A Meta-analysis of Comparison between operative and nonoperative Treatment on the midshaft clavicle fractures

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Abstract: Clavicular fractures account for 2% to 2.6% of all fractures, while fractures of the midshaft account for 69% to 82% percent of all clavicular fractures. However, the optimal treatment for midshaft clavicle fracture remains a topic of debate. A meta-analysis of randomized controlled trials was conducted to evaluate the functional outcome and satisfaction of operative treatment and conservative treatment in midshaft calvicle fractures. A systematic electronic literature search was performed using 4 electronic databases (MEDLINE, EMBASE, Biosis Previews and PubMed). After evaluation of the methodological quality of included publications, five RCTs were identified comparing operative treatment and conservative treatment for midshaft clavicular fracture. Five studies with 401 clavicular fractures were included. Operative treatment significantly reduced nonunion rates, malunion rates, union-time, as well as neurologic symptoms. More satisfaction with ultimate appearance was also associated with operative treatment than with conservative treatment. The available evidence suggests that operative treatment is a safe and effective method for performing midshaft clavicular fractures.

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1. Introduction

Clavicle fractures are common in adults and children. It account for 2.6 to 4 percent of all adult fractures and 10 to 15 percent of all children fractures (Altamimi and McKee, 2008). The major reasons of clavicular fractures has been reported to be falls, sporting injures and traffic accidents (Postacchini et al., 2002). Around 80 percent of clavicle fractures involve the midshaft and over half of these fractures are displaced (Nordqvist and Petersson, 1994).

Traditionally, midshaft clavicle fractures have been treated non-operatively with a simple sling or figure-8 brace (Postacchini et al., 2002). At that time, people believed that improper surgery was the main cause of non-union (Neer, 1960 and Rowe CR, 1968). However, in the past 20 years, more studies have shown that relying only on conservative treatment without considering character of fracture may lead to higher incidence of non-union and mal-union. The conservative approach has been questioned. Recent studied have found that of all midshaft clavicular fractures, especially in displaced or shortened midshaft clavicle fractures, incidence rate of non-union rose to 15 percent and more (Pearson et al.,2010; Shen et al., 2008; Zlowodzki et al., 2005) and two-thirds end up have some degree of mal-union(Hillen et al., 2010) after conservative treatment, as well as a decrease in shoulder function and arm strength(Hill et al., 1997; McKee et al., 2006).

Currently described relative indications for surgical treatment of midshaft clavicle fractures include polytrauma, complete displacement, open fractures and those associated with neurovascular compromise requiring exploration. The surgical approach is most often accomplished with the use of various plate and pin combination. A number of surgical techniques have been described but none is considered the gold standard, each has associated complications, including infection, wound breakdown, non-union, poor cosmetic results, refracture after hardware removal and so on. Actually, the optimal treatment for midshaft clavicle fracture remains controversial and this controversy promoted the randomized controlled trial studies which sought to compare functional outcome and complication after either operative or nonoperative treatment.

In order to clarify this debate further, we searched available medical databases for published randomized controlled trials and performed this meta-analysis to address the key question of whether surgical approach superior results to conservative treatment. Our objective was to study the outcomes and complications of the operative and nonoperative approaches used for treating patients with midshaft clavicle fractures.

2. Material and Methods

2.1. Literature search strategy

The study included randomized and

quasi-randomized controlled clinical studies, which comparing operative vs nonoperative methods treatment of midshaft clavicle fractures. On May 1, 2014, a systematic electronic literature search were performed using the following keywords: Midshaft, Clavicle/Clavicular, Fracture/Fractures, which in combinations as follows: "midshaft AND (clavicle OR clavicular) AND (fracture OR fractures)". The following electronic databases were used for the search: MEDLINE (1966-present), EMBASE (1974-present), Biosis Previews (1926-present) and PubMed (1989-present). The search was with restriction by English and collected studies only conducted on human subjects. The titles and abstracts of studies indentified by the search results were reviewed. Articles whose abstracts were of interest were obtained and read critically to assess if they met our inclusion criteria.

2.2. Inclusion and exclusion criteria

Randomized and quasi-randomized controlled trials comparing operative versus nonoperative treatment for midshaft clavicle fractures were included. Inclusion criteria for patients were as follows: (1) A midshaft fracture of the clavicle, (2) patients irrespective of age, race or gender, (3) no medical contraindication for general anesthesia. Exclusion criteria included the following: (1) nonrandomized studies or animal research, (2) combined with other upper limb fractures, (3) pathological fracture, (4) an old fracture, (5) any weakness in the upper extremity resulting from a head or neurovascular injury, (6) inability to obtain the relevant information needed in this study.

2.3. Data extraction and quality assessment

Any literatures consistent with the inclusion and exclusion criteria were extracted independently by 2 authors (L.GQ. and Z.XY.), For each trial, we gathered data on study type, randomization process, allocation concealment process, blinding, selective reporting, involved cases, lost of follow-up and so on. The quality of the studies was assessed according to Cochrane RCT evaluation criteria, which included: (1) to assess if the randomization process is correct, (2) to assess whether the trial has adopted allocation concealment process, (3) assessment for the level of blinding, (4) assessment for potential bias related to drop-out/lost to follow-up, if there are drop-out or lost to follow-up, to assess if the trial use the intention-to-treat (ITT) analysis as a supplement. Based on the criteria described above, studies were broadly divided into 3 levels:(1) level A. all the evaluation criteria are correct; (2)level B. only one evaluation criterion is unclear; (3)level C. only one evaluation criterion is incorrect or unused. Level A indicates low risk of bias, level C indicates high risk of bias and level B in the range between them.

2.4. Statistical analysis

The statistical was conducted using Review Manager 4.2.2 software. The treatment effects were expressed as risk ratios (RR) with 95% CI for dichotomous outcomes. Using the weighted mean difference (WMD) for analyzing continuous variables, standardized mean difference (SMD) were used for data from disparate outcome measures, both WMD and SMD were accompanied with 95% CI. Heterogeneity was assessed by x^2 test with significance set at α=0.1. if data provided by trials can not be analyzed by meta analysis, we will use qualitative description for them.

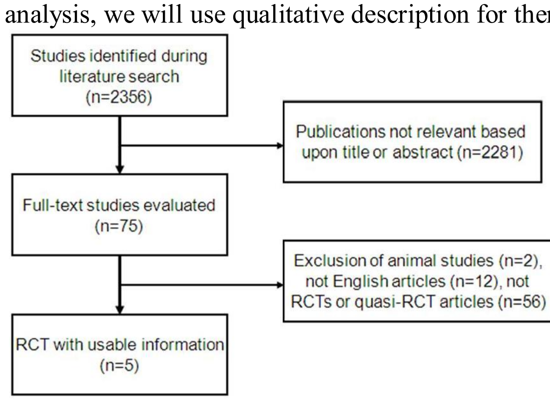

Figure 1. Flow chart shows how articles were selected. (RCT, randomized controlled trial)

Table1. Characteristics of included trials.

Author group	Involved cases				Study type	Adequate randomized process	Blinding	Allocation concealment	Loss follow-up	Quality level
	Operative treatment		Nonoperative treatment	Total						
	Plate	Pin								
Kulshrestha V[13] 2011	45		28	73	RCT	Yes	Unclear	Yes	Yes	B
Smekal V[15] 2009		30	30	60	RCT	Yes	Unclear	Yes	NO	B
Judd D.B[14] 2009		29	28	57	RCT	Yes	Unclear	Yes	Yes	B
Society COT[16] 2007	62		49	111	RCT	Yes	Unclear	Yes	Yes	B
Smith[17] 2001	50		50	100	RCT	Unclear	Unclear	Unclear	NO	B

3. Results

Accroding to our literature search strategy, we identified 2356 articles, of 75 were potentially relevant after screeing the title and abstract. Then full-text articles of them were obtained for assessing independently by 2 authors to evaluate whether they met criteria above. Ultimately, 5 studies matched our inclusion criteria(Fig 1)(Kulshrestha et al., 2011; Judd et al. 2009; Smekal et al., 2009; Society COT, 2007; Smith et al., 2001), all of them were reported to be randomized controlled trials and 401 midshaft clavicle fractures were include in the analysis.

3.1. Quality assessment

Among 401 midshaft clavicle fractures, 216 midshaft clavicle fractures were randomized to surgical treatment and 185 to conservative treatment. All studies included were of a parallel design and had a positive control group, whereas all the blind description were unclear. The level of quality of them is evaluated for B. The study quality of evidence is summarized in Table1.

3.2. Nonunion rates

All the 5 randomized controlled trials included 401 fractures provided data on the incidence of nonunion. Meta analysis showed that there was no statistically significant heterogeneity was detected among these studies (P=0.37, I^2=5.6%). We used fixed effect model for analysis and found that treatment with surgical method resulted in a lower incidence of

nonunion events compared with conservative treatment (Fig 2)(RR,0.12; 95% CI, 0.04~0.31; P<0.0001). This result indicated that surgical treatment was more beneficial to reduce the nonunion rates of midshaft clavicle fractures than conservative treatment.

3.3. Malunion rates

Three studies reported data on malunion, including 244 cases. There was no statistically significant heterogeneity (P=0.71, I^2=0%). fixed effect model was used for analysis. Mata analysis showed that malunion rate was significantly lower with the use of surgical method compared with conservative treatment (Fig 3)(RR,0.10; 95% CI, 0.03~0.32; P=0.0001).

3.4. Union-time

Two of the studies with 171 cases evaluated the union-time for healing the fractures. The measure of heterogeneity was significant between the two studies (P=0.03, I^2=76%), so random effects model were used. A mata analysis favored surgical treatment in the union-time(Fig 4)(WMD, -10.23; 95% CI, -12.79 ~ -7.66; P=0.00001). Thus, we concluded that surgical treatment result in less union-time.

3.5. Neurologic symptoms

Three studies were selected for meta-analysis for the incidence of neurologic symptoms. Based on the results of the studies by Society et al.(2007), Smith et al. (2001) and Smekal et al. (2009). The meta-analysis showed that patients who were treated with surgical method presented better results for this outcome (Fig 5) (RR,0.12; 95% CI, 0.03~0.39; P=0.0005) and there was no statistical heterogeneity between them(P=0.52, I^2=0%).

3.6. Satisfaction with appearance

Two studies with 211 cases were used to assess the satisfaction with appearance of patients receiving surgical method versus conservative treatment. Meta-analysis revealed that surgical method to be superior to the conservative treatment, there was significantly more satisfaction with appearance in patients treated with surgical method (Fig 6)(RR,1.68; 95% CI, 1.39~2.03; P<0.00001). There was no statistical heterogeneity (P=0.52, I^2=0%) and fixed effect model were used.

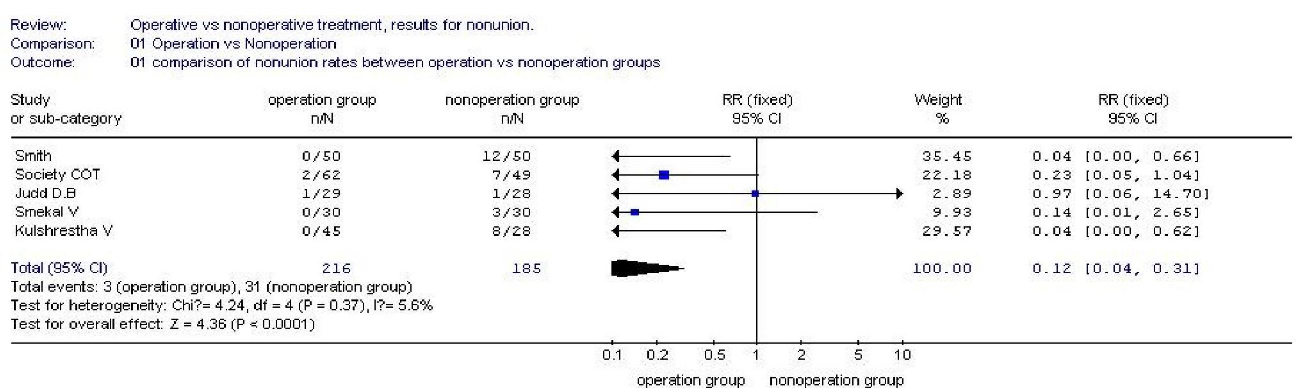

Figure 2. Operative vs nonoperative treatment, results for nonunion. (CI, confidence interval)

4. Discussions

The goal of our study was to compare the outcome of surgical treatment and conservative treatment in midshaft clavicle fractures, which included nonunion, malunion, union-time, neurologic symptoms and satisfaction with appearance. There are 5 randomized controlled trails included in this study.

First of all, the following limitations of this meta-analysis have to be addressed. Owing to the fact that only MEDLINE, EMBASE, Biosis Previews and PubMed were used for search, plus retrieval method and language limitation, some valuable information might be lost. Meanwhile, we recognized that the amount.

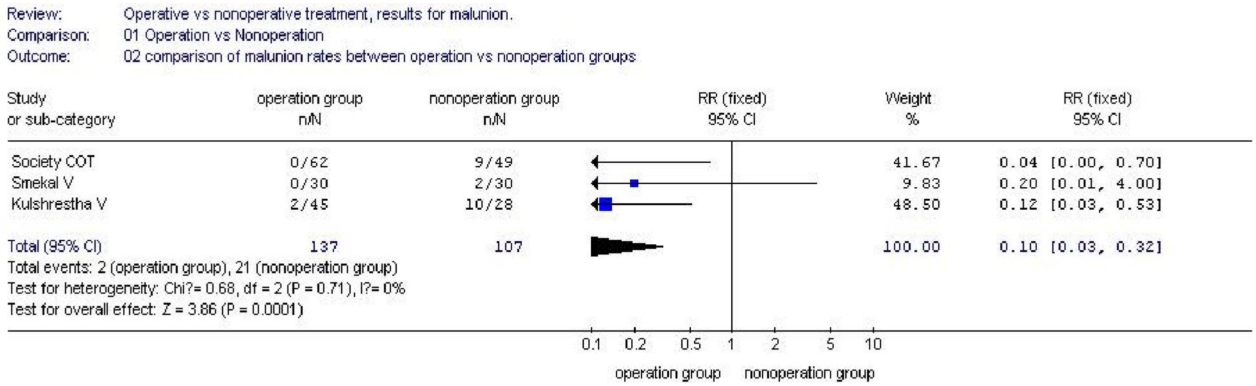

Figure 3. Operative vs nonoperative treatment, results for malunion. (CI, confidence interval)

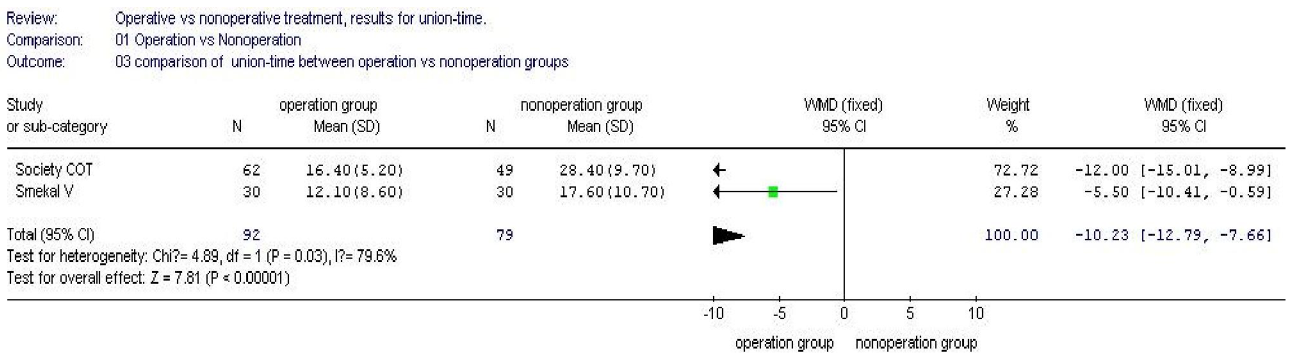

Figure 4. Operative vs nonoperative treatment, results for union-time. (CI, confidence interval; SD, standard deviation)

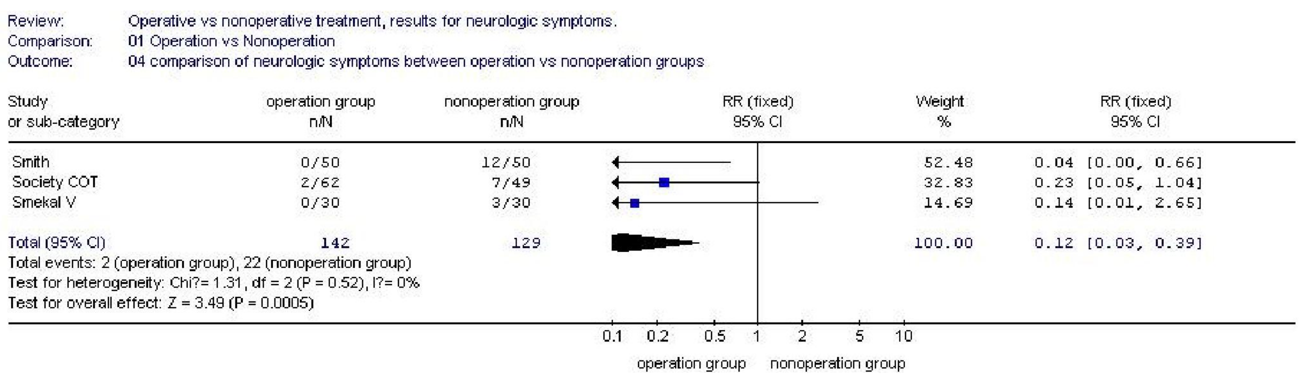

Figure 5. Operative vs nonoperative treatment, results for neurologic symptoms. (CI, confidence interval)

The available literature is small, but this emphasizes the need for future high quality studies comparing surgical treatment and conservative treatment with adequate randomization process, allocation concealment and blinding. In the current selected literature, only two studies (Smekal et al., 2009; Smith et al., 2001) reported the situation of follow-up, although the articles without follow-up performed ITT analysis(Kulshrestha et al., 2011; Judd et al., 2009; Society COT, 2007), they still made this meta-analysis a moderate loss of bias. Adequate allocation concealment can void selection bias and lead to an overestimation of the treatment effect. Four studies (Kulshrestha et al., 2011; Judd et al., 2009; Smekal et al., 2009; Society COT, 2007) included in this meta-analysis reported adequate allocation concealment. No study described blinding for participants or investigators. We concluded that the articles were all "B" level evidence for this meta-analysis, which means a better representativeness and homogeneity.

In our meta-analysis, the nonunion rate of surgical treatment is 1.8%, which is less than 14.1% in conservative treatment. This finding reflects that surgical treatment can effectively reduce the risk of nonunion and it is in agreement with the previous review by several researchers (McKee et al., 1995; Poigenfurst et al., 1992; Zlowodzki et al., 2005; Brinker et al., 2005). Three comparative studies reported malunion rates after treatment. In 137 patients who had undergone surgical treatment, malunion were encountered in 2 cases. Whereas 21 malunion cases were found in 107 patients who were treated conservatively, which shows that the malunion rate in conservative group is significantly higher than that in surgical group. The union-time of clavicle fractures were described in two studies, it was from 12.10 to 16.4 weeks with a mean time of 13.4 weeks for fracture to unite in patients with surgical approach, the fracture healing time of patients with conservative treatment was in 17.60-28.40 weeks(23.4 weeks). The same findings were also reported in the literature (Lee et al., 2007; Collinge et al., 2006). Besides, we also found strong evidence for a fewer neurologic symptoms and increased satisfaction with cosmetic appearance for surgical method compared with conservative treatment.

Both surgical and conservative treatment have their own advantages and disadvantages. Plate fixation has been considered the gold standard for operative treatment of displaced midshaft clavicular fracture, but it is not free from complications, including infection, hypertrophic scars, implant loosening and refracture after implant removal (Bostman et al., 1997). Compared to plate fixation, intramedullary fixation is technically more demanding, proponents believed that it can avoid periosteal stripping (Ngarmukos et al., 1998). But it also has some complications, for example, migration and perforation of the device (Smekal et al., 2009). Nevertheless, several studies described excellent results after plate and intramedullary fixation of displaced midshaft clavicle fractures with significant improvement of shoulder function, low rate of infection, good cosmetic results and minimal nonunion rates (Duan et al., 2011), which supported our results in the meta-analysis previously reported.

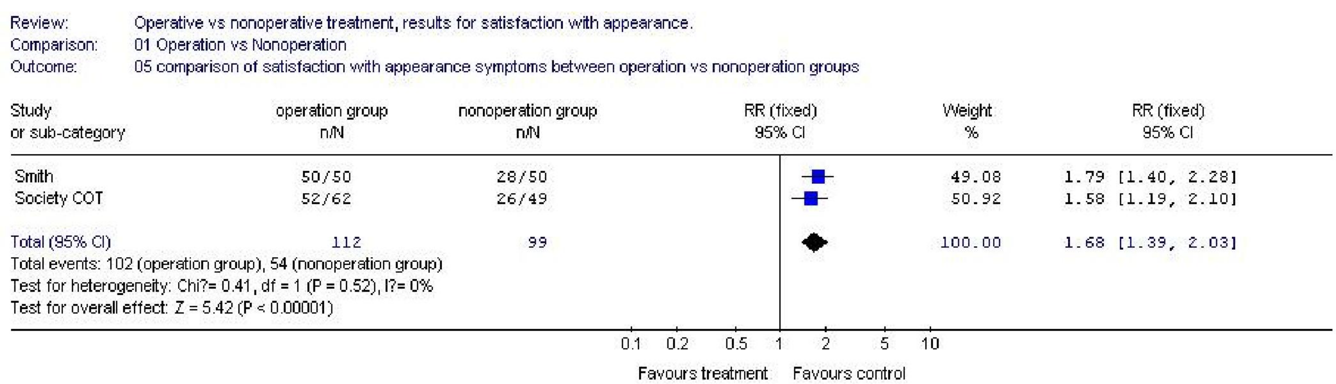

Figure 6. Operative vs nonoperative treatment, results for satisfaction with appearance. (CI, confidence interval)

In the 1960s, Neer and Rowe reported on the nonoperative treatment of clavicle fractures. They found that the nonunion rate were relatively low when conservative treatment was used to address clavicle fractures and suggeusted a higher nonunion rate with operative care. Afterwards, several studies also verified their views and made conservative treatment as the main clinical approach to clavicular fractures (Lee et al., 2007; Barlow et al., 2013). However, the outcomes of our meta-analysis contradicted the findings reported by them. We found that nonunion, malunion, as well as neurologic symptoms, often occurred in patients undergoing conservative treatment, which consistent with a meta-analysis study conducted by Zlowodzki et al (Zlowodzki et al., 2005). Thus, our results showed that operative treatment was, contrary to nonoperative treatment, a safe and reliable procedure in curing midshaft clavicle fractures, especially displaced midshaft clavicle fractures.

However, due to some limitations, the results of this meta-analysis should be cautiously accepted. Although many studies have proved the advantages of surgical treatment in decreasing the rate of nonunion and symptomatic malunion, the correctness of these results were still in doubt. For example, Ban et al. (Ban et al., 2012) questioned the clinical relevance of the shoulder outcome scores used to assess the functional outcome of clavicle fracture treatment, and thus leads to a suspicion on the previous results of surgical treatment. Combined with the opportunity of over treatment may occur, they believed that clavicle fractures may best be treated conservatively. The study of a recent systematic rewiew (Barlow., et al. 2014) also questioned the efficacy of operative treatment, However, they focused mainly on the long-term functional outcome of operative intervention. They suggested that decisions should be made after a carefully evaluation of the superiority and risk of both operative and nonoperative treatments which was still lack in this area.

In fact, the debate on the two treatments has never stopped. More high-quality randomized controlled trials with long term follow-up and large sample size are required to assess the effects of surgical or conservative treatment. For now, we are more sympathetic to the veiw of Meijden et al. (Meijden et al., 2012), which means that the management of them should be individualized to the patient's goals and activity level.

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