JOURNAL OF PURE AND APPLIED MICROBIOLOGY, June 2015. Vol. **9**(2), p. 885-892

Comparison between Staged ORIF and EFLIF in Treatment of Pilon Fracture: A Systematic Review

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(Received: 24 February 2015; accepted: 09 April 2015)

To analyze and compare the differences in curative effect between staged open reductionand internal fixation (staged ORIF) and external fixation with limited internal fixation (EFLIF) by systematic review. Literatures about the effectiveness analysis of staged ORIF and EFLIF, published from 2000 to 2014, were collected through database retrieval and manual search. The index words were "Pilon fracture, tibia fracture, staged ORIF, EFLIF, therapy". The evaluation indicators were set as soft tissue infection rate, osteomyelitis incidence rate, bone nonunion, malunion incidence rate and arthrodesis incidence rate. RevMan5.2 software was adopted to make relevant analysis. Six studies were included after the full text analysis. The results indicated that the soft tissue infection rate in Staged ORIF group was significantly lower than that of EFLIF group (Z = 2.82, *P* = 0.005). And there were no differences between the two groups respectively in osteomyelitis incidence rate(Z = 0.97, *P* = 0.33), bone nonunion(Z = 0.48, *P* = 0.63) , malunion incidence rate(Z = 1.86, *P* = 0.06) and arthrodesis incidence rate(Z = 1.46ÿ*P* = 0.14). The soft tissue infection rate was lower when the technique of staged open reduction and internal fixation was used. However, with respect to the overall curative effect, there was no obvious difference comparing with the method external fixation with limited internal fixation.

Key words: Staged ORIF; EFLIF; pilon fracture; systematic review.

Pilon fracture belongs to intra-articular fractures, which is the distal tibial fracture involving tibial articular surface. It accounts for almost 4%-10% of the tibia and ankle fracres [1].Because pilon fractures often occur in the special area and have complex damage mechanism and types, there has been no unified method on the treatment. At present, the therapeutic methods are various, such as non-surgical way, open reduction and internal fixation, external fixation, limited ORIF and combination of multiple method, etc[2]. However, many complications usually appear during the treatment of pilon fractures, which may be related to the weak soft tissue, poor blood circulation, injury mechanism, soft tissue dissection and subcutaneous plate placement in distal tibia[3]. In order to improve the therapeutic effect of pilon fractures, two aspects should be paid more attention, namely increasing of fracture reduction treatment and reducing soft tissue injuries. Only choose the right operation time and the correct way of fixing fracture, can the best protection of soft tissue and operation effect be achieved[4].

After Sirkin *et al*[5] put forward the concept of staged open reduction and internal fixation(staged ORIF) which meant fixing fibula and bridging bracket to restore most lines of force in early phase, cutting the reconstructive joint surface to conduct the final internal fixation

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treatment in the second phase .The main advantages of this method are that it could protect soft tissue around the fracture against double attacks of trauma and operation, appropriately delay the surgery time, make soft tissue restore well before conducting open reduction and internal fixation[6,7]. More and more physicians began to try this solution. In addition, as for high-energy or open pilon fractures, they often show as crushing fracture, articular surface subsidence and associated with severe soft tissue injury and simple internal fixation cannot achieve good therapeutic effect. Therefore, Leung *et al*.[8] proposed the technique of external fixator combined with limited internal fixation, which could reduce the damage of tissue blood supply ,effectively avoid skin necrosis and own strong fixed action. This method is not only suitable for type I and II fractures but also applicable to open fractures with severe soft tissue loss.

Here, we designed this study to systematically summarize and compare the advantages and disadvantages of staged ORIF and EFLIF in treatment of pilon fractures, and try to provide some theoretical references for improving the therapeutic effect of pilon fractures.

MATERIALS AND METHODS

Search strategies

A systematic literature search was performed based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement[9].The search terms included "staged open reduction and internal fixation", "limited internal fixation combined with an external fixator", "internal fixation", "external fixation", "pilon fracture", "surgery", "therapy". The languages were restricted as English and Chinese, and the date was limited to from 2000 to 2014. MEDLINE, Excerpta Media DataBase (EMBASE), Cochrane Database of Systematic Reviews (CDSR), China National Knowledge Infrastructure (CNKI), Wanfang Database and VIP Database were retrieved to find the eligible literatures. Two of our authors independently reviewed the possible abstracts and retrieved the full articles if the screening criteria were met. A consensus was obtained through discussion to solve disagreements between the two authors.

Inclusion and exclusion criteria

We identified articles that met the following eligibility criteria: (1) Studies comparing the staged ORIF and LIFEF in treatment of pilon fracture. (2) All randomized controlled trials and nonrandomized studies, whether prospective or retrospective. (3)Adult patients, excluding children, followed-up more than six months. (4) Primary outcomes containing soft tissue infection, osteomyelitis, nonunion, malunion and arthrodesis.

Literatures would be ruled out if the following situations existed: (1) Retrospective case report but non-control study. (2) Patient with susceptible factors such as cachexia, diabetes, taking immunosuppressants. (3) Old fractures. (4) Patient with a history of fracture around the ankle joint.

Data extraction

Two authors independently extracted the data which included study type, sample size, mean follow-up, patients' average age, gender, fixation technique and fracture type, complications related with surgery or fracture, operation characteristics and various functional scores.

Quality assessment

The level of evidence (LoE) rating according to the Oxford Centre of Evidence Based Medicine (http://www.cebm.net) and the modified version of the Cochrane Bone, Joint and Muscle Trauma Group's former quality assessment tool(QAT) were used to assess the methodological quality of the included studies[10].Every study was labeled according to their LoE(Level I:high evidence, Level II: moderate evidence, Level III: low evidence, Level IV: very low evidence). And QAT tool was adopted to analyze the research quality in more detail.

Statistical analysis

Review Manager 5.2 software was employed to perform the meta-analysis. The odds ratio (OR) with the 95% confidence interval (CI) was used to analyze the dichotomous data. Heterogeneity among studies was detected using the I^2 value. When heterogeneity was significant (I^2 >50%), the random-effect model was used to conduct the meta-analysis. The fixed-effect

model would be selected if the heterogeneity was not significant. Statistical significance was set as $P<0.05$.

RESULTS

Literature screening

A total of 185 articles were identified, 9 of which were potentially relevant after screening the title and abstract. After further evaluation, six studies[6, 11-15] were included finally (Table 1), and a total of 300 pilon fractures were involved. Among these patients, 124 patients were treated with staged ORIF and 176 patients treated with EFLIF.

Soft tissue infection

A total of five studies with 232 fractures were included in the meta-analysis [6, 12-15].The rate of soft tissue infection was 11.29 %(14/124) in staged ORIF group and 20.45 %(36/176) in EFLIF group. From the forest plot (Fig 1) and funnel plot, we could see that the soft tissue infection rate in staged ORIF group was significantly lower than that of EFLIF group (Z=2.82, P=0.005). And the five articles had no significant publication bias.

Osteomyelitis

A total of three studies with 162 fractures were included in the meta-analysis[6, 11,14].The rate of osteomyelitis was 6.45%(8/124) in staged ORIF group and 1.70%(3/176)in EFLIF group. From the forest plot(Fig 2), we could see that the osteomyelitis incidence rate in staged ORIF group had no significant difference with that of EFLIF group(Z=0.97, P=0.33). Because the number of included studies was too few, the publication bias was a little difficult to judge.

Nonunion

All included studies reported the nonunion[6,11-15].The rate of nonunion was 8.06%(10/124) in staged ORIF group and 3.98%(7/176)in EFLIF group. By analysis(Fig 3), it was found that the bone nonunion in staged ORIF group was different with that of EFLIF group, however, the difference was of no statistical significance(Z=0.48, P=0.63). From the funnel plot, there existed no publication bias.

Malunion

Five of these included studies with 264 fractures conducted exploration of malunion[6,11,13-15].The rate of malunion was 5.65%(7/124) in staged ORIF group and 10.80%(19/176) in EFLIF group. The malunion incidence rate had no statistical difference between staged ORIF group and EFLIF group (Z=1.86, P=0.06) (Fig 4). Also, there existed no publication bias among these literatures.

Arthrodesis

All included studies reported the arthrodesis[6,11-15].The rate of arthrodesis was 29.84%(37/124) in staged ORIF group and 28.41%(50/176) in EFLIF group. There was no significant difference about arthrodesis between staged ORIF group and EFLIF group (Z=1.46, P=0.14) (Fig 5). From the funnel plot, there existed no publication bias.

Table 1. Postoperative characteristics of included studies

Author/year	Group	Soft tissue infection	Osteomyelitis	Nonunion	Malunion	Arthrodesis	Total
Waston 2000	Staged ORIF	Invalid	2	4	1	3	25
	EFLIF	Invalid	0	2	3	4	43
Blauth 2001	Staged ORIF	1	Unknown	0	Unknown	0	8
	EFLIF	7	Unknown	0	Unknown	4	28
Koulouviris 2007	Staged ORIF	1	Unknown	0	1	1	13
	EFLIF	6	Unknown	0	7	5	42
Bacon 2008	Staged ORIF	3	5	4	2	2	25
	EFLIF	5	3	4	3	1	13
Wang 2010	Staged ORIF	3	1	1	1	12	27
	EFLIF	12	0	1	3	19	29
Davidovitch 2011	Staged ORIF	6	Unknown	1	2	19	26
	EFLIF	6	Unknown	0	3	17	21

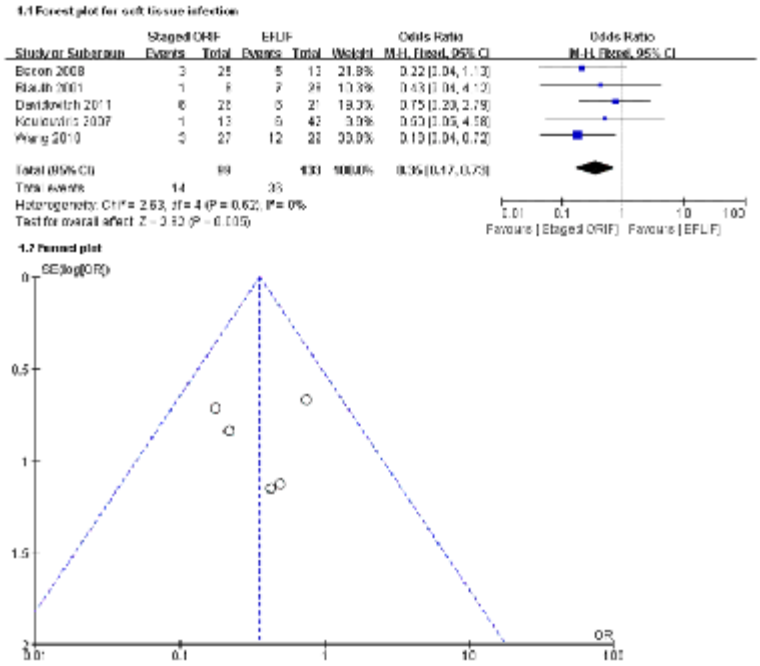

Fig. 1. Meta-analysis for soft tissue infection

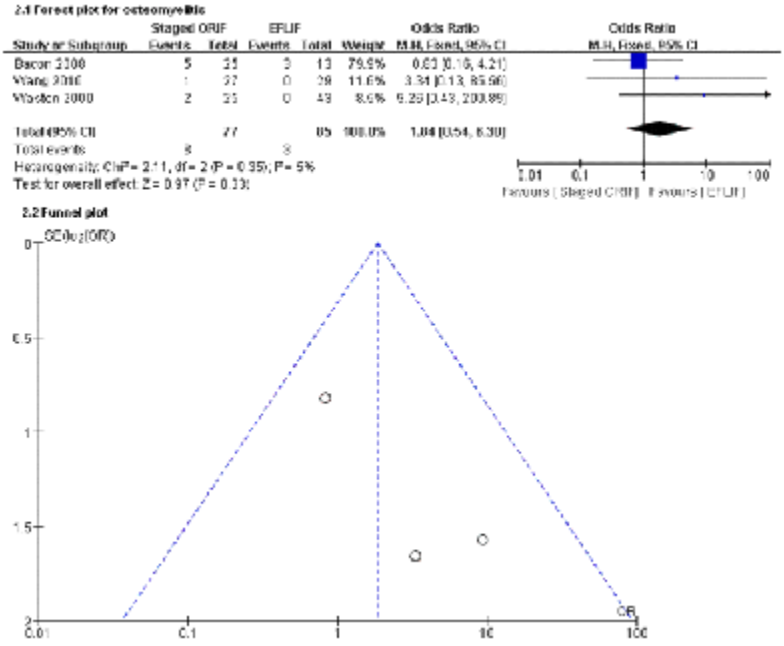

Fig. 2. Meta-analysis for osteomyelitis

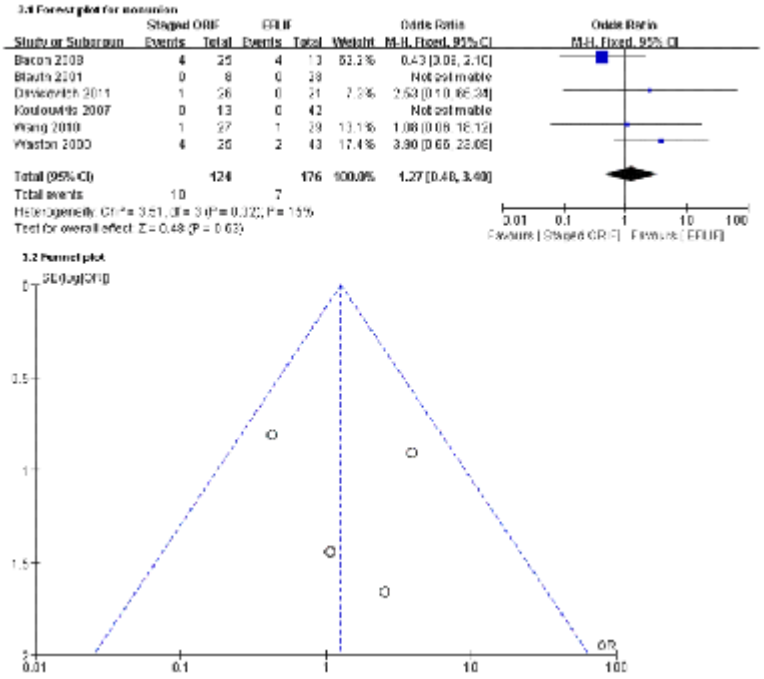

Fig. 3. Meta-analysis for nonunion

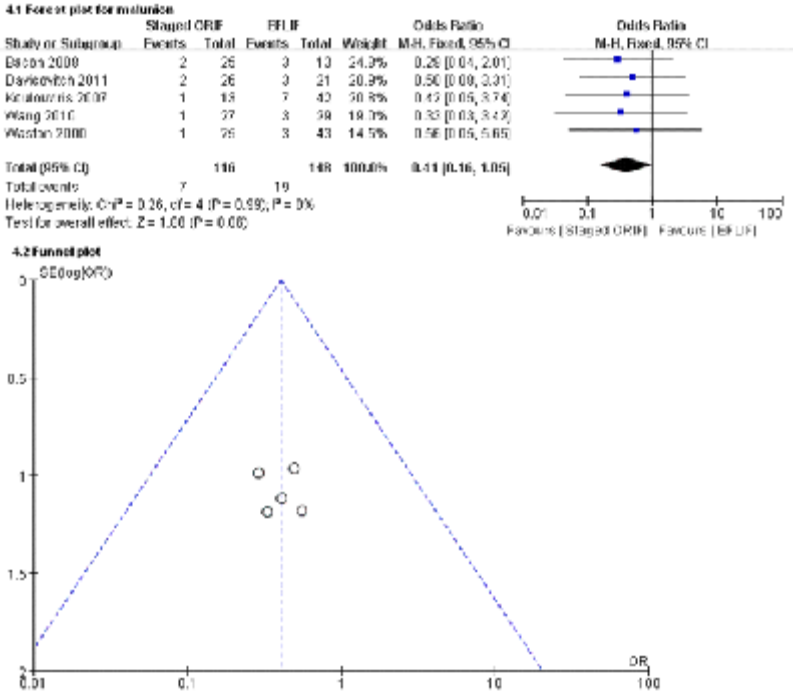

Fig. 4. Meta-analysis for malunion

DISCUSSION

So far, the selection for surgical treatment strategies and methods of tibial pilon fractures remains controversial. In clinical, no a constant procedure can be to follow and physicians have to design individualized treatment plan according to the specific condition of patient[2]. Generally, the first phase reconstruction of ankle joint lateral structure and staged ORIF are used to treat high-energy injuries of the tibia pilon fractures, which can gain balance among joint surface anatomical reduction, internal fixation and soft tissue, effectively reduce the incidence rate of postoperative soft tissue complications and traumatic arthritis , and promote fracture healing[3]. However, external fixator combined with limited internal fixation completes the articular surface immobilization and anatomical reduction through Kirscher wire fixation and screw internal fixation, which can largely improve the joint reduction effect , be conducive to limb function recovery , and enhance the stability of fracture carries counterpoint[16].

Reports about the application of staged ORIF and EFLIF are limited and have different conclusions. Golubovic *et al*[17] conducted a retrospective study of 47 patients with pilon fractures and found EFLIF technique could ensure the early treatment of the soft tissue ,significantly reduce local complications and osteomyelitis and create conditions for fracture healing. Davidovitch *et al*[15] analyzed the therapeutic outcome of 63 patients with C type pilon fractures and concluded that the occurrence rates was similar and the differences had no statistical significance in aspects of ankle joints mobility ,arthritis and ankle function score between staged ORIF group and EFLIF group. In this study, by comprehensive evaluation we found that the differences of postoperative measurements including osteomyelitis, nonunion, malunion and arthrodesis, except soft tissue infection, between staged ORIF group and EFLIF group were not significant. This was different from the viewpoint

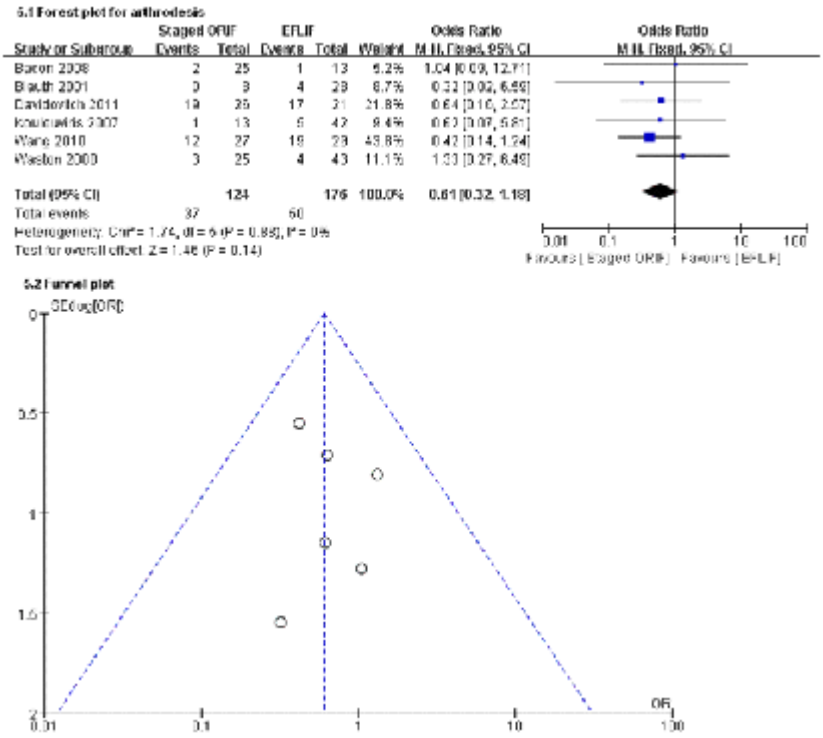

Fig. 5. Meta-analysis for arthrodesis

of Bacon *et al*[14] who thought that staged ORIF group had longer fracture healing time but lower infection rate, nonunion rate and malunion rate than those of EFLIF group. Some reports believed that though EFLIF technique was applicable to treat patients with severe comminuted fracture and poor soft tissue condition , complications in pin-track infection were most common[11,18,19]. Helfet *et al*[20] adopted two-staged treatment of 34 cases with high-energy pilon fractures and obtained good operation effect. Endres *et al*[21] compared the curative effect of EFLIF and traditional technique and found the satisfaction rate was 33.3% higher in EFLIF group than controls.

In a word, staged ORIF has better effect on protecting soft tissue, but has no more advantages than EFLIF. More factors should be taken into account comprehensively in the actual treatment. And the surgical means and surgical time should be selected flexibly. Individualized treatment solution is still be supported and encouraged and this study just provides reference for choosing the best operation method. More in-depth researches remain to be performed in this field.

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