Received: 4 February 2023 | Revised: 18 March 2023 | Accepted: 11 April 2023

DOI: 10.1111/edt.12851

Dental Traumatology WILEY

ORIGINAL ARTICLE

Manual versus rigid intraoperative maxillo-mandibular fixation in the surgical management of mandibular fractures: A European prospective analysis

Federica Sobrero[1] | Fabio Roccia[1] | Valentines Vilaplana[2] | Antonio Mari Roig[2] | Elisa Raveggi[1] | Guglielmo Ramieri[1] | Maximilian Goetzinger[3] | Gian Battista Bottini[3] | Ali O. Rizvi[4] | Sean Laverick[4] | Predrag Knežević[5] | Emil Dediol[5] | Mario Kordić[6] | Anamaria Sivrić[6] | Dimitra Ganasouli[7] | Stylianos N. Zanakis[7] | Drago Jelovac[8] | Vitomir S. Konstantinovic[8] | Anže Birk[9] | Aleš Vesnaver[9] | Alessandro Rabufetti[10] | Paolo Scolozzi[10] | Fatma Eriş Derkuş[11] | Utku Nezih Yilmaz[11] | Constantinus Politis[12] | Kathia Dubron[12]

[1]Division of Maxillofacial Surgery, Department of Surgical Science, University of Turin, Turin, Italy

[2]Department of Oral and Maxillofacial Surgery, University Hospital of Bellvitge, Barcelona, Spain

[3]Department of Oral and Maxillofacial Surgery, Paracelsus Medical University, Salzburg, Austria

[4]Department of Oral and Maxillofacial Surgery, University of Dundee, Dundee, UK

[5]Department of Maxillofacial Surgery, University Hospital Dubrava, Zagreb, Croatia

[6]Clinic for ENT and OMS, University Clinical Hospital, Mostar, Bosnia and Herzegovina

[7]Department of Oral and Maxillofacial Surgery, Hippocratio General Hospital, Athens, Greece

[8]Clinic of Maxillofacial Surgery, School of Dental Medicine, University of Belgrade, Belgrade, Serbia

[9]Department of Maxillofacial and Oral Surgery, University Medical Centre, Ljubljana, Slovenia

[10]Division of Oral and Maxillofacial Surgery, Department of Surgery, Faculty of Medicine, University of Geneva & University Hospitals of Geneva, Geneva, Switzerland

Abstract

Purpose: Intraoperative stabilisation of bony fragments with maxillo-mandibular fixation (MMF) is an essential step in the surgical treatment of mandibular fractures that are treated with open reduction and internal fixation (ORIF). The MMF can be performed with or without wire-based methods, rigid or manual MMF, respectively. The aim of this study was to compare the use of manual versus rigid MMF, in terms of occlusal outcomes and infective complications.

Materials and Methods: This multi-centric prospective study involved 12 European maxillofacial centres and included adult patients (age ≥16 years) with mandibular fractures treated with ORIF. The following data were collected: age, gender, pre-trauma dental status (dentate or partially dentate), cause of injury, fracture site, associated facial fractures, surgical approach, modality of intraoperative MMF (manual or rigid), outcome (minor/major malocclusions and infective complications) and revision surgeries. The main outcome was malocclusion at 6 weeks after surgery.

Results: Between May 1, 2021 and April 30, 2022, 319 patients—257 males and 62 females (median age, 28 years)—with mandibular fractures (185 single, 116 double and 18 triple fractures) were hospitalised and treated with ORIF. Intraoperative MMF was performed manually on 112 (35%) patients and with rigid MMF on 207 (65%) patients. The study variables did not differ significantly between the two groups, except for age. Minor occlusion disturbances were observed in 4 (3.6%) patients in the manual MMF group and in 10 (4.8%) patients in the rigid MMF group ($p > .05$). In the rigid MMF group, only one case of major malocclusion required a revision surgery. Infective

[11]Department of Oral and Maxillofacial Surgery, Dicle University, Diyarbakir, Turkey

[12]Department Oral and Maxillofacial Surgery, Faculty of Medicine, Catholic University of Leuven, Leuven, Belgium

Correspondence
Federica Sobrero, Division of Maxillofacial Surgery, Department of Surgical Science, University of Turin, Città della Salute e delle Scienze Hospital, Via Genova 3, Torino.10131, Italy.
Email: federica.sobrero@unito.it

complications involved 3.6% and 5.8% of patients in the manual and rigid MMF group, respectively ($p > .05$).

Conclusion: Intraoperative MMF was performed manually in nearly one third of the patients, with wide variability among the centres and no difference observed in terms of number, site and displacement of fractures. No significant difference was found in terms of postoperative malocclusion among patients treated with manual or rigid MMF. This suggests that both techniques were equally effective in providing intraoperative MMF.

KEYWORDS
internal fixation device, jaw fixation techniques, mandibular fractures, multi-centric study, open fracture reduction, prospective study

1 | INTRODUCTION

Mandibular fractures are common maxillofacial injuries that represent a significant socioeconomic and healthcare burden.[1,2]

Although therapeutic strategies have evolved over time, the treatment goal in these injuries remains the restoration of pre-trauma anatomy and occlusion through stabilisation of bone fragments, while minimising perioperative complications.[3] Open reduction and internal fixation (ORIF) using titanium plates and screws, usually preceded by intraoperative maxillo-mandibular fixation (MMF), is the current gold standard for treatment.[3–5] MMF is usually performed using arch bars, self-tapping and self-drilling screws (STSDSs), or eyelet wires.[6–9] The MMF obtained by such wire-based methods, defined as 'rigid', is a reliable technique to maintain a stable alignment of the bone fragments. However, it has several disadvantages, including the risk of needle-stick injuries and infection transmission, periodontal and root damage, hardware loosening or ingestion.[6–8,10] Furthermore, rigid MMF is time-consuming and significantly prolongs the operating time.[7,8,11,12]

An increasing number of studies have reported the use of manual intraoperative MMF, without the need for wire-based techniques, for certain mandibular fractures since the 1990s.[6,7,9,11–18] However, a recent systematic review and meta-analysis by Singh et al.[8] on isolated single or double mandibular fractures suggested that the current evidence in favour of manual MMF is based on a few retrospective and prospective, single-centre studies, with a high risk of bias.

Therefore, the present prospective multi-centre study compared the occlusal outcomes and infective complications between manual and rigid MMF in the surgical treatment of mandibular fractures using plate osteosynthesis.

2 | MATERIALS AND METHODS

2.1 | Study design and sample

Twelve European centres (Table 1) prospectively collected data on patients hospitalised for mandibular fractures and treated with ORIF between 1 May 2021 and 30 April 2022. An Excel (Microsoft Corp.) instruction template was sent to the centres to ensure uniformity in data collection. An evaluation of the accuracy of compilation was performed 6 months after the study started. The inclusion criteria were age ≥16 years and plate osteosynthesis of all mandibular fracture sites. Comminuted or infected fractures, edentulous patients and those treated with resorbable plates were excluded.

2.2 | Surgical procedure and follow-up

Preoperatively, all patients underwent thorough clinical assessment, laboratory tests, radiological imaging, and pre-anaesthetic evaluation. Surgery was performed with patients under general anaesthesia. Perioperative antibiotic prophylaxis was performed according to the protocols of each centre. Fracture osteosynthesis was performed using a 2.0-mm titanium plating system. Surgical procedures were performed by experienced staff surgeons from the participating centres. Patient outcomes were recorded at 6 weeks postoperatively.

2.3 | Study variables

The following data were recorded: age, sex, cause of fracture (road traffic accident, fall, assault, sports or work-related accidents, and others), site, and type (non-displaced, displaced, or comminuted) of fracture, associated maxillofacial fractures, status of occlusion (dentate or partially dentate), surgical approach (intraoral, transbuccal or extraoral), intraoperative MMF modality (manual, arch bars, STSDSs, orthodontic brackets or other), occlusal outcomes (normal occlusion, minor malocclusion or major malocclusion), soft tissue or bone infections, and revision surgeries.

'Manual MMF' was achieved by an operator tightly holding the mandibular fragments together and against the maxilla in the occlusal position, with the use of both hands, after fracture reduction, while another operator performed the osteosynthesis. All methods of wired-based MMF, whereby the dental arches were temporarily locked in position using wires and different types of hardware, were classified as 'rigid MMF'.

TABLE 1 Maxillofacial surgery units participating in the EURMAT project.

Country	City	Affiliation
Austria	Salzburg	Dpt. Oral and Maxillofacial Surgery, Paracelsus Medical University
Belgium	Leuven	Dpt. Oral and Maxillofacial Surgery, University Hospitals Leuven
Bosnia and Herzegovina	Mostar	Clinic for ENT and OMS University Clinical Hospital
Croatia	Zagreb	Dpt. of Maxillofacial Surgery, University Hospital Dubrava
Greece	Athens	Dpt. Oral and Maxillofacial Surgery, Hippocratio General Hospital
Italy	Turin	Division of Maxillofacial Surgery, Città della Salute e della Scienza, University of Turin
Serbia	Belgrade	Clinic of Maxillofacial Surgery, School of Dental Medicine, University of Belgrade
Slovenia	Ljubjana	Dpt. of Maxillofacial and Oral Surgery, University Medical Centre
Spain	Barcelona	Dpt. of Oral and Maxillofacial Surgery, University Hospital of Bellvitge
Switzerland	Geneva	Division of Oral and Maxillofacial Surgery, University Hospital of Geneva
Turkey	Diyarbakir	Maxillofacial Surgery, Dicle University
United Kingdom	Dundee	Dpt. Oral and Maxillofacial Surgery, University of Dundee

Malocclusion was defined as any deviation from the pre-traumatic occlusion, as assessed clinically by the surgeon or reported by the patient. Minor malocclusion was defined as an occlusal problem that could be managed in the outpatient clinic, whereas major malocclusion was defined as an occlusion disturbance that required revision surgery under general anaesthesia.[15] Postoperative infection was defined as purulent discharge from the surgical site, oedema or induration with erythema, or hardware exposure with pus discharge.

Based on the Ribeiro-Junior et al. study,[19] patients with all teeth present and no free ends in the right or left arch, and those with an isolated missing tooth but no free ends, were classified as 'dentate'. Patients with an unstable occlusion, with free ends or >6 missing dental elements, were classified as 'partially dentate'.

This study was approved by the Institutional Review Board (IRB; s65440) and was performed in accordance with the Declaration of Helsinki.

2.4 | Data analysis

Statistical analyses were performed using SPSS Statistics software (version 28.0.1.0; IBM Corp.). The predictors and outcomes were analysed using Fisher's exact, chi-square, Kruskal–Wallis and Mann–Whitney *U*-tests, as appropriate. All statistical analyses were two-tailed and the significance level was set at $p < .05$.

3 | RESULTS

Between 1 May 2021 and 30 April 2022, 446 mandibular fracture patients were hospitalised, of whom, 319 (257 males and 62 females; sex ratio, 4.1:1; median age, 28 years; IQR [interquartile range], 21 years) met the inclusion criteria. These included 78% ($n = 248$) dentate and 22% ($n = 71$) partially dentate patients.

Assaults were the most frequent cause of injury (42%, $n = 134$), followed by falls (25%, $n = 79$), road traffic accidents (18%, $n = 56$), sports injuries (9%, $n = 30$), work-related injuries (4%, $n = 13$) and other causes (2%, $n = 7$). A total of 471 (1.5 per patient) fractures occurred, of which, 82% were displaced. The fracture site distribution is shown in Table 2. Single fractures were the most common (58%, $n = 185$), followed by double (36%, $n = 116$) and triple (6%, $n = 18$) fractures (Table 3). Associated maxillofacial fractures were present in 16% of the patients.

Manual MMF was performed in 112 (35%) patients, while STSDSs and arch bars or orthodontic brackets were used in 110 (34%) and 97 (31%) patients, respectively (Table 3). Most of the single and double mandibular fracture patients underwent rigid MMF (66% in both groups), while most of the triple fractures (61%) were treated with manual MMF. An equal proportion of displaced and non-displaced fractures (35% each) were treated with manual MMF (Table 3).

When patients treated with rigid MMF are considered, single fractures were significantly more frequently treated with arch bars

(60%) rather than STSDSs (40%) when compared to double fractures (30% with arch bars, 70% with STSDSs) ($p < .001$, Chi square test) and triple fractures (14% with arch bars, 85% with STSDSs) ($p = .04$, Fisher's exact test) (Table 3).

The distribution of study variables (particularly sex, occlusion, cause of fracture, associated maxillofacial fractures, number of fractures and fracture displacement) did not differ significantly between the manual and rigid MMF groups (Table 4). However, patients who underwent manual MMF were significantly older (median, 32 years; IQR, 26 years) than those treated with rigid MMF (median, 27 years; IQR, 17 years) ($p = .035$, Mann–Whitney *U* test).

Postoperative complications at 6 weeks after surgery are shown in Table 5. Soft tissue infections occurred in 4 (3.6%) patients in the manual MMF group (4 angle fractures) and 12 (5.8%) patients in the rigid MMF group (6 angle, 3 body, 1 parasymphysis, 1 condylar and 1 ramus fractures), but the difference was not statistically significant. Bone infections occurred only in 2 (1%) patients treated with rigid MMF (1 body and 1 parasymphysis fractures).

TABLE 2 Site and type of the mandibular fractures.

	Non displaced *n* (%)	Displaced *n* (%)	Total *n*
Angle	33 (22)	115 (78)	148
Parasymphysis	19 (17)	92 (83)	111
Condyle	5 (5)	92 (95)	97
Body	11 (17)	52 (83)	63
Symphysis	10 (26)	29 (74)	39
Ramus	5 (38)	8 (62)	13
Total	83 (18)	388 (82)	471

Minor occlusal disturbances were present in 14 patients, 4 treated with manual MMF and 10 with rigid MMF ($p > .05$). Only one patient with parasymphyseal fracture who underwent intraoperative MMF with arch bars developed a major malocclusion and required revision surgery (Table 6). Overall, the complication rate was higher in the rigid MMF group (12.1%, $n = 25$) than in the manual MMF group (7.1%, $n = 8$), but the difference was not statistically significant ($p > .05$) (Table 5).

4 | DISCUSSION

The present study compared occlusal and infective outcomes between mandibular fracture patients who underwent ORIF with or without wired-based fixation methods. It showed no significant differences between the two groups.

In 1999, Fordyce et al.[13] first challenged the need for rigid MMF to reduce mandibular fractures. Since then, an increasing number of studies have reported the use of manual MMF and compared it to rigid MMF. A 2005 survey conducted by Gear et al.[20] found that 16% of maxillofacial surgeons frequently used manual MMF for single non-comminuted mandibular fractures in dentate patients, while 23% used it occasionally. In a 10-year study from 2001 to 2011, Kopp et al.[18] reported a significant reduction in the use of rigid intraoperative MMF and a simultaneous increase in the use of manual MMF. Although few European centres were found to use manual MMF routinely in the present study (Table 6), the percentage was significantly greater than that reported by Gear et al.[20] The increased use of manual MMF may be justified by the reduced operator and patient risks, including needle-stick injuries, communicable disease transmission, and mucosal and dental injuries.[7,12,18] It is also

TABLE 3 Type of intraoperative MMF by fracture site.

	Rigid MMF				
	Arch bars *n* (%)	STSDSs *n* (%)	All rigid MMF methods *n* (%)	Manual MMF *n* (%)	Total *n*
Single fractures					
Displaced	65	43	108 (68)	50 (32)	158
Non displaced	8	7	15 (56)	12 (44)	27
Total	73	50	123 (66)	62 (34)	185
Double fractures					
At least one displaced fracture	17	39	56 (65)	30 (35)	86
Non displaced	6	15	21 (70)	9 (30)	30
Total	23	54	77 (66)	39 (34)	116
Triple fractures					
At least one displaced fracture	1	6	7 (39)	11 (61)	18
Non displaced	0	0	0	0	0
Total	1	6	7 (39)	11 (61)	18
All fractures	97 (31)	110 (34)	207 (65)	112 (35)	319

Abbreviation: MMF, maxillo-mandibular fixation.

TABLE 4 Study variables distribution with patients grouped according to the use of intraoperative MMF.

	Manual MMF (*n* = 112)	Rigid MMF (*n* = 207)	*p* value
Sex *n* (%)			
Male	89 (80)	168 (81)	>.05[a]
Female	23 (20)	39 (19)	
Age *median (IQR)*	32 (26)	27 (17)	.035[c]
Status of occlusion *n* (%)			
Dentate	87 (78)	161 (78)	>.05[a]
Partially dentate	25 (22)	46 (22)	
Cause of fracture *n* (%)			
Road traffic accidents	16 (14)	40 (19)	>.05[b]
Assault	42 (38)	92 (44)	
Fall	29 (26)	50 (24)	
Sport	12 (11)	18 (9)	
Work	8 (7)	5 (3)	
Other	5 (4)	2 (1)	
Associated maxillofacial fractures *n* (%)			
Yes	13 (12)	37 (18)	>.05[a]
No	99 (88)	170 (82)	
No of fractures *n* (%)			
Single	62 (55)	123 (59)	>.05[c]
Double	39 (35)	77 (37)	
Triple	11 (19)	7 (4)	
Displacement of at least one fracture *n* (%)			
Yes	92 (82)	170 (82)	>.05[a]
No	20 (18)	37 (18)	

Abbreviations: IQR, interquartile range; MMF, maxillo-mandibular fixation.

[a]Chi-square test.

[b]Fisher exact test.

[c]Mann-Whitney *U* test.

TABLE 5 Complications and re-operations by type of intraoperative maxillo-mandibular fixation.

	Manual reduction (*n* = 112)	Rigid MMF (*n* = 207)	*p* value
Soft tissue infection	4 (3.6%)	12 (5.8%)	>.05[b]
Bone infection	0	2 (1.0%)	>.05[a]
Malocclusion	4 (3.6%)	11 (5.3%)	>.05[b]
Minor malocclusion	4 (3.6%)	10 (4.8%)	
Major malocclusion	0	1 (4.8%)	
Any complication	8 (7.1%)	25 (12.1%)	>.05[b]
Re-operations	0	1	>.05[a]

Abbreviation: MMF, maxillo-mandibular fixation.

[a]Fisher's exact test.

[b]Chi-square test.

TABLE 6 Use of intra-operative MMF by maxillo-facial centre.

	Manual reduction (*n* = 112)	Rigid MMF (*n* = 207)
Centre 1	0	39 (100%)
Centre 2	1 (3%)	28 (97%)
Centre 3	1 (5%)	19 (95%)
Centre 4	3 (10%)	28 (90%)
Centre 5	2 (17%)	10 (83%)
Centre 6	12 (27%)	32 (73%)
Centre 7	5 (28%)	13 (72%)
Centre 8	2 (29%)	5 (71%)
Centre 9	11 (42%)	15 (58%)
Centre 10	14 (67%)	7 (33%)
Centre 11	16 (84%)	3 (16%)
Centre 12	45 (85%)	8 (15%)
Total	112 (35%)	207 (65%)

Abbreviation: MMF, maxillo-mandibular fixation.

more economical because it reduces the operative and hospitalisation times, and the cost related to hardware manufacturing and the personnel needed to apply and remove it.[8,13,14,16] However, most authors agree on the need of an experienced assistant to perform manual MMF.[8,13–16]

There is no consensus regarding the indications for manual MMF because most of the previous studies have focused on certain fracture patterns or have included fractures that were treated conservatively.[7,12,15–17] The present study only included mandibular fractures treated with ORIF, and excluded those managed conservatively. In these latter cases, both intra- and postoperative MMF were necessary for bone healing.

Other single-centre, retrospective studies have reported that manual MMF was more frequently used for single fractures than in double mandibular fractures (Bell et al.[15]: 38% and 33%; Weill et al.[9]: 46% and 21%; Fordyce et al.[13]: 69% and 48%, respectively). In the present study, manual intraoperative MMF was performed in 34% of single and double fractures, regardless of fracture type. This was in contrast to previous studies that have recommended manual MMF only for displaced or minimally displaced mandibular fractures.[9,15]

Consistent with previous studies, the incidence rates for postoperative malocclusion in this study were 3.6% and 5.3% in the manual and rigid MMF groups, respectively.[6,7,12–15] Kopp et al.[18] reported postoperative malocclusion rates of 4.5% and 3.6% in the manual and rigid MMF groups, respectively, with no statistically significant differences. The Weill et al.[9] study also found no significant differences in the occlusal results between the two methods. A recent systematic review by Singh et al.[8] reported significantly fewer occlusal disturbances in the manual MMF group (OR [odds ratio], 0.27; 95% CI [confidence interval], 0.09–0.78), but with only moderate certainty because of the high risk of bias in the included studies.

Few studies have reported the incidence of infective complications according to the type of intraoperative MMF. The reported rates range from 3% to 6% in the manual MMF group and from 7% to 12% in the rigid MMF group.[6–8,15,16,18] Singh et al.[8] reported a significantly lower number of infective events in the manual group (OR, 0.38; 95% CI, 0.15–0.97). In agreement with previous reports, the present study found a higher incidence of infective complications in the rigid MMF group (5.8% soft tissue infections and 1% bone infections) compared to the manual MMF group (3.6% soft tissue infections and no bone infections), but without statistical significance.[6,15,18] The authors believe that the lower incidence of infective complications in the manual MMF group may be because of the reduced operative time and lower risk of needle-stick injuries and hardware compression.[21] However, further studies are required to analyse the possible confounding factors, such as the type of fixation, the use and duration of postoperative MMF, and the use of different antibiotic prophylaxis.

In the present study, only one patient in the rigid MMF group required re-intervention for malocclusion. Similarly, in the study by Fordyce et al.,[13] only 1 of the 66 patients in the manual MMF group and 2 of the 49 patients in the rigid MMF group required reoperation, while Bell et al.[15] reported that only two patients in the rigid MMF group underwent a second operation under general anaesthesia for malunion or nonunion.

A few limitations of the present study must be acknowledged. First, the surgical procedures were performed by different maxillofacial surgeons in different centres. Second, variations among the hardware's brands may have influenced the results. Finally, because of the low incidence of postoperative complications, analysis by fracture site was not possible. Comparison with previously reported results was further complicated by heterogeneity in the inclusion criteria and outcomes.

5 | CONCLUSIONS

This European, multi-centre, prospective study suggests that manual and rigid MMF are comparable for temporary stabilisation of bone fragments during ORIF in dentate and partially dentate mandibular fractures, with no significant differences in occlusal and infective complications. Surgeons may select the type of MMF based on the fracture pattern, surgical experience, economic resources, and available staff. Future prospective, randomised studies are needed to determine which of the two methods is superior for the treatment of specific mandibular fracture patterns.

FUNDING INFORMATION

This research received no external funding.

CONFLICT OF INTEREST STATEMENT

The authors have stated explicitly that there are no conflicts of interest in connection with this article. FUNDING: This research received no external funding.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ORCID

Federica Sobrero https://orcid.org/0000-0002-2473-3802
Fabio Roccia https://orcid.org/0000-0002-4765-6395
Elisa Raveggi https://orcid.org/0000-0002-4196-4047
Guglielmo Ramieri https://orcid.org/0000-0002-3131-9669
Gian Battista Bottini https://orcid.org/0000-0002-4116-6264
Alessandro Rabufetti https://orcid.org/0000-0002-5336-8250
Kathia Dubron https://orcid.org/0000-0003-1275-2771

REFERENCES

1. Roccia F, Iocca O, Sobrero F, Rae E, Laverick S, Carlaw K, et al. World Oral and Maxillofacial Trauma (WORMAT) project: a multicenter prospective analysis of epidemiology and patterns of maxillofacial trauma around the world. J Stomatol Oral Maxillofac Surg. 2022;123:e849–57.
2. Chrcanovic BR. Factors influencing the incidence of maxillofacial fractures. Oral Maxillofac Surg. 2012;16:3–17.
3. Ehrenfeld M, Prein J, Assael L, Ueeck B, Gellrich NC, Schoen R, et al. Mandibular fractures. In: Ehrenfeld M, Manson PN, Prein J, editors. Principles of internal fixation of the craniomaxillofacial skeleton. Trauma and orthognathic surgery. Stuttgart: Georg Thieme Verlag KG; 2012. p. 137–79.
4. Ellis E. Open reduction and internal fixation of combined angle and body/symphysis fractures of the mandible: how much fixation is enough? J Oral Maxillofac Surg. 2013;71:726–33.
5. Ellis E. An algorithm for the treatment of noncondylar mandibular fractures. J Oral Maxillofac Surg. 2014;72:939–49.
6. Hsu E, Crombie A, To P, Marquart L, Batstone MD. Manual reduction of mandibular fractures before internal fixation leads to shorter operative duration and equivalent outcomes when compared with reduction with intermaxillary fixation. J Oral Maxillofac Surg. 2012;70:1622–6.
7. Bhushan K, Unakalkar S, Sahu R, Sharma ML. Compare the efficacy of open reduction and internal fixation of mandibular fractures with and without use of intra-operative inter-maxillary fixation. Indian J Otolaryngol Head Neck Surg. 2021;74:10–3.
8. Singh AK, Dahal S, Singh S, Krishna KC, Chaulagain R. Is manual reduction adequate for intraoperative control of occlusion during fixation of mandibular fractures? A systematic review and meta-analysis. Br J Oral Maxillofac Surg. 2022;60:271–8.
9. Weill P, Garmi R, Thobie A, Benateau H, Veyssiere A. Focus on the use of maxillomandibular fixation in mandibular fracture oseosynthesis. J Stomatol Oral Maxillofac Surg. 2022;123:e614–8.
10. Coletti DP, Salama A, Caccamese JF. Application of intermaxillary fixation screws in maxillofacial trauma. J Oral Maxillofac Surg. 2007;65:1746–50.
11. Vural E, Ragland J, Key JM. Manually provided temporary maxillomandibular fixation in the treatment of selected mandibular fractures. Otolaryngol–Head Neck Surg. 2008;138:528–30.
12. El-Anwar MW, Sayed El-Ahl MA, Amer HS. Open reduction and internal fixation of mandibular fracture without rigid maxillomandibular fixation. Int Arch Otorhinolaryngol. 2014;19:314–8.
13. Fordyce AM, Lalani Z, Songra AK, Hildreth AJ, Carton ATM, Hawkesford JE. Intermaxillary fixation is not usually necessary to reduce mandibular fractures. Br J Oral Maxillofac Surg. 1999;37:52–7.

14. Dimitroulis G. Management of fractured mandibles without the use of intermaxillary wire fixation. J Oral Maxillofac Surg. 2002;60:1435–8.
15. Bell RB, Wilson DM. Is the use of arch bars or interdental wire fixation necessary for successful outcomes in the open reduction and internal fixation of mandibular angle fractures? J Oral Maxillofac Surg. 2008;66:2116–22.
16. Laurentjoye M, Majoufre-Lefebvre C, Caix P, Siberchicot F, Ricard AS. Treatment of mandibular fractures with Michelet technique: manual fracture reduction without arch bars. J Oral Maxillofac Surg. 2009;67:2374–9.
17. Song SW, Burm JS, Yang WY, Kang SY. Microplate fixation without maxillomandibular fixation in double mandibular fractures. Arch Craniofac Surg. 2014;15:53–8.
18. Kopp RW, Crozier DL, Goyal P, Kellman RM, Suryadevara AC. Decade review of mandible fractures and arch bar impact on outcomes of nonsubcondylar fractures. Laryngoscope. 2016;126:596–601.
19. Ribeiro-Junior PD, Senko RA, Momesso NR, Izidoro JH, Padovan LEM, Viswanath A. Occlusal instability results in increased complication rates after treatment of mandibular fractures. J Oral Maxillofac Surg. 2020;78(1163):e1–7.
20. Gear AJL, Apasova E, Schmitz JP, Schubert W. Treatment modalities for mandibular angle fractures. J Oral Maxillofac Surg. 2005;63:655–63.
21. Cheng H, Chen BPH, Soleas IM, Ferko NC, Cameron CG, Hinoul P. Prolonged operative duration increases risk of surgical site infections: a systematic review. Surg Infect (Larchmt). 2017;18:722–35.

How to cite this article: Sobrero F, Roccia F, Vilaplana V, Roig AM, Raveggi E, Ramieri G, et al. Manual versus rigid intraoperative maxillo-mandibular fixation in the surgical management of mandibular fractures: A European prospective analysis. Dental Traumatology. 2023;39:448–454. https://doi.org/10.1111/edt.12851