Archives of Otolaryngology and Rhinology

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Dates: Received: 01 November, 2016; **Accepted:** 15 November, 2016; **Published:** 16 November, 2016

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www.peertechz.com

ISSN: 2455-1759

Keywords: Mandible; Fracture; Mandibular angle; Arch bars; Maxillomandibular fixation; Manual reduction

Research Article

Outcomes of Manual Reduction vs Arch Bars for Mandibular Angle Fractures

Abstract

Objective: To compare post-operative complications of mandibular angle fractures treated with manual reduction, arch bar maxillomandibular fixation (MMF), and non-arch bar MMF.

Study Design: Retrospective chart review

Methods: A retrospective review of patients with mandibular angle fractures at a tertiary care level 1 trauma center between 2001 and 2013. Reduction of the fracture(s) was classified into one of 3 groups: manual reduction, non-arch bar MMF, and arch bar MMF. The main outcome variables were post-operative malocclusion and infection.

Results: The sample was composed of 176 patients: single angle fracture (n=47), angle with 1 non-angle fracture (n=118), angle with 2 non-angle fractures (n=10), and bilateral angle fractures (n=1). For all fractures, arch bar MMF was found to have significantly lower malocclusion rates than both manual reduction (2.8% vs 17.5%, p=0.01) and non-arch bar MMF (2.8% vs 13.3%, p=0.04). For patients with single angle fractures, there was no statistically significant difference in infection or malocclusion rates when comparing manual reduction, non-arch bar MMF, and arch bar MMF. For patients with an angle fracture plus 1 non-angle fracture, arch bar MMF had significantly lower malocclusion rates than manual reduction (3.2% vs 25.0%, p<0.01) and was not significantly different compared to non-arch bar MMF.

Conclusion: The results of this study suggest that manual reduction of single angle fractures may be the preferred method of stabilization. However, arch bar MMF is still the preferred method of stabilization and reduction for patients with a single angle fracture plus at least one additional fracture.

Introduction

Mandibular angle fractures account for 20 - 34% of all mandible fractures [1,2]. They have the highest rate of post-operative complications in many studies possibly due to this region's thin cross-sectional area of bone, difficult access, impacted third molars, and the inability to stabilize the fracture by stabilizing the occlusion [3,4]. The goals of mandibular angle fracture repair are to completely reduce the fracture segments to prevent malunion and to stabilize the fracture segments to prevent nonunion. Re-establishing premorbid occlusion is the most important indicator of successful reduction and stabilization.

The treatment of mandible fractures has evolved as we have come to better understand bone healing and the biomechanics of the mandible. External fixation and interosseous wiring were the rule until the 1960s when Luhr introduced biocompatible compression plating for mandible fractures based on orthopedic biomechanical studies which suggested accelerated bone healing through compression and rigidity [5,6]. In 1973, Michelet et al. reported on the osteosynthesis of mandible fractures using small, malleable, noncompression bone plates placed transorally and secured with monocortical screws [7]. This technique was in contrast to Luhr's emphasis on absolute compression and rigidity. In 1978, Michelet's approach to fixation was advanced by Champy et al., who identified, through experimentation with miniplates, "ideal lines of osteosynthesis" on the mandible [8]. Miniplates placed along these lines were shown to counteract distraction forces and provide optimal fixation and stability. This study demonstrated the shift in our understanding and treatment of mandible fractures from maximal fixation to adequate fixation.

For mandibular angle fractures, the ideal line of osteosynthesis is along the external oblique line. Champy advocated that a single 6-hole monocortical miniplate should be placed either along or just below the external oblique line for internal fixation of mandibular angle fractures with at least three screws on either side [8]. The adequacy of this technique for mandibular angle fractures, although widely used, is a continuing subject of debate. Kroon et al., demonstrated that posterior loading (bite) forces near the mandibular angle fracture line caused distraction of the inferior mandibular margin which would not be prevented by the Champy technique [9]. Choi et al., demonstrated that a second inferior miniplate improved fixation during functional loading forces [10]. Therefore, some surgeons advocate a Champy plate and a second inferior miniplate for adequate mandibular angle fracture fixation [11] (Table 1).

The treatment of mandibular angle fractures also traditionally involves maxillomandibular fixation (MMF). Arch bars with rigid wire fixation are a classic form of MMF. They are placed during mandible fracture repair to bring the dentition into premorbid occlusion and stabilize the fracture segments during internal fixation. Rigid MMF may be continued post-operatively. Alternatively, training elastics

Table 1: Postoperative complication rates of mandibular angle fractures.

	Manul	Non-Arch Bar	Arch Bar
Single Angle			
N	14	15	18
Infection	14.3% (2)	20.0% (3)	11.1%(2)
Malocclusion	7.1% (1)	20.0% (3)	5.6% (1)
Angle + non-angle			
N	24	14	80
Infection	0% (0)	21.4% (3)	10.0%(8)
Malocclusion	25.0% (6)	7.1%(1)	2.5% (2)

can be placed on the arch bars to assist with occlusal alignment, allowing for early jaw physiotherapy. Even if the patient is not placed in rigid or elastic MMF, the empty arch bar functions as a tension band across the mandibular arch adding further stability based on biomechanical principles, although this is not true for isolated angle fractures. Despite the value of traditional arch bars, they increase the risk of puncture wounds to surgeons during and after placement, damage surrounding tissues, and increase patient discomfort.

In the literature, there are many reports on internal fixation and MMF techniques for mandibular angle fractures with varying outcomes. There is no consensus on optimal treatment and few prospective trials. At our institution, traditional mandibular angle fracture repair involves open reduction internal fixation (ORIF) with 1-2 monocortical plates and up to 6 weeks of post-operative arch bars with or without elastic MMF per individual surgeon preferences. However, we have observed a trend away from post-operative MMF and even away from the placement of arch bars for certain mandibular angle fractures. Instead, surgeons are using manual reduction or temporary non-arch bar MMF, such as embrasure wires, ivy loops, Ernst ligature, or intermaxillary fixation screws. The purpose of this study is to compare outcomes of mandibular angle fractures treated with manual reduction, non-arch bar MMF, and arch bar MMF. The investigators hypothesized that non-arch bar MMF was as effective as arch bar fixation in the treatment of isolated mandibular angle fractures (Table 2).

Methods

The investigators performed a retrospective cohort study of patients with mandibular angle fractures treated at SUNY Upstate Medical University hospital, a tertiary care Level 1 trauma center, between 2001 and 2013. The Institutional Review Board granted approval and exemption from formal review. Diagnostic codes were used to identify patients with a mandibular angle fracture. Inclusion criteria included at least one post-operative visit, dentition, and the absence of subcondylar and midfacial fractures. One hundred and nine patients were lost to follow up or had incomplete medical records. Patients were excluded with greenstick fractures. All surgical procedures were performed by faculty surgeons in the SUNY Upstate Otolaryngology Department who are experienced in open reduction internal fixation and MMF techniques. Each patient was separated into one of three groups based on the method used to reduce and stabilize the fractures: manual reduction, Erich arch bar MMF, and non-arch bar MMF. The primary outcomes investigated were post-operative malocclusion and infection. Malocclusion was defined by patient reported malocclusion and/or objective mal-alignment of wear facets at the last follow up visit. Infection was defined by signs consistent with infection and treatment with antibiotics. Other data included etiology of trauma, gender, age, additional mandible fracture locations, and total follow-up time. Fisher's exact test compared categorical variables. Differences resulting in p value < 0.05 were considered statistically significant.

Operative protocol and technique

General anesthesia was administered by nasotracheal intubation. Premorbid occlusion was evaluated with bimanual manipulation. To achieve reduction and stabilization, fractures were treated with either manual reduction, non-arch bar MMF, or arch bar MMF. Methods of reduction used in this study that were considered non-arch bar MMF included use of intermaxillary fixation screws, Ernst ligature, embrasure wires, and ivy loops. All methods of non-arch bar fixation were removed at the end of the surgery. If Erich arch bars were used, they were applied to the maxilla and mandible using 24- and 26-gauge circumdental wires. Rigid MMF was placed to reduce the mandible fractures and establish premorbid occlusion. Mini plates were used to stabilize the fracture(s) in all patients. The MMF was released as needed to assess the occlusion and stability. If arch bars were kept in place at the end of the surgery, then rigid MMF or training elastics were placed post-operatively if further stability was needed. Arch bars were left in place for 6 weeks and removed in the outpatient clinic. Antibiotics and 0.1% chlorhexidine gluconate oral rinse were continued for 7 to 10 days post-operatively.

Results

We identified 337 patients with mandibular angle fractures. Of those, 176 patients met inclusion criteria for this study. 40 patients (22.7%) were treated with manual reduction; 30 (17.0%) with non-arch bar MMF, and 106 (60.2%) with arch bar MMF. Fracture distributions were grouped as follows: single angle fracture (n=47), angle and 1 non-angle fracture (n=118), angle and 2 non-angle fractures (n=10), and bilateral angle fractures (n=1). Due to the low number of bilateral angle fractures and the combination of a single angle fracture plus 2 non-angle fractures, we were unable to perform meaningful statistical analysis on these fracture distributions.

The most common etiology was assault (73%) followed by motor vehicle accident (13%), fall (9%), sports (2%), and other (3%). Ninety-one percent of the patients were male, and the average age was 27 years old. The average follow-up time was 6 months with a range of 1 week to 62.1 months.

For all fractures, manual reduction was found to have significantly lower infection rates than non-arch bar MMF (5.0% vs 23.3%, $p<0.03$) but not significantly lower than arch bar MMF (5.0% vs 13.2%, $p=0.24$). Arch bar MMF was found to have significantly lower malocclusion rates than both manual reduction (2.8% vs 17.5%, $p=0.01$) and non-arch bar MMF (2.8% vs 13.3%, $p=0.04$).

For patients with single angle fractures, there was no statistically significant difference in infection or malocclusion rates when comparing manual reduction, non-arch bar MMF, and arch bar MMF.

Citation: Schroeder II RJ, Archer K, Kellman R, Suryadevara A (2016) Outcomes of Manual Reduction vs Arch Bars for Mandibular Angle Fractures. Arch Otolaryngol Rhinol 2(2): 070-073. DOI: 10.17352/2455-1759.000028

Table 2: Comparison of postoperative complication rates of manual reduction, arch bar MMF, and non-arch bar MMF.

	Manual	Non-Arch Bar	P-Value	Manul	Arch Bar	p-value	Non-Arch Bar	Arch Bar	p-value
All Fractures									
N	40	30		40	106		30	106	
Infection	5.0% (2)	23.3% (7)	0.03	5.0% (2)	13.2% (14)	0.24	23.3% (7)	13.2% (14)	0.25
Malocclusion	17.5% (7)	13.3% (4)	0.75	17.5& (7)	2.8% (3)	0.01	13.3% (4)	2.8% (3)	0.04
Single Angle									
N	14	15		14	18		15	18	
Infection	14.3% (2)	20.0% (3)	1.00	14.3% (2)	11.1% (2)	1.00	20.0% (3)	11.1% (2)	0.64
Malocclusion	7.1% (1)	20.0% (3)	0.60	7.1% (1)	5.6% (1)	1.00	20.0% (3)	5.6% (1)	0.31
Angle + 1 non-Angle									
N	24	14		24	80		14	80	
Infection	0% (0)	21.4% (3)	0.04	0% (0)	10.0% (8)	0.19	21.4% (3)	10.0% (8)	0.36
Malocclusion	25.0% (6)	7.1% (1)	0.23	25.0% (6)	2.5% (2)	<0.01	7.1% (1)	2.5% (2)	0.39

For patients with an angle plus 1 non-angle fractures, arch bar MMF had significantly lower malocclusion rates than manual reduction (3.2% vs 25.0%, p<0.01) and was not significantly different compared to non-arch bar MMF. However, manual reduction had significantly lower infection rates than non-arch bar MMF (0% vs 21.4%, p=0.04) and was trending to have lower infection rates compared to arch bar MMF (0% vs 10.0%, p=0.19).For patients who underwent manual reduction, there was a trend for lower malocclusion rates in single angle fractures compared to angle plus 1 non-angle fractures (7.1% vs 25.0%, p=0.23).

Discussion

We endeavored to compare surgical outcomes of mandibular angle fractures treated with manual reduction, non-arch bar MMF, and arch bar MMF. Overall, our study showed that arch bar MMF had lower malocclusion rates than manual reduction or other forms of MMF. However, when looking only at single angle fractures, there was no statistically significant difference between malocclusion rates between arch bar MMF, non-arch bar MMF, and manual reduction. This suggests that the stability of the contralateral hemimandible in isolated angle fractures significantly aids in achieving adequate occlusion regardless of the method of fracture reduction and stabilization. When comparing rates of infection, our study showed that manual reduction had significantly lower rates of infection suggesting that MMF techniques may come with an additional morbidity compared to manual reduction. Therefore, our data suggests that use of manual reduction may be the preferred method of reduction for isolated angle fractures.

However, manual reduction had a significantly higher rate of malocclusion compared to both arch bar MMF and non-arch bar MMF when used in patients with multiple fractures. This study also showed that arch bar MMF had similar infection rates and lower malocclusion rates compared to non-arch bar MMF. This suggests that manual reduction may be inadequate for more complex fractures, and the use of arch bar MMF may be preferred over non-arch bar MMF in reduction of patients with an angle fracture and at least 1 additional fracture.

Traditionally, Erich arch bar MMF has been described as standard of care for reduction and stabilization of fracture segments during internal fixation of mandibular angle fractures. Importantly, arch bars provide a tension band for fracture stability. Advantages of arch bars include promoting strict compliance with a non-chewing diet, improving follow-up, and allowing for minor adjustments of malocclusion with elastic traction as needed.

Although arch bars have a significant role in mandibular fracture repair, there are many disadvantages. Arch bars extend operative time, which translates into longer general anesthesia time and higher healthcare costs. Arch bars increase the risk of puncture wounds to the surgical team, increase patient discomfort, and observationally increase the number of post-operative visits to the Emergency Department. Arch bars decrease oral hygiene, which may place patients at higher risk for dental complications. The circumdental arch bar wires may damage tooth roots. Patient centered outcome studies have not been done at our institution, but observationally, patients are more satisfied with their surgical treatment when arch bars are not applied. In 2005, Gear et al., surveyed surgeons from North America and Europe [12]. Of 83 surgeons who treat more than 10 mandible fractures per year, the majority of surgeons did not use arch bars in non-comminuted, simple angle fractures. Instead of arch bars, surgeons used manual reduction or temporary forms of intra-operative MMF for fracture reduction and stabilization. In 2016, Kopp et al., noted a decreasing trend in the use of arch bars in nonsubcondylar mandible fractures from a high of 80% in 2004 to a low of 19% in 2011 [13]. They also noted that there was no difference in overall complication rates (malunion, malocclusion, and infection) of arch bar MMF compared to manual reduction in the treatment of nonsubcondylar mandible fractures.

There are several reports in the literature on mandibular angle fractures treated without arch bars. In 2002, Dimitroulis performed a retrospective review of unilateral angle fractures treated with arch bars compared to manual reduction [14]. At 6 weeks, there was no difference in malocclusion or post-reduction anatomic alignment. They concluded that arch bars are unnecessary in the management of unilateral angle fractures, provided there is a skilled assistant to help manually reduce fracture segments for plating. In 2008, Bell and Wilson performed a retrospective review of mandibular angle fractures comparing arch bars, manual reduction, and 24 gauge interdental "Stout" wires [15]. They found no significant difference in complications amongst the 3 groups.

This retrospective study has several limitations. Selection bias was present as patients with multiple fractures are much more likely to be treated with arch bars compared to isolated angle fractures. Additionally, manual reduction is more likely to be used in non-displaced or minimally displaced fractures. Observationally, some surgeons who routinely perform manual reduction of a single angle fracture have low complication rates but our study data did not allow us to statistically compare each surgeon. In this study, there was variable use of rigid and elastic post-operative MMF in patients treated with arch bars. With improving experience and technology in plating techniques at the angle, the added benefit of post-operative rigid MMF is thought to be minimal for isolated angle fractures.

In this study, a large number of patients were lost to follow-up. At our tertiary care Level 1 trauma institution, the catchment area includes patients from hours away. Many post-operative patients are unable to travel for follow-up care and instead transfer care to a local surgeon or dentist. Due to this, we may have under-represented complication numbers as patients are more likely to present to their local Emergency Departments.

In this study, the method of internal fixation was variable and surgeon dependent. Methods included a single 4- or 6-hole miniplate across the external oblique line, 2 miniplates, or a 4-hole box plate. There are many reports in the literature on plating techniques for mandibular angle fractures. Ellis and Walker reported a 25% incidence of infection for angle fractures treated with 2 noncompression miniplates and arch bars compared to a 10% incidence of minor infection for angle fractures treated with 1 noncompression miniplate and arch bars [16,17]. Fox and Kellman reported a 2.9% incidence of infection and a 5.9% incidence of malocclusion for angle fractures treated with 2 miniplates and arch bars.[11] Danda performed a prospective randomized clinical trial comparing 1 versus 2 miniplates with arch bars for angle fractures and found no significant difference in infection or malocclusion rates [18]. As there are conflicting results in the literature regarding optimal technique, it is unknown whether the method of internal fixation represents a major confounding factor in this study. Further statistical analysis is necessary.

Future research should include a prospective randomized controlled trial to standardize plating techniques, method of intra-operative MMF in patients treated without arch bars, and post-operative MMF regimen in patients treated with arch bars. Future research should also include a study of mandible fracture outcomes using the hybrid MMF systems as an alternative to traditional Erich arch bars.

Conclusion

The results of this study suggest that manual reduction of single angle fractures may be the preferred method of stabilization since malocclusion and infection rates are similar to both arch bar and non-arch bar MMF. However, arch bar MMF has lower malocclusion rates for patients with a single angle fracture plus at least one additional fracture, so it is still the preferred method of stabilization and reduction for this group of fractures.

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Citation: Schroeder II RJ, Archer K, Kellman R, Suryadevara A (2016) Outcomes of Manual Reduction vs Arch Bars for Mandibular Angle Fractures. Arch Otolaryngol Rhinol 2(2): 070-073. DOI: 10.17352/2455-1759.000028