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Management of mandibular angle fractures using 3- dimensional or standard miniplates: A systematic review and meta-analysis

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ABSTRACT

Purpose: This study proposed to compare clinical outcomes between three-dimensional (3D) plate and standard miniplate fixation systems for the management of mandibular angle fractures (MAFs).

Methods: A systematic review search of several databases, including MEDLINE-Ovid, Embase, Springer Link, and PubMed, for relevant articles in English and without date restrictions was performed in February 2018. The quality of studies was assessed, and the relative risk (RR) with its corresponding 95% confidence interval (CI) was assessed to measure postoperative complications.

Results: Eleven publications were enrolled in the analysis. The results showed that there were significant differences in overall complications (RR, 0.453; 95% CI, 0.311–0.660; P = 0.007). The incidence of hardware failure showed a statistically significant difference in the outcome, favoring 3D miniplates (fixed: RR 0.156; 95% CI, 0.042–0.581; P = 0.0006). Subgroup analyses indicated that the 3D miniplate caused a lower incidence rate of malunion and hardware failure than the standard miniplate with 8 or 10 holes (P = 0.006, P = 0.03, respectively). In addition, the use of standard miniplates had a shorter operation time than the use of 3D miniplates (P = 0.002).

Conclusion: The present study demonstrates that the three-dimensional miniplate was a better fixation system than the standard miniplate technique in reducing postoperative complications in the management of mandibular angle fracture (P = 0.007).

1. Introduction

The mandibular angle is one of the more common sites for mandible fractures, accounting for 30% of all mandibular fractures (Al-Moraissi and Ellis, 2014). The management of MAFs (mandibular angle fractures) is controversial and complicated by the anatomical relationship and complex biomechanical relationships of the mandibular angle, involving the unique anatomical location of a thin cross-sectional area, abrupt alteration in curvature, masticatory force of muscles' attachment, and the presence of third molars (Al-Moraissi and Ellis, 2014) (Al-Moraissi et al., 2014).

Various innovations in surgical approaches have been performed to validate a reliable technical approach in the management and treatment of mandibular angle fractures. Over the past decades, two-point fixations with miniplates and monocortical screws for angle fractures was common, but was found to have a much higher complication rate than one-point fixation. Therefore, the single miniplate has become the standard technique for angle fractures in many units (Jain et al., 2010).

The stability provided by the miniplate fixation system of mandibular angle fractures has become a point of controversy among maxillofacial surgeons. This is based on recent clinical and experimental studies wherein some authors have attributed inferior border distraction to application of loading forces close to the fracture line (Jain et al., 2010). Recently, shortcomings of standard miniplate have led to the development of the 3D miniplate. It was introduced in the treatment of mandibular angle fractures to challenge the Champy technique for the fixation of mandibular

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fractures and possesses easy adaptation to bone without distortion, which ascribes to meeting the requirements of semi-rigid fixation with fewer complications (Singh et al., 2012).

Therefore, the null hypothesis was that the 3D miniplate was as effective as a standard miniplate in the treatment of mandibular angle fractures, and the specific aim of this study is to answer the following question: Among patients with mandibular angle fracture, does the 3D plate reduce the overall complication rate and operative time in comparison to the standard procedure?

2. Materials and methods

2.1. Literature search

A systematic review search of several databases, including MEDLINE-Ovid, Embase, Springer Link, and PubMed, for relevant articles in English and without date restrictions was performed in February 2018.

The keywords and combinations of the following search terms contained: “conventional” OR “champy” OR “champys” OR “standard” OR “linea oblique” AND “3-dimensional” OR “3D” OR “3-D” OR “strut” OR “grid”) AND “mandibular angle” OR “jaw.” “rigid fixation” OR “osteo-synthesis” OR “grid miniplate” OR “matrix miniplate” “3D strut miniplate” AND “Champy” OR “locking miniplate versus non-locking miniplate” AND “one miniplate” OR “internal rigid fixation in mandibular angle fractures” OR “bone plate” OR “osteosynthesis of mandibular angle fractures”.

2.2. Inclusion and exclusion criteria

We reviewed the abstracts of all citations and reviewed studies. The following criteria were used to accept studies published in English: only controlled trials that compared the efficacy of different fixation systems in the treatment of MAFs were included; studies were included regardless of whether they were randomized controlled trials (RCTs) or quasi-randomized controlled trials, or retrospective studies. In addition, the studies had to contain sufficient raw data for relative risk [RR] assessment with 95% confidence intervals (CIs). In addition, the reference lists of the papers searched were also reviewed to find additional relevant papers, and the studies had to be performed on human patients. We excluded articles according to the following criteria: in vitro studies comparing different fixation methods, animal studies, technical and case reports, review reports, retrospective studies, studies using bioabsorbable materials, reports that included infected mandibular fracture, and edentulous mandible fractures.

2.3. Data extraction and quality assessment

Eligibility of all studies reviewed from the databases was independently extracted by 2 investigators using a predefined model, which included the following relevant information: name of the first author, exact time of publication, regions of the population, age and sex composition of the patients, sample sizes, and study outcomes. Final decision after disagreement was handled through a discussion involving a third investigator.

2.4. Risk of bias in individual studies

A methodological quality rating was performed by combining the proposed criteria of the Meta-analysis of Observational Studies in Epidemiology statement (Stroup et al., 2000), the Strengthening the Reporting of Observational Studies in Epidemiology statement (Von Elm et al., 2014), and the Preferred Reporting Items for Systematic Reviews and Meta-analyses (Moher et al., 2009) to verify the strength of scientific evidence in clinical decision making. The classification of the risk for bias potential for each study was based on the following five criteria: random selection in the population, definition of inclusion and exclusion criteria, report of losses to follow-up, validated measurements, and statistical analysis. A study that included all these criteria was classified as having a low risk for bias, and a study that did not include one of these criteria was classified as having a moderate risk for bias. When two or more criteria were missing, a study was considered to have a high risk for bias.

2.5. Statistical analysis

Dichotomous variables (the incidence of overall complication, postoperative infection rate, and operation time) were analyzed using RevMan 5.26 software, which was provided by Cochrane Collaboration. Heterogeneity among studies was evaluated by using the Cochrane-based Q test and I^2 statistic (Higgins and Green, 2008). $P < 0.05$ was considered statistically significant. If the results of the trials had heterogeneity ($I^2 > 50\%$), a random-effects model was used for meta-analysis. Otherwise, the fixed-effects model was implemented when they lacked pronounced heterogeneity ($I^2 \leq 50\%$) (Liu et al., 2014).

3. Results

3.1. Literature search

Based on the search strategy, a total of 1408 studies were identified from the preliminary search, including the relevant database sources from PubMed, Embase, Springer Link, and the Cochrane Library. After excluding the duplicate publications and removing the irrelevant articles through title and abstract reading and browsing, the remaining 30 studies were chosen through a full-text reading process. Subsequently, another 19 articles were eliminated because they did not mention the comparison effect between 3-dimensional plates and standard miniplates. Consequently, a set of 11 studies were included for this review. The detailed procedure of study selection is presented in Fig. 1.

3.2. Characteristics of including study

There were 6 randomized controlled trials and 5 retrospective studies in this review. A total of 456 patients were enrolled in these 11 studies that compared the 3D plate with the standard two-miniplate technique at varying follow-up periods (Table 1). There were no statistically significant differences regarding infection, wound dehiscence, nonunion/malunion, and paresthesia. The cumulative analysis showed advantages of the 3D miniplate over the standard two-miniplate technique in the fixation of MAFs, and this advantage reached statistical significance (RR, 0.453; 95% CI, 0.311–0.660; $P = 0.007$).

3.3. Risk of various bias and quality of studies

The quality assessment of the included studies is shown in Fig. 2. The risk of selection bias, performance bias, and detection bias were relatively high. However, the risk of attrition bias, reporting bias, and other biases were relatively low. In summary, the overall bias risk was medium.

3.4. Comparison of outcomes between 3D miniplate and standard miniplate

As a result, the cumulative analysis showed choosing the 3D miniplate over the standard miniplate technique in the fixation of

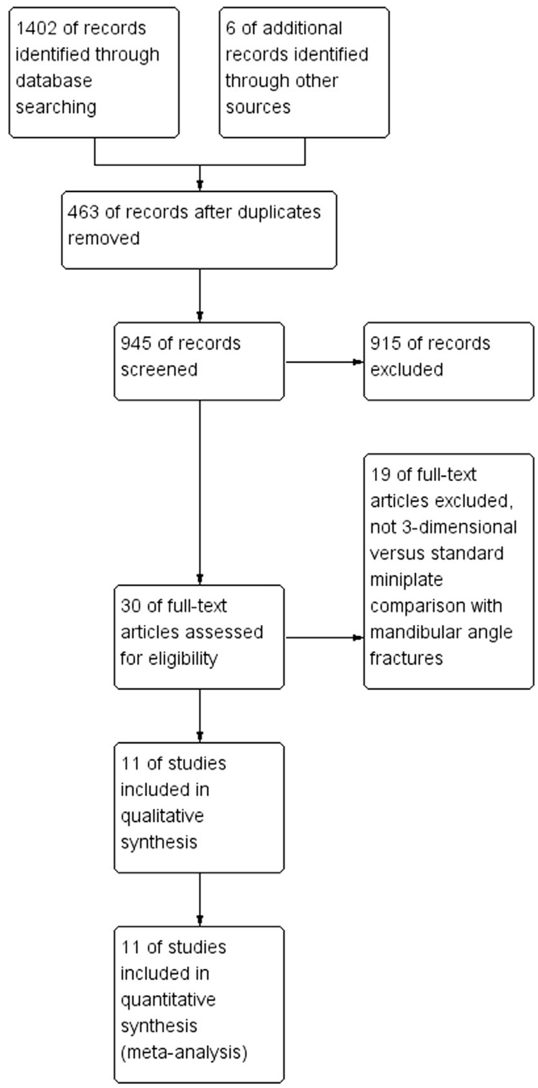

Fig. 1. Study flow diagram.

MAFs offered the advantage of reducing postoperative complications, and this advantage showed statistical significance (RR, 0.453; 95% CI, 0.311–0.660; P = 0.007) (Fig. 3).

Data on postoperative infection was given in 11 studies. The cumulative analysis showed an advantage for the 3D miniplate group regarding infection (fixed: RR 0.354; 95% CI, 0.161–1.780) (Fig. 3).

Malocclusions were involved in 4 studies. The cumulative analysis showed no statistically significant difference in the outcome but favoring 3D miniplates (fixed: RR 0.334; 95% CI, 0.135–0.825; P = 0.07) (Fig. 3).

The incidence of wound dehiscence was reported in 8 studies, the outcome of wound dehiscence favoring the 3D miniplate group (fixed: RR 0.543; 95% CI, 0.179–1.648; P = 0.35) without statistical significance (Fig. 3).

Thirteen studies reported the outcomes of hardware failure. The cumulative analysis showed a statistically significant difference in the outcome, favoring 3D miniplates (fixed: RR 0.156; 95% CI, 0.042–0.581; P = 0.006) (Fig. 3).

Four studies evaluated the incidence of malunion. The analysis showed no statistical advantage for the 3D miniplate with respect to union (fixed: RR 0.716; 95% CI, 0.221–2.319; P = 0.50) (Fig. 3).

The incidence of paresthesia was reported in 6 studies. The cumulative analysis showed that there was no statistically significant difference between the 3D and standard miniplate groups (fixed: RR 0.899; 95% CI, 0.408–1.983; P = 0.53) (Fig. 3).

3.5. Subgroup analysis result

When stratified by different sizes of 3D miniplates, results on postoperative complication in the outcomes were not significantly different except in infection, hardware failure, and malunion (Table 2).

The 8- and 10-hole 3D plates had a significantly reduced hardware failure rate over the standard miniplate (RR 0.158, 95% CI, 0.041–0.616, P = 0.006); in addition, 8- and 10-hole 3D plates had a significantly reduced malunion rate over the standard miniplate (RR 0.341, 95% CI, 0.118–0.986, P = 0.03).

3.6. Operation time

Six studies provided information on the mean operation time. However, only three studies reported the standard deviation; therefore, comparisons of continuous outcomes are necessary. Operative times were shorter in the standard plate groups than in the 3D miniplate groups for mandibular fractures (Fig. 4).

3.7. Publication bias

The publication bias for the outcome of complications, which appeared in 9 studies, was estimated. As revealed in the funnel plot (Fig. 5), an obvious asymmetry was not observed, indicating the absence of publication bias in this meta-analysis.

4. Discussion

The ideal goal of treatment of mandibular angle fractures should include anatomical restitution, immobilization, prevention of postoperative complications, and rehabilitation of function (Vineeth et al., 2013). The use of 3D plates has been one of the methods of fixation to challenge the standard miniplate fixation of mandibular angle fractures, because several sufficient clinical trials have compared the efficacy of 3D plate systems with standard plate systems for the management of maxillofacial trauma. Consequently, we performed a meta-analysis of the clinical effort of the 3D plate system compared to the standard plate in the treatment of mandibular angle fractures to determine the best fixation method with the fewest postoperative complications and whether there is a significant difference in clinical outcomes between 3D miniplate and standard plate fixation in the treatment of MAFs.

This meta-analysis included a set of 11 studies to evaluate the efficiency of the standard miniplate and 3D miniplate on the treatment of MAFs. As a result, we found that the 3D miniplate significantly reduced the incidence of hardware failure compared to the standard miniplate. However, we did not detect any significant difference between these two treatments in the outcomes of wound dehiscence, infection, malocclusion, malunion, or paresthesia.

Subgroup analysis revealed that when analyzed by different plate sizes of the 3D plate, the outcomes were the same as the overall results, except for hardware failure and malunion; 3D plates of 8 holes or 10 holes have significantly reduced the incidence of hardware failure and malunion compared with the standard miniplate (P = 0.006, P = 0.03), respectively.

For the management of MAFs, the failure to achieve a stable condition in the correct anatomical position, which enables undisturbed healing, could result in malocclusion, infection, or

Table 1
Comparison between fixation Methods (3d Plate, two conventional Miniplates)In mandibular angle fractures.

Study and year published	study design	Patients (n)	Follow-Up Period	MF Fixation Methods	Mean Length of Operation (min)	MFs	Region of MFs
Höfer et al. (2012)	RS	G1:30 G2:30	7,14,28 days, 3,6,12 months	G1: Single2.0-mm 6-hole miniplate at the external oblique line (n = 30) (G2) Single rectangular 2.0-mm 4-hole 3Dminiplate (n = 30)	G1:89 G2: 81	90	Angle (n = 60) (G1, G2):body (n = 25) ascending ramus (n = 5)
Xue et al. (2013)	RCT	G1:6 G2:7	1–2 weeks 4–6 weeks 6 months	G1: Single2.0-mm 4-hole miniplate at the external oblique line (n = 7) G2: Single curved 2.0-mm 10-hole3D miniplate (n = 6)	G1:42 G2:102	22	Angle (n = 13) parasymphysis (n = 8) subcondylar (n = 1)
Guy et al. (2013)	RS	G1:22 G2:68	G1:47 days G2:55 days	G1: One or two 2.0-mm 4-hole miniplate (n = 22) G2: Single curved 2.0-mm 8-hole3D miniplate (n = 68)	G1:232.2 G2:219.5	161	Angle (n = 96) parasymphysis (n = 41) body (n = 11) condyle (n = 5) coronoid (n = 2) ramus (n = 6)
Moore et al. (2013)	RS	G1:32 G2:72	NM	G1: Single2.0-mm 4- or6-hole miniplate at the external oblique line (n = 33) G2: Single curved 2.0-mm 8-hole3D miniplate (n = 73)	NM	168	Angle (n = 106), parasymphysis (n = 51) body (n = 11)
Tairi et al. (2015)	RS	G1:8 G2:8	1,3,6month	G1:two miniplates fixation G2:3D miniplate	NM	16	Mandibular angle (16)
Singh et al. (2012)	RCT	G1:25 G2:25	1,4,8,12WK	G1: Single2.0-mm 4-hole miniplate at the external oblique line or on the lateral cortex (n = 10) G2:Single rectangular 2.0-mm 6-hole 3Dminiplate (n = 10)	G1:49.57 G2:43	56	Angle (n = 20) parasymphysis (n = 35) symphysis (n = 1)
Vineeth et al. (2013)	RCT	G1:10 G2:10	1 day 1 week1 month 3 months	G1: Single2.0-mm 4-hole miniplate at the external oblique line (n = 10) G2: Single rectangular 2.0-mm 6- or 8-hole3D miniplate (n = 10)	NM	29	Angle (n = 20) additional fractures (n = 9; G1,n = 5; G2,n = 4)
Elsayed et al. (2015)	RS	G1: 10 G2: 10	1, 2, 3, 4 weeks 3.6 months	G1: single 2.0-mm locking miniplate G2: single rigid 2.3-mm plate	G1: 33.20 ± 2.44 G2: 42.0 ± 2.32	36	Angle (n = 5) Combined fractures (n = 16) subcondylar (n = 1)
Al-Moraissi et al. (2015)	RCT	G1:10 G2:10	1 week, 1, 2, 3 and 6 month	G1: Single2.0-mm standard mini-plate G2: 1.0-mm mini-plate (n = 73)	G1:39.7 ± 9.1 G2:33 ± 4.6	NM	NM
Sehgal et al. (2014)	RCT	G1:15 G2:15	1,3 months	G1:two miniplates fixation G2:3D miniplate	NM	53	Parasymphysis: 16, Condyle: 13 Body: 11, Angle: 10, Symphysis: 3
Mishra et al. (2017)	RCT	G1:20 G2:20	1,3 months	G1: Single2.0-mm 4-hole mini-plate G2: Single rectangular 2.0-mm 4- or6-hole3D miniplate	G1:55.2 ± 20.9 G2:33 ± 4.6	NM	Angle, body 20) parasymphysis symphysis

NM, not mentioned; RCT, randomized controlled trials; CCT, controlled clinical trials; RS, retrospective studies; G1,group1(standard miniplates); G2, group 2(3Dminiplates).

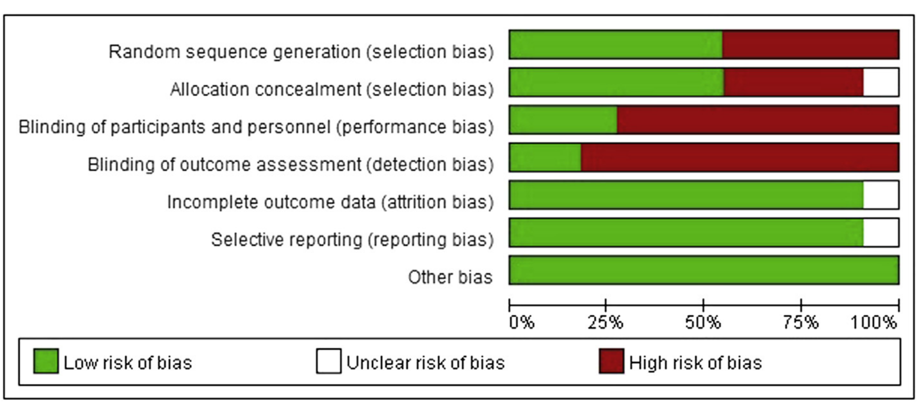

Fig. 2. Assessment of the risk of bias for the included studies. Methodological quality graph: authors' judgment about each methodological quality item presented as percentages across all included studies.

nonunion (Vineeth et al., 2013). The 3D miniplate has the advantage of simultaneous stabilization of the tension and compression zones (Al-Moraissi et al., 2014), which might contribute to the lower incidence of postoperative complications and the good clinical results (Chranovic, 2014). Zix et al. report that the 1.0-mm thick 3D plate is as stable as the much thicker 2.0-mm miniplate. This offers better bending stability and more resistance to out-of-plane movement or torque (Zix et al., 2007).

In the literature, the postoperative infection rate in patients with angle fractures that have been repaired with 3D miniplates has been shown to be lower than that when using standard miniplates (Elsayed et al., 2015). However, several studies observed a

Study or Subgroup	3-dimensional miniplate Events	3-dimensional miniplate Total	Standard miniplate Events	Standard miniplate Total	Weight	Risk Ratio M-H, Random, 95% CI
Infection						
Ai-Moraissi et al 2015	1	10	1	10	1.6%	1.00 [0.07, 13.87]
Elsayed et al 2015	0	10	1	10	1.2%	0.33 [0.02, 7.32]
Guy et al 2013	3	68	2	22	3.7%	0.49 [0.09, 2.72]
Höfer et al 2012	0	30	3	30	1.3%	0.14 [0.01, 2.65]
Mishra et al 2017	1	20	6	20	2.7%	0.17 [0.02, 1.26]
Moore et al 2013	2	73	0	33	1.2%	2.30 [0.11, 46.56]
Sehgal et al 2014	0	15	0	15		Not estimable
Singh et al 2012	2	10	3	10	4.5%	0.67 [0.14, 3.17]
Tairi et al 2015	0	8	1	8	1.2%	0.33 [0.02, 7.14]
Vineeth et al 2013	0	10	2	10	1.3%	0.20 [0.01, 3.70]
Xue et al 2013	1	6	0	7	1.2%	3.43 [0.16, 71.36]
Subtotal (95% CI)		**260**		**175**	**19.9%**	**0.49 [0.23, 1.04]**
Total events	10		19			
Heterogeneity: Tau² = 0.00; Chi² = 5.32, df = 9 (P = 0.81); I² = 0%						
Test for overall effect: Z = 1.86 (P = 0.06)						
Wound dehiscence						
Ai-Moraissi et al 2015	0	10	1	10	1.2%	0.33 [0.02, 7.32]
Elsayed et al 2015	0	10	1	10	1.2%	0.33 [0.02, 7.32]
Guy et al 2013	4	68	2	22	4.2%	0.65 [0.13, 3.30]
Höfer et al 2012	0	30	3	30	1.3%	0.14 [0.01, 2.65]
Mishra et al 2017	0	20	0	20		Not estimable
Moore et al 2013	1	73	0	33	1.1%	1.38 [0.06, 32.97]
Sehgal et al 2014	0	15	0	15		Not estimable
Xue et al 2013	1	6	0	7	1.2%	3.43 [0.16, 71.36]
Subtotal (95% CI)		**232**		**147**	**10.1%**	**0.61 [0.21, 1.73]**
Total events	6		7			
Heterogeneity: Tau² = 0.00; Chi² = 2.76, df = 5 (P = 0.74); I² = 0%						
Test for overall effect: Z = 0.94 (P = 0.35)						
Malocclusion						
Guy et al 2013	2	68	2	22	3.1%	0.32 [0.05, 2.16]
Höfer et al 2012	0	30	2	30	1.2%	0.20 [0.01, 4.00]
Sehgal et al 2014	6	15	9	15	19.9%	0.67 [0.32, 1.40]
Vineeth et al 2013	0	10	2	10	1.3%	0.20 [0.01, 3.70]
Subtotal (95% CI)		**123**		**77**	**25.5%**	**0.54 [0.28, 1.05]**
Total events	8		15			
Heterogeneity: Tau² = 0.00; Chi² = 1.64, df = 3 (P = 0.65); I² = 0%						
Test for overall effect: Z = 1.82 (P = 0.07)						
Hard ware failure						
Guy et al 2013	1	68	1	22	1.5%	0.32 [0.02, 4.96]
Höfer et al 2012	0	30	2	30	1.2%	0.20 [0.01, 4.00]
Moore et al 2013	2	73	6	33	4.6%	0.15 [0.03, 0.71]
Xue et al 2013	0	6	1	7	1.2%	0.38 [0.02, 7.93]
Subtotal (95% CI)		**177**		**92**	**8.5%**	**0.20 [0.07, 0.64]**
Total events	3		10			
Heterogeneity: Tau² = 0.00; Chi² = 0.42, df = 3 (P = 0.94); I² = 0%						
Test for overall effect: Z = 2.74 (P = 0.006)						
Malunion						
Guy et al 2013	4	68	2	22	4.2%	0.65 [0.13, 3.30]
Mishra et al 2017	0	20	2	20	1.2%	0.20 [0.01, 3.92]
Moore et al 2013	3	73	1	33	2.2%	1.36 [0.15, 12.56]
Sehgal et al 2014	0	15	0	15		Not estimable
Subtotal (95% CI)		**176**		**90**	**7.6%**	**0.66 [0.20, 2.21]**
Total events	7		5			
Heterogeneity: Tau² = 0.00; Chi² = 1.03, df = 2 (P = 0.60); I² = 0%						
Test for overall effect: Z = 0.67 (P = 0.50)						
Paresthesia						
Elsayed et al 2015	1	10	0	10	1.2%	3.00 [0.14, 65.90]
Guy et al 2013	1	68	1	22	1.5%	0.32 [0.02, 4.96]
Mishra et al 2017	7	20	4	20	9.8%	1.75 [0.61, 5.05]
Singh et al 2012	4	10	5	10	11.5%	0.80 [0.30, 2.13]
Tairi et al 2015	2	8	1	8	2.3%	2.00 [0.22, 17.89]
Vineeth et al 2013	2	10	1	10	2.2%	2.00 [0.21, 18.69]
Subtotal (95% CI)		**126**		**80**	**28.4%**	**1.22 [0.65, 2.27]**
Total events	17		12			
Heterogeneity: Tau² = 0.00; Chi² = 2.82, df = 5 (P = 0.73); I² = 0%						
Test for overall effect: Z = 0.62 (P = 0.53)						
Total (95% CI)		**1094**		**661**	**100.0%**	**0.63 [0.45, 0.88]**
Total events	51		68			
Heterogeneity: Tau² = 0.00; Chi² = 22.70, df = 32 (P = 0.89); I² = 0%						
Test for overall effect: Z = 2.69 (P = 0.007)						
Test for subgroup differences: Chi² = 8.71, df = 5 (P = 0.12), I² = 42.6%						

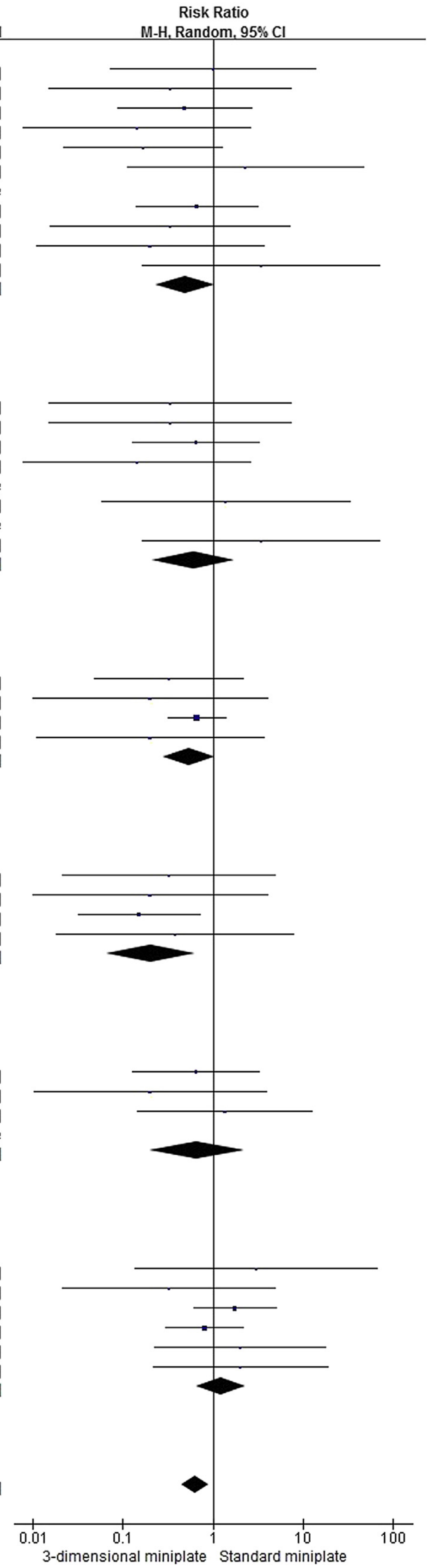

Fig. 3. Forest plots of the effect comparisons between 3D miniplate and standard miniplate.

Table 2
Results of the quality assessment.

Indicator	Group	Sample size		Test of analysis			Model	Heterogenety		I^2 (%)
		Cases	Controls	RR (95% CI)	Z	P value		Chi^2	P value	
The size of plate										
Infection	8,10 hole plate	147	62	1.26	0.17	0.87	Fixed	1.64	0.44	0
	<8 hole	103	103	0.25	2.51	0.01	Fixed	2.39	0.79	0
	8,10 hole plate	68	22	0.32	1.16	0.24	Fixed	–	–	–
Mal-occlusion										
Wound dehiscence	<8 hole	55	55	3	1.87	0.06	Fixed	1.31	0.77	0
	8,10 hole plate	147	62	1.27	0.12	0.91	Fixed	0.96	0.62	0
	<8 hole	85	85	–	1.66	0.1	Fixed	0.21	0.90	0
Hardware failure	8,10 hole plate	147	62	0.158	2.77	0.006	Fixed	0.42	0.94	0
	<8 hole	30	30	–	1.05	0.29	–	–	–	–
Malunion	8,10 hole plate	141	55	0.34	2.13	0.03	Fixed	0.97	0.33	0
	<8 hole	35	35	–	1.06	0.29	–	–	–	0
Paresthesia	8,10 hole plate	68	22	0.34	0.81	0.42		–	–	–
	<8 hole	58	58	1.455	1.11	0.39	Fixed	1.89	0.76	0

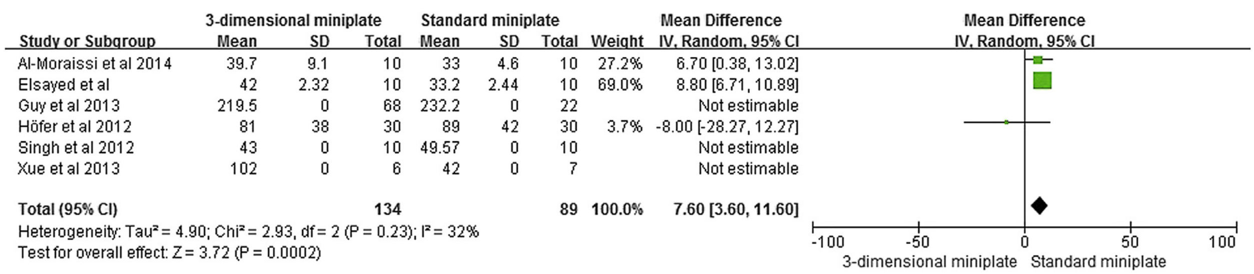

Fig. 4. Forest plots: 3D plate versus miniplate in MAFs (operative time). CI, confidence interval; IV, inverse variance.

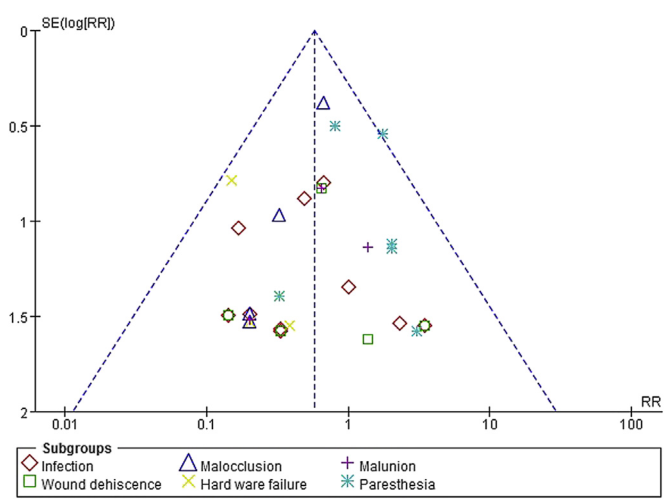

Fig. 5. Funnel plot for publication bias test of the comparison between 3-D miniplates and standard miniplates in postoperative complications.

comparable efficiency between these two techniques (Guy et al., 2013), which might be due to the excessive implant material (Jain et al., 2010). Notably, the results in the present meta-analysis exhibited a 3.84% induction of the incidence of infection rate by using 3D miniplates, compared to the standard method ($p = 0.06$). The high postoperative complication of two miniplate fixation systems may be ascribed to muscle attachment and more periosteum in the anatomical region of the angle, which would be detrimental to both healing and blood supplement, as well as to the oral condition of contamination with oral bacteria; all these factors may increase postoperative complications with wound care (Al-Moraissi and Ellis, 2014).

With regard to the incidence of malocclusion, the present meta-analysis showed a relatively lower incidence with the 3D miniplate than with the standard miniplate (RR 0.334, 95% CI 0.135–0.825, $P = 0.07$). Even though a statistically significant difference between the techniques did not develop in the follow-up period, better interfragmentary stability may be an influence on lower postoperative complication rates with the use of the 3D miniplate fixation system in the management of MAFs (Al-Moraissi and Ellis, 2014).

Concerning wound dehiscence, the results of this study revealed a lower incidence with 3D miniplates, which is ascribed to the proximity of the plate to the incision. This is barely seen with the 3D plate when it is covered by the masseter along the buccal cortex, well away from the incision (Al-Moraissi et al., 2015).

Hardware failure is a significant complication in MAFs, and a meta-analysis favors the use of 3D miniplates because it could markedly decrease the incidence of hardware failure, compared to standard miniplates for the treatment of MAFs (RR 0.156, 95% CI 0.042–0.581, $P = 0.006$). Vineeth et al. (2013) showed that 3D titanium miniplates revealed better initial interfragmentary stability than single titanium miniplates in their study. Study results of an in vitro study (Yang and Patil, 2015) observed that the 3D miniplate technique had more favorable biomechanical behavior than that of the standard miniplate. The 3D miniplate technique in the angle regions of the superior and inferior borders facilitates reduction and stabilization (Xue et al., 2013).

The incidence of paresthesia was observed between the two techniques ($P = 0.53$). Six studies reported the complication of paresthesia, and incidents of paresthesia were checked before and after surgery in their study (Tairi et al., 2015). During surgery, aggressive manipulation may cause additional nerve injury, and sometimes drill-hole preparation near the mandibular canal can also cause permanent alterations (Farmand, 1996). Therefore, checking for paresthesia before surgery is essential to prevent this postoperative complication.

Six studies showed the operating time, revealing that the standard plating system required a shorter operating time ($p = 0.0002$). Due to the broad size of the plate and because more screws are needed (6–10 holes), fixation of 3D plates in the angle region usually takes more time. Intraoral placement of the six-to 10-hole 3D miniplate is also more difficult (Singh et al., 2012).

The period of follow-up is also an essential factor to be taken into consideration, because one study did not report mean periods of follow-up. The maximum follow-up period in the included studies varied from 1 month to 12 months. Some minor complications might occur several months or even years after successful treatment; therefore, the complication rate could increase with the length of follow-up (Barry and Kearns, 2007).

There were several limitations in the present meta-analysis. First, the present meta-analyses included both RCTs and retrospective studies that were published in English only, which caused language bias. Second, nine studies were associated with additional mandibular fractures (such as those of the contralateral body or parasymphysis or condyle) to the mandibular angle fractures. Of those studies, true complication rates may be overestimated as single fractures of the mandibular site. Third, two studies included small numbers of patients. Last, the difference in the age of patients, detailed surgical practice, and fracture site will result in different biases. Therefore, there is a need for prospective, randomized studies with a large sample size of patients, and a long follow-up period to evaluate whether one technique of fixation results in lower postoperative complication rates than the other would be ideal.

5. Conclusion

The present study demonstrates that the 3-dimensional miniplate was a better fixation system than the standard miniplate technique in reducing postoperative complications in the management of mandibular angle fracture ($P = 0.007$). It shows that complication rates are more likely associated with the fixation system than with surgical technique in the treatment of mandibular angle fractures. In addition, 8- and 10-hole 3D miniplates might contribute to a successful treatment.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jcms.2019.01.032.

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