Dental Traumatology 2008; **24**: 17–21; doi: 10.1111/j.1600-9657.2006.00498.x

Open or closed repositioning of mandibular fractures: is there a difference in healing outcome? A systematic review

Jens Ove Andreasen[1], Simon Storgård Jensen[2], Thomas Kofod[1], Ole Schwartz[1], Sören Hillerup[1]

[1]Department of Oral and Maxillofacial Surgery, University Hospital (Rigshospitalet), Copenhagen, Denmark; [2]Department of Oral Surgery and Stomatology, School of Dental Medicine, Berne, Switzerland

Correspondence to: Jens Ove Andreasen, Department of Oral and Maxillofacial Surgery, University Hospital, Glostrup, Denmark
Tel.: (45) 35 45 2431
Fax: (45) 35 45 2364
e-mail: jens.ove.andreasen@rh.hosp.dk

Accepted 1 March, 2006

Abstract – The clinical outcome of closed vs open reduction and rigid fixation was compared based on a systematic review of the literature. Ten non-randomized retrospective studies were found. In six of these ten studies, the complication rate was significantly increased when open reduction and plating was performed. In the remaining studies, a slightly elevated (but not significant) infection rate was found when compared with closed reduction. Altogether, an infection rate of 5.0% was found in the closed reduction group whereas 10.6% and 14.6% were found when open reduction was performed using either plates or wires. Nerve injuries were slightly increased when open reduction was found (although not significant). With regard to occlusal disturbances, no difference was found in the open and closed reduction group. Concerning overall complication problems, six of seven studies showed more problems after open than closed reduction. In conclusion, this literature review using retrospective studies has raised doubts regarding the superiority of open reduction and rigid splinting, compared to closed reduction and intermaxillary splinting. However, a bias concerning the preferential use of open reduction in case of more complicated fractures cannot be excluded, which might explain the differences found between the two procedures. Prospective, randomized clinical trials are needed to illuminate this problem.

Before 1970, most jaw fractures, especially non-displaced fractures, were treated by conservative means, i.e. by closed repositioning and intermaxillary fixation (IMF). Based on a series of animal experiments (mainly using dogs) the AO group in Switzerland came out with a concept osteosynthesis (fixation) using open reduction and various plating systems (1). Through the work of Champy, this concept was further developed using miniaturized plating designs applied to fracture sites where a maximum of shearing or tension stress was found (2, 3).

Few years later, clinical studies could demonstrate the effect of this treatment based on a substantial number of cases (4, 5). In the early 1990s, however, many studies were published comparing treatment results of closed or open treatment procedures (6–13, 19, 31). These studies, generally showing complications when using open procedures vs closed repositioning procedures, had apparently very little impact on the general use of open reposition and internal fixation (14–16).

Before considering a comparison between these two techniques, it might be useful to analyze the cellular events related to jaw fracture healing. The normal healing stages progresses from bleeding and formation of a coagulum between fractured fragments – initially stemming from the marrow area and later from non-injured parts of the periosteum. In this regard, a bony/cartilaginous callus is soon formed which creates stability between fragments. This callus later remodels so that the anatomy in the region is regenerated (17). In several experimental studies, two major factors have been found to control events related to healing, namely optimal vascularity in the healing site and absence of a significant amount of bacteria (18).

Close proximity and absolute immobility between the fractured fragments, a concept proposed by the AO group, has been claimed to lead to an accelerated healing and less risk of infection; however, such a relationship has not been proven clinically (19).

A recent bone repair study found that controlled micro movements accelerate bone formation (20). Actually, this concept is part of the principle of distraction osteogenesis (21). In open reduction and osteosynthesis, surgical access to the fracture site is created via an extraoral or intraoral approach. Thereafter, repositioning is carried out under visual control, and splinting performed via plates or wires. Due to the raising of a flap and exposure of the fracture site, a significant amount of the vascularity to the fracture site is severed. Furthermore, bacteria from the oral cavity or the skin may be introduced to the wound site and finally foreign bodies (plates or wire) are placed in the wound healing site.

Based on these premises it could be expected that the infection rate would be elevated.

Over the years, a controversy has existed concerning the cost–benefit of these two techniques (22).

The proponents of **open reduction** and **internal fixation** claim the following advantages:

1. fast restored occlusal function;
2. optimized reposition; and
3. economic advantages because of less loss at time of work (23–25).

The proponents of **closed repositioning** and **intermaxillary splinting** claim the following advantages (22):

1. less traumatogenic procedure (22, 36, 37);
2. preserving the vascularity of the trauma site (22, 26);
3. advantages because of shorter hospitalization (8) and less expenses due to hardware (9, 11, 27);
4. reduced risk of nerve lesions and occlusal dysfunction (13);
5. usually outpatient service; and
6. less operator sensitive.

However, an analysis of the relevance of these divergent opinions has so far not been carried out. Therefore it seemed relevant to search for comparative studies where the same department has published results using both the techniques, and ideally, if this is performed in a randomized approach.

The purpose of the present study was to analyze the following questions based on the best available evidence:

1. Is there a difference in the infection rate between open and closed reduction?
2. Is there a difference in nerve lesions?
3. Is there a difference in occlusal problems?

Material and methods

Literature analysis

WINSPEAR, MEDLINE, and COCHRANE databases were searched for relevant studies. The following key words were used: jaw fractures, mandibular fractures, maxillary fractures, open reduction, closed reduction and randomised studies. The search went from 1980 to 2006. Condylar fractures were excluded from this study.

Retrieved studies were analyzed if they appeared to fulfill the approved standards for acceptable randomized studies. Treatment results were checked (if not performed in the study) using a chi-square test. In case of 2×2 tables, a Fisher's test was used. In both cases, a 5% probability level (double sided) was selected.

The healing outcome was defined as plus/minus infection episodes, nerve injuries, occlusal disturbances, and wound dehiscence. Finally, a compilation of all healing complications was made (infection, wound dehiscence, nerve injuries, and occlusal disturbances).

Results

Ten retrospective studies were retrieved where treatment outcome after open or closed repositioning results were compared within the same department (Table 1). All studies were retrospective in nature and no randomized studies were found. Eight studies had to be eliminated for the following reasons: too few patients in one or both groups (24, 28, 34, 35), lack of definition of closed reduction (29), mixture of plating and wires (27), and lack of data concerning healing (5, 30).

Infection rate

Six studies showed a significant increase concerning infection after the open reduction (using plates or wire fixation) (Table 1) (8–11, 19, 31). In four studies, plates and wires could be compared and in two studies wires resulted in more infection than plates (8, 10).

Nerve injuries

In three studies this factor was reported and a 2–3 times elevated risk was found in the open reduction group. However, these differences were not significant (Table 2).

Postoperative occlusal disturbances

In four of five studies occlusal disturbances were slightly more frequent in the open reduction group whereas one study showed the opposite (Table 3).

Overall complications

In two of seven studies, the overall number of complications was significantly higher in cases treated with open reduction (Table 4).

Table 1. Comparison of postoperative infection rates related to open or closed reduction and type of internal fixation

	1 Closed			2 Open + plating			3 Open + wire			Probability level			
Author	*n*	*x*	%	*n*	*x*	%	*n*	*x*	%	1 and 2	1 and 3	1 and 2 + 3	2 and 3
Cawood (6), 1985	50	4	8	50	6	12				0.73			
Thaller et al. (25), 1990	40	2	5	98	12	12	77	13	17	0.35	0.12	0.18	0.51
Maloney et al. (12), 1991	81	3	3	46	2	4				0.99	0.99		
El-Degwi and Mathog (8), 1993	154	11	7	75	16	21	166	16	9	0.004	0.54	0.08	0.02
Stone et al. (10), 1993	155	0	0	80	5	6	49	10	20	0.004	<0.001	0.01	0.03
Terris et al. (9), 1994	37	1	3	112	8	9	39	1	3	0.003	0.99	0.68	0.44
Schmidt et al. (11), 1995	96	3	3	155	25	16				0.002			
Ehrenfeld et al. (13), 1996	38	0	0	129	4	4				0.57			
Moreno et al. (19), 2000	136	6	4	45	6	13				0.03			
Lamphier et al. (31), 2003	341	11	3	253	23	9				0.004			
			$\bar{x}$=5.0			$\bar{x}$=10.6			$\bar{x}$=14.8				

Table 2. Comparison of postoperative nerve disturbances related to open or closed repositioning and type of internal fixation

	1 Closed			2 Open + plating			3 Open and wired			Probability level			
Author	*n*	*x*	%	*n*	*x*	%	*n*	*x*	%	1 and 2	1 and 3	1 and 2 + 3	2 and 3
Cawood (6)	50	4	8	50	8	16				0.35			
El-Degwi and Mathog (8)	154	0	0	75	2	3	166	1	0.6	0.10	0.99	0.28	0.22
Ehrenfeld et al. (13)	38	1	3	129	12	9				0.30			

Table 3. Comparison of postoperative occlusal disturbances related to open or closed reposition and type of internal fixation

	1 Closed			2 Open + plating			3 Open + wire			Probability level			
Author	*n*	*x*	%	*n*	*x*	%	*n*	*x*	%	1 and 2	1 and 3	1 and 2 + 3	2 and 3
Cawood (6)	50	4	8	50	6	12				0.73	0.73		
El-Degwi and Mathog (8)	154	8	5	75	4	5	166	8	5	0.99	0.91	0.88	0.99
Thaller et al. (25)	40	6	15	98	2	2	77	2	3	0.05	0.09	0.003	0.99
Ehrenfeld et al. (13)	38	1	3	129	8	6				0.68			
Moreno et al. (19)	136	4	2	45	2	4				0.63			

Table 4. Comparison of all postoperative complications: infection, nerve dysfunction, occlusal problems, wound dehiscence, non-union, malunion, open or closed reposition and types of internal fixation

	1 Closed			2 Open + plating			3 Open + wired			Probability level			
Author	*n*	*x*	%	*n*	*x*	%	*n*	*x*	%	1 and 2	1 and 3	1 and 2 + 3	2 and 3
Cawood (6)	50	24	48	50	34	68				0.07			
El-Degwi and Mathog (8)	154	27	18	75	29	39	166	37	22	0.10	0.99	0.03	0.01
Thaller et al. (25)	40	9	23	98	15	15	77	26	34	0.44	0.29	0.93	0.007
Terris et al. (9)	37	3	8	112	17	15	39	7	18	0.40	0.31	0.37	0.87
Ehrenfeld et al. (13)	38	3	8	129	21	16				0.25			
Moreno et al. (19)	136	15	11	45	10	24				0.10			
Lamphier et al. (31)	341	31	9	253	74	29				0.0001			
$\bar{x}$	17.9			29.4			21.3						

Discussion

The results reported in Tables 1–4 seem to indicate that open reduction carries a higher risk of postoperative complications. However, it must be strongly emphasized that none of the cited studies had a randomized design. This might suggest that a more complicated case (multiple and or severely displaced fractures) was selected for open reduction. Such a factor was apparently not controlled in any of the reported studies but one author suggested such a relation could be present (7). If such a bias exists, the difference in healing outcome in relation to open or closed reduction could possibly be explained. In a previous study (32), a strong relation was found between complexity of mandibular fractures and the risk of healing complications. A moderate change in the complexity of fractures could double the chances of healing complications (Fig. 1). A previous study found a relationship between complexity of fractures and healing complications (33).

In the present analysis, four healing parameters were analyzed – infection nerve injuries, occlusal dysfunction, and a combination of all complications. Concerning the first parameter the increased rate of infection after open reduction could be explained by the fact that vascular supply to the cortical bone is severed as the mucoperiostal flap is elevated, which imply temporary arrest of a very significant part of the vascular nourishment to this part of the jaw (26). In addition, further damage will occur to the vascular supply by the drilling and insertion of screws or wires. All these factors are known to increase the likelihood of infection (19). Furthermore, surgical access to the fracture site will naturally introduce a number of oral and/or skin bacteria into the wound site.

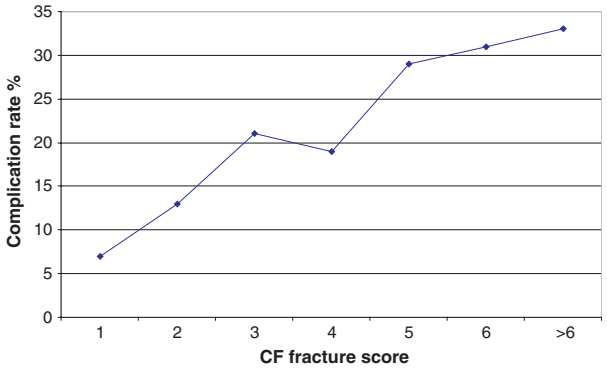

Fig. 1. Relation between complicated jaw fracture score and the frequency of healing complications [after Edwards et al. 32].

Nerve complications

The slight increase (although not significant) in nerve injuries calls for an explanation. The manipulations related to repositioning are likely to be the same; however, surgical access to the fracture site can possibly explain an increased risk of damage to the oral branches of the trigeminal nerve and/or the facial nerve (ramus marginalis).

Occlusal complications

The slight increase in occlusal problems registered in the open reduction scenario is possible related to the fact that open reductions are not always successful in the sense that fragments are not repositioned in an anatomically correct position. Furthermore, when rigid plating is used, an introduced occlusal problem cannot be corrected by elastic intermaxillary traction.

When the results from seven studies were pooled, it appeared that there was an overall complication rate of 17.9% in closed procedures, and 29.4% in open procedures using plates, i.e. an almost twofold increase in the complication rate (Table 4).

In conclusion, the present findings seem to indicate that open reduction and rigid fixation is a technique-sensitive procedure, which may elevate the complication rate in a significant number of cases. A serious drawback of this study is that all studies were retrospective in their nature and did not control for confounders such as severity of displacement, location of fractures, drug abuse, etc. All these factors may have seriously distorted the figures. Randomized controlled studies of the effect of/on open reduction and rigid splinting are needed.

References

1. Spiessl B (ed). Osteosynthese des Unterkiefers. Manual der AO-Prinzipien. Springer Verlag: Berlin, Heidelberg, 1988.
2. Champy M, Lodde JP, Jaeger JH Wilk A, Gerber JC. Osteosynthesis mandibulaires selon la technique de Michelet. I. Bases biomechaniques. II. Presentation d'un nouveau materiel. Resultats. Rev Stomatol Chirurg Maxillo-Faciale (Paris) 1976;77:569, 577, 582.
3. Champy M, Lodde JP, Schmit R, Jaeger JH, Muster D. Mandibular osteosynthesis by miniature screwed plates via a buccal approach. J Maxillofac Surg 1978;6:14–21.
4. Raveh J, Vuillemin T, Lädrach L, Roux M, Sutter F. Plate osteosynthesis of 367 mandibular fractures: The unrestricted indication for the interoral approach. J Craniomaxillofac Surg 1987;15:244.
5. Oikarinen K, Altonen M, Kauppi H, Laitakati K. Treatment of mandibular fractures. Need for rigid internal fixation. J Craniomaxillofac Surg 1989;17:24–30.
6. Cawood JI. Small plate osteosynthesis of mandibular fractures. Br J Oral Maxillofac Surg 1985;23:77–91.
7. Dodson TB, Perrott DH, Kaban LB, Gordon NC. Fixation of mandibular fractures: a comparative analysis of rigid internal fixation and standard fixation techniques. J Oral Maxillofac Surg 1990;48:362–6.
8. El-Degwi A, Mathog RH. Mandible fractures – medical and economic considerations. Otolaryngol Head Neck Surg 1993;108:213–9.
9. Terris DJ, Lalakea ML, Tuffo KM, Shinn JB. Mandible fracture repair: specific indication for newer techniques. Otolaryngol Head Neck Surg 1994;111:751–7.
10. Stone IE, Dodson TB, Bays RA. Risk factors for infection following operative treatment of mandibular fractures: a multivariate analysis. Plast Reconstr Surg 1993;91:64–8.
11. Schmidt B, Kearns G, Perrott D, Kaban LB. Infection following treatment of mandibular fractures in human immunodeficiency virus seropositive patients. J Oral Maxillofac Surg 1995;53:1134–9.
12. Maloney PL, Welch TB, Doku HC. Early immobilization of mandibular fractures: a retrospective study. J Oral Maxillofac Surg 1991;49:698–702.
13. Ehrenfeld M, Roser M, Hagenmaier C, Mast G. Unterkieferfrakturen mit unterschiedlichen Fixationstechniken – Ergebnisse einer prospektiven Frakturstudie. Fortshr. Kiefer Gesichtsehn 1996;41:67–71.
14. Perrott DH. Maxillofacial trauma assessment and treatment. Curr Opin Dent 1991;1:271–6.
15. Assael LA. Treatment of mandibular angle fracture. Plate and screw fixation. J Oral Maxillofac Surg 1994;52:757–61.
16. Calloway DM, Anton MA, Jacobs JS. Changing concepts and controversies in the management of mandibular fractures. Clin Plast Surg 1992;19:59.
17. Andreasen JO, Torabinejad M, Finkelman RD. Response of oral tissue to trauma and inflammation and mediators of hand tissue resorption. In: Andreasen JO, Andreasen FM, editors. Textbook and color atlas of traumatic injuries to the teeth, 3rd edn. Copenhagen: Munksgaard; 1993. p. 77–133.
18. Gottrup F, Andreasen JO. Wound healing subsequent to injury. In: Andreasen JO, Andreasen FM, editors. Textbook and color atlas of traumatic injuries to the teeth, 3rd edn. Copenhagen: Munksgaard; 1993. p. 13–76.
19. Moreno JC, Fernández A, Ortiz JA, Montalvo JJ. Complication rates associated with different treatments for mandibular fractures. J Oral Maxillofac Surg 2000;58:273–80.
20. Joos U, Piffko J, Meyer U. New aspects in managing mandibular fractures. Mund Kiefer Gesichtschir. 2001;5:2–16.
21. Jensen O. Alveolar distraction osteogenesis. Chicago, IL: Quintessence; 2002.
22. Sorel B. Open versus closed reduction of mandible fractures. Oral Maxillofac Surg Clin North Am 1998;10:541–65.
23. Brown JS, Grew N, Taylor C, Millar BG. Intermaxillary fixation compared to miniplate osteosynthesis in the management of the fractured mandible: an audit. Br J Oral Maxillofac Surg 1991;29:308–11.
24. Hoffman WY, Barton RM, Price M, Mathes SJ. Rigid internal fixation vs. traditional techniques for the treatment of mandible fractures. J Trauma 1990;30:1032–6.
25. Thaller SR, Reavie D, Daniller A. Rigid internal fixation with miniplates and screws: a cost-effective technique for treating mandible fractures? Ann Plast Surg 1990;24: 469–74.
26. Bradley JC. Age changes in the vascular supply of the mandible. Br Dent J 1972;132:142–4.
27. Leach J, Truelson J. Traditional methods vs. rigid internal fixation of mandible fractures. Arch Otolaryngol Head Neck Surg 1995;121:750–3.
28. Morgan CE, Hicks JN, Eby TL, Borton TE. Repair of mandibular fractures: plating vs. traditional techniques. Otolaryngol Head Neck Surg 1992;106:245–9.
29. Kellman RM. Repair of mandibular fractures via compression plating and traditional techniques: a comparison of results. Laryngoscope 1984;94:1560–7.
30. Uglešić V, Virag K, Aljinović N, Macan D. Evaluation of mandibular fracture treatment. J Craniomaxillofac Surg 1987;15:244.
31. Lamphier J, Ziccardi V, Ruvo A, Janel M. Complications of mandibular fractures in an urban teaching center. J Oral Maxillofac Surg 2003;61:745–9.
32. Edwards THC, David DJ, Simpson A, Abbott H. The relationship between fracture severity and complication rate

in miniplate osteosynthesis of mandibular fractures. Br J Oral Maxillofac Surg 1991;29:308–11.
33. Joos U, Meyer U, Tkotz T, Weingart D. Use of mandibular fracture score to predict the development of complications. J Oral Maxillofac Surg 1999;57:5–7.
34. Renton TF, Wiesenfeld D. Mandibular fracture osteosynthesis a comparison of three techniques. Br J Oral Maxillofac Surg 1991;29:308–11.
35. Dhariwal DK, Gibbons AJ, Murphy M, Llewelyn J, Gregory MC. A two year review of the treatment and complications of mandibular angle fractures. J R Army Med Corps 2002;148:115–7.
36. Winstanley RP. The management of fractures of the mandible. Br J Oral Maxillofac Surg 1984;22:170–7.
37. Winstanley RP. Fractures of the mandible: the case for minimal intervention. Oral Surg Oral Med Oral Pathol 1995;380.