays and complication rates. Therefore, the present study retrospectively analysed the treatment outcome of fracture fixation with macroplates by means of an extraoral approach in 18 patients with 21 fractures of the atrophic edentulous mandible.

Patients and methods

In this study, we included 18 edentulous patients with 21 fractures of the atrophic mandible who were surgically treated in the Department of Oral and Maxillofacial Surgery at the University of Munich from December 1997 to November 2005. All patients gave written consent to participate in the study. The length of follow-up was calculated from the point of the first treatment to the last follow-up in December 2007. If patients did not show up for follow-ups after discharge from the hospital, their relatives or treating dentists were contacted by phone or in written form. All patients were retrospectively analysed for gender, age, mechanism of injury, location of fracture, postoperative complications, postoperative rehabilitation of masticatory function as well as for their preoperative prosthetic status. Clinical and radiographic features were reviewed. Only patients with complete documentation were included in this study. Exclusion criteria were comminuted or defect fractures requiring primary bone grafting for reconstruction.

Mandible height was measured by preoperative panoramic X-rays, and atrophic categorised according to the Luhr classification (class I=16–20 mm, class II=11–15 mm, class III<10 mm) [6]. The patients' general conditions were preoperatively assessed by means of the classification by the American Society of Anesthesiology (ASA 1: normal healthy patient, ASA 2: patient with mild systemic disease, ASA 3: patient with severe systemic disease, ASA 4: patient with severe systemic disease that is a constant threat to life, ASA 5: moribund patient who is not expected to survive without the operation) [8, 9].

All fractures were treated by open reduction and rigid fixation with three different types of commercially available titanium macroplates (AO 2.4 universal fracture plate, AO 2.0 large profile unilock plate, AO 2.4 unilock reconstruction plate; Synthes GmbH, Freiburg, Germany) by means of an extraoral approach. A later removal of the osteosynthesis material was only scheduled in case of complications, such as infection, loosening of osteosynthetic material or difficulties with prosthetic rehabilitation. Impairment of mandibular nerve function was not assessed because some patients could not reply properly; therefore, preoperative data were frequently missing.

Postoperative X-ray images were available for all patients (panoramic and posteroanterior radiographs). Data were tabulated and subjected to descriptive statistical analysis for the purpose of presentation. Continuous data were summarised according to medians and means. Calculations were done with the statistical software SPSS 15.0 for Windows (SPSS Corp., Chicago, IL, USA).

Results

The study population consisted of five men (28%) and 13 women (72%). Age at the time of diagnosis ranged from 56 to 93 years (mean age 78.2 years, median 78 years). The mean follow-up duration was 28 months (median 18 months, range 7–88 months). Seven patients presented at the hospital for follow-up on a regular basis, the other 11 patients were contacted by phone, either personally or through their relatives, or by query of their local dentist. Three patients died within the follow-up period (14, 24 and 25 weeks postoperatively).

The most common cause for fracture was accidental fall (n=9; 50% of all patients) followed by pathologic fractures after minor surgical procedures, such as dental implantation or tooth removal (n=4; 22%), traffic accidents (n=3; 17%) and physical assaults (n=2; 11%).

Eighteen patients showed 21 fractures. The mandibular body presented the most frequently involved region (n=14; 67%) followed by the mandibular angle (n=5; 24%) and the paramedian region (n=2; 9%). According to the classification by Luhr, three fractures belonged to class I atrophy, seven to class II and 11 to class III (see Table 1). According to the ASA classification, the collective showed a mean value of 3. The mean duration of surgical procedures was 2 h (range 0.55–3.00 h), and the mean duration of hospital treatment was 10 days (range 3–14 days). Three patients had to be postoperatively monitored in intensive care for 1 day.

Wound healing after surgery was uneventful in 16 patients. Two patients developed postoperative wound infection, one of them requiring reosteosynthesis due to a

Table 1 Atrophic mandible fractures–characterisation of patients

Patient	Age (years)	Gender	Treatment date	Location	Height (mm; class of atrophy)	ASA	Treatment (system, compression)	Follow-up (months)	Bone overlap by plate	Prosthesis capability		Complications	Secondary operation (months following primary operation)
										Pre-operation	Post-operation		
1	89	F	Dec 1997	Body left	7 (III)	3	AO 2.4	8	Yes	No	No	None	No
2	78	M	Oct 1998	Body left	12 (II)	4	AO 2.4	24	No	Yes	No	None	No
3	78	F	Dec 1998	Angle left	12 (II)	2	AO 2.4	25	No	Yes	Yes	None	No
4.1 4.2	80	F	Jul 1999	Angle right Angle left	9 (III) 9 (III)	2	AO 2.4 AO 2.4	42	No No	Yes	Yes	Screw loosening, Screw perforation	Plate removal (4)
5.1 5.2	85	F	Aug 1999	Body right Body left	8 (III) 8 (III)	4	AO 2.0 Unilock AO 2.0 Unilock	16	No No	No	No	Screw perforation	Screw removal (5)
6	77	M	Sep 1999	Angle left	18 (I)	3	AO 2.4	88	No	Yes	Yes	None	No
7	72	M	Nov 1999	Body left	12 (II)	3	AO 2.4	14	No	No	No	None	No
8	76	M	Dec 2000	Body right	13 (II)	3	AO 2.4 Unilock	72	No	Yes	Yes	Screw perforation	Screw shortening LA (10)
9	90	F	Feb 2002	Body right	8 (III)	3	AO 2.4 Unilock	17	Yes	No	No	Screw loosening, local infection	Screw removal (17)
10	92	F	Jun 2002	Paramed. left	14 (II)	3	AO 2.4 Unilock	11	Yes	Yes	Yes	Screw perforation	Partial plate removal (11)
11	86	F	Jun 2002	Body right	8 (III)	2	AO 2.4 Unilock	8	Yes	No	No	Marginal mandibular nerve palsy	No
12	56	F	Nov 2002	Body left	20 (I)	3	AO 2.0 Unilock	27	No	Yes	Yes	None	No
13	60	M	Jul 2003	Angle right	18 (I)	3	AO 2.4	7	No	Yes	Yes	None	No
14	63	F	Feb 2004	Body left	12 (II)	2	AO 2.4	45	No	Yes	Yes	Screw perforation	Screw shortening LA (35)
15	75	F	Apr 2004	Body left	8 (III)	3	AO 2.0 Unilock	26	No	Yes	Yes	None	No
16	74	F	Oct 2004	Paramed. right	11 (II)	3	AO 2.4	20	No	No	No	Local infection	Plate removal (8), reosteosynthesis
17	93	F	Aug 2005	Body right	4 (III)	3	AO 2.0 Unilock	7	Yes	No	No	None	No
18.1 18.2	83	F	Nov 2005	Body right Body left	9 (III) 9 (III)	3	AO 2.4 Unilock AO 2.4 Unilock	7	No No	No	No	None	No

ASA American Society of Anesthesiology, *LA* local anaesthesia

persisting infection 8 weeks after primary surgery. One patient experienced temporary palsy of the marginal branch of the facial nerve. These figures resulted in an overall complication rate of 16.7%. All patients were able to eat at least a soft diet 1 week after surgery. In the further postoperative course, five patients needed partial (four) or complete (one) removal of the osteosynthesis material in local or general anaesthesia to enable them to continue to wear mandible dentures. Secondary intervention was undergone, in the mean 14 months after primary surgery (range 4–35 months).

Nine out of 18 patients (50%) were carrying dentures before surgery. All but one was able to wear dentures postoperatively. Out of the seven patients with class III atrophy, only two were carrying dentures preoperatively and were able to do so postoperatively. Additionally, five out of seven patients with class II atrophy wore dentures preoperatively. One of these patients was not able to use his mandible denture postoperatively. All three patients with class I atrophy were able to wear their prosthesis pre- and postoperatively.

Discussion

Fractures of the edentulous atrophic mandible represent a challenge for surgeons because of the limited bone quality and quantity, and for anaesthetists because of the frequently reduced general condition of elderly patients [10, 11]. In an 8-year period, 18 patients were treated for fractures of the edentulous atrophic mandible in the Department for Oral and Maxillofacial Surgery, Munich. In the present study, cause of injury and location of fracture were similar to previous reports in the literature [12–15]. Treatments varied in respect of approach, choice of conservative or operative regimes, dimension of hardware applied for fixation and use of primary bone grafts [7, 12–14, 16–20]. None of these methods has shown to be entirely satisfactory as some series report mal-union or non-union rates of up to 25% [7, 16, 17]. Some authors recommend the use of miniplates [5, 16, 21], whereas others prefer the rigid fixation with plates of a larger dimension [1, 4, 7, 14, 22]. The literature indicates a high incidence of postoperative plate fracture for the use of miniplates [2, 4, 17]. Our series did not show any plate fractures, which might indicate the superiority of macroplates over miniplates in this context. In summary, we encountered a complication rate of 16.7% (three out of 18) as two surgical revisions became necessary due to infection (one minor revision necessitating screw removal in local anaesthesia and one major revision with complete reosteosynthesis). Thus, the rate of serious complications with a non-union rate of 5.5% (one out of 18) is rather low compared to other studies [7, 16, 17]. However, late intraoral screw perforation was seen in five patients. Most of the screw perforations occurred after prosthetic rehabilitation (four out of 5). The pressure of the mandible denture on the lingual mucosa made screw removal necessary during follow-up. If the number of secondary screw shortenings or plate removals is added, our overall complication rate will rise up to 44.4% (eight out of 18). Thus, exact measuring of the width of the mandible after drilling is highly important. In accordance to other studies, class II and class III patients did not differ with regard to the frequency of complications (local infections, screw perforations) [12, 15].

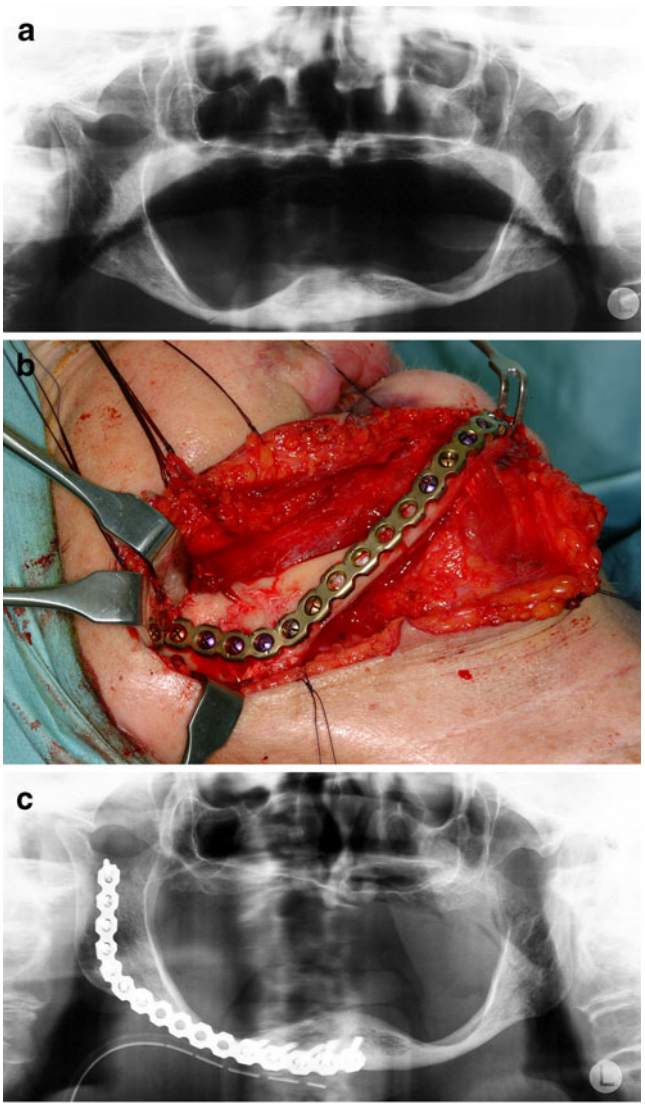

Fig. 1 Patient no. 18: 86-year-old woman after traffic accident, ASA 2, Luhr class III atrophy, fracture of the right mandibular body. **a** Preoperative panoramic radiograph. **b** Intraoperative situs, after osteosynthesis with an AO 2.4 unilock-macro plate by means of an extraoral approach; placement of the screws in the symphysis and angle region. **c** Postoperative panoramic radiograph

All operations were done via an extraoral approach for adequate surgical exposure. We believe that this is necessary for osteosynthesis of fractures of atrophic mandibles with macroplates, and special care should be taken of accurate reduction of fractures. The plate stabilisation screws should be placed well away from the fracture site, if possible in the muscle-covered parts of the mandible, best in the angle and the symphyseal region (see Fig. 1a–c). Furthermore, the risk of damage to the mandible nerve is reduced by screw positioning in bone areas away from the fracture zones in the atrophic mandibular body.

Wide exposure may be achieved transorally or transfacially. We prefer the transfacial (extraoral) approach when conducting an open reduction since, in atrophic mandibles, internal fixation with 2.4 locking plates is very difficult to achieve with an intraoral approach. Additionally, positioning is much more time-consuming, and procedures should be kept short, particularly in elderly patients. Clinical experience with patients subgrouped into transoral versus. extraoral approaches suggests that the transoral approach is more often associated with infection and non-union [23]. Disadvantages of the extraoral approach are the visible scar and the danger of damaging the marginal branch of the facial nerve during surgery. However, a scar should not be a major problem since it can be hidden in the wrinkles at the neck, and damage to the facial nerve may be prevented by careful preparation. Problems may arise when the bone level of a high-grade atrophic mandible is surmounted by the reconstruction plate. The width of the AO reconstruction plate is 8 mm. During surgery, the plates used to be adjusted to the inferior border of the mandible. Particularly patients with class III atrophy frequently require bone overlapping by the osteosynthesis plate, which makes prosthetic rehabilitation without plate removal extremely difficult, thus a second intervention is often required. We found that only two out of eight patients with class III atrophy used mandibular dentures preoperatively. Both patients were able to wear their prostheses after the operation. None of the patients with highly atrophic mandibles, in whom the plates surmounted the alveolar ridge after surgery, had used a mandibular prosthesis preoperatively. Therefore, the problems caused by the plate's volume are not responsible for the disability to wear mandible dentures because highly atrophic jaws do also not allow the preoperative wearing of dentures.

Some authors advise immediate bone grafting [2, 12, 24, 25]. In the present case series, bone grafting was not necessary for fracture healing. We favour bone augmentation in comminuted fractures or highly atrophic mandibles if dental implantation is planned. These cases were excluded from this study.

The average patients' age in our group was 78.2 years; 15 patients were 70 years or older. The majority of these patients presented considerable anaesthetic risks, mainly due to ischemic heart disease and chronic airflow limitation, resulting in an average of ASA 3 according to the classification by the American Society of Anesthesiology [8, 9]. Particularly in patients with reduced general condition and compliance, early mobilisation and buttressing of the mandible is necessary to allow free movement of the mandible, normal speech and the immediate uptake of a soft or solid diet [4, 17]. These requirements are made possible by a rigid internal fixation and a load-bearing plate. Load sharing is no objective because atrophic mandibles are unable to bear loads [2, 4]. Rigidity seems to be the most important factor in fracture healing, particularly in fractures of edentulous atrophic mandibles [6, 12].

Conclusion

For fractures of edentulous, highly atrophic mandibles, a rigid internal fixation with load-bearing osteosynthesis is indicated to restore both immediate and long-term function with a minimum of convalescent morbidity or inconvenience. Fracture stabilisation with macroplates showed good results and low complication rates. The use of a load-bearing plate may reduce the length of the convalescence time and result in less frequent second interventions due to plate fracture. In highly atrophic mandibles, the intraoral disturbance caused by big plates preventing prosthetic rehabilitation seems to be of minor relevance because highly atrophic mandibles are usually unsuitable for dentures.

Conflict of interest The authors declare that they have no conflict of interest.

References

1. Marciani RD (2001) Invasive Management of the fractured atrophic edentulous mandible. J Oral Maxillofac Surg 59:792–795
2. Ellis E 3rd, Price C (2008) Treatment protocol for fractures of the atrophic mandible. J Oral Maxillofacial Surg 66:421–435
3. Sidal T, Curtis DA (2006) Fractures of the mandible in the aging population. Spec Care Dentist 26:145–149
4. Tiwana PS, Abraham MS, Kushner GM, Alpert B (2009) Management of atro, phic edentulous mandibular fractures: the case for primary reconstruction with immediate bone grafting. J Oral Maxillofac Surg 67:882–887
5. Mugino H, Takagi S, Oya R, Nakamura S, Ikemura K (2005) Miniplate osteosynthesis of fractures of the edentulous mandible. Clin Oral Investig 9:266–270
6. Luhr HG, Reidick T, Merten HA (1996) Results of treatment of fractures of the atrophic edentulous mandible by compression plating: a retrospective evaluation of 84 consecutive cases. J Oral Maxillofac Surg 54:250–254

7. Bruce RA, Ellis E 3rd (1993) The second Chalmers J. Lyons Academy study of fracture of the edentulous mandible. J Oral Maxillofac Surg 51:904–911
8. Little JP (1995) Consistency of ASA grading. Anaesthesia 50:658–659
9. Junger A, Engel J, Quinzio L, Banzhaf A, Jost A, Hempelmann G (2002) Risk predictors, scoring systems and prognostic models in anesthesia and intensive care. Part I: anesthesia. Anasthesiol Intensivmed Notfallmed Schmerzther 37:520–527
10. Seper L, Piffko J, Joos U, Meyer U (2004) Treatment of fractures of the atrophic mandible in the elderly. J Am Geriatr Soc 52:1583–1584
11. Turrentine FE, Wang H, Simpson VB, Jones RS (2006) Surgical risk factors, morbidity, and mortality in elderly patients. J Am Coll Surg 203:865–877
12. Luhr HG, Reidick T, Merten HA (1996) Fractures of the atrophic mandible—a challenge for therapy. Fortschr Kiefer Gesichtschir 41:151–154
13. Newman L (1995) The role of autogenous primary rib grafts in treating fractures of the atrophic edentulous mandible. Br J Oral Maxillofac Surg 33:381–386
14. Kunz C, Hammer B, Prein J (2001) Fractures of the edentulous atrophic mandible. Fracture management and complications. Mund Kiefer Gesichtschir 5:227–232
15. Wittwer G, Adeyemo WL, Turhani D, Ploder O (2006) Treatment of atrophic mandibular fractures based on the degree of atrophy—experience with different plating systems: a retrospective study. J Oral Maxillofac Surg 64:230–234
16. Thaller SR (1993) Fractures of the edentulous mandible: a retrospective review. J Craniofac Surg 4:91–94
17. Eyrich GK, Grätz KW, Sailer HF (1997) Surgical treatment of fractures of the edentulous mandible. J Oral Maxillofac Surg 55:1081–1088
18. Sikes JW Jr, Smith BR, Mukherjee DP (2000) An in vitro study of the effect of bony buttressing on fixation strength of a fractured atrophic edentulous mandible model. J Oral Maxillofac Surg 58:56–62
19. Nasser M, Fedorowicz Z, Ebadifar A (2008) A Cochrane systematic review finds no reliable evidence for different management options for the fractured edentulous atrophic mandible. Gen Dent 56:356–362
20. Holland I (2007) The fractured edentulous atrophic mandible—open or closed treatment? Evid Based Dent 8:87
21. Iatrou I, Samaras C, Theologie-Lygidakis N (1998) Miniplate osteosynthesis for fractures of the edentulous mandible: clinical study 1986–96. J Craniomaxillofac Surg 26:400–404
22. Anderson T, Alpert B (1992) Experience with rigid fixation of mandibular fractures and immediate function. J Oral Maxillofac Surg 50:555–560
23. Madsen MJ, Haug RH, Christensen BS, Aldridge E (2009) Management of atrophic mandible fractures. Oral Maxillofac Surg Clin North Am 21:175–183
24. Louis P, Holmes J, Fernandez R (2004) Resorbable mesh as a containment system in reconstruction of the atrophic mandible fracture. J Oral Maxillofac Surg 62:719–723
25. Benson PD, Marshall MK, Engelstad ME, Kushner GM, Alpert B (2006) The use of immediate bone grafting in reconstruction of clinically infected mandibular fractures: bone grafts in the presence of pus. J Oral Maxillofac Surg 64:122–126