Review Article

Treatment of displaced intraarticular calcaneal fractures with or without bone grafts: A systematic review of the literature

Yunfeng Yang, Hongmou Zhao, Jiaqian Zhou, Guangrong Yu

Abstract

Background: The necessity of bone grafts in the treatment of intraarticular calcaneal fractures continues to be one of the most debated topics in foot and ankle surgery. The purpose of this study was to determine whether there are sufficient objective cumulative data in the literature to compare the two methods and if the bone graft was needed in surgical treatment of intraarticular calcaneal fractures.
Materials and Methods: A comprehensive search of all relevant articles from 1990 to 2010 was conducted. Two reviewers evaluated each study to determine its suitability for inclusion and collected the data of interest. Meta-analytic pooling of group results across studies was performed for the two treatment methods.
Results: The systematic review identified 32 primary studies with 1281 fractures, which contained 4 comparative studies, 13 with bone grafts, and 15 without bone grafts in treatment methods. The infection rate in bone graft group was higher through statistically insignificant than in non-graft group (8.3% vs. 6.3%) No significant difference was found between good reduction rate, postoperative osteoarthritis rate, and subtalar fusion rate. The average full weight-bearing time in bone graft group was significantly lower (5.4 months) than in non-graft group (10.5 months). The mean postoperative Böhler's angle was significantly higher in bone graft group (lose due to collapse was significancy less). For the efficacy outcomes, the bone graft group had a lower American Orthopaedic Foot and Ankle Society Score (AOFAS) (71.4 points vs. 80.5 points) but a higher Creighton score (89.9 points vs. 81.0 points) compared with non-graft group. Pooled mean results showed 35% of the patients in bone graft group had an excellent result, 40% had a good result, 21% had a fair result, and 4% had a poor result. In the non-graft group, the corresponding values were 34, 42, 14, and 10%, respectively.
Conclusions: The operative treatment of intraarticular calcaneal fractures with bone grafts could restore the Böhler's angle better and the patients could return to full weight bearing earlier. However, the functional and efficacy outcomes appear to be similar between the two treatment groups. There were more joint depression and comminuted fractures in the bone graft group, and the mean followup time was shorter. Large sample comparative studies are still needed.

Key words: Bone graft, calcaneal fracture, operative treatment

Introduction

Displaced intraarticular calcaneal fractures continue to be a therapeutic challenge for orthopedic surgeons. After Lenormant first described the use of bone graft to fill the space created after open reduction of calcaneal fracture in 1928, this technique has maintained its popularity. The category choices have included autogenous and allogenous cancellous bone graft, Polymethylmethacrylate (PMMA), and bone substitutes. However, the necessity of bone grafts in the treatment of intraarticular calcaneal fracture is still controversial and there is no strong evidence supporting the functional benefits of using bone grafts. A nationwide survey in the Netherlands reported that the definite use of bone grafts in the open reduction and internal fixation (ORIF) group was 20%, a total of 42% used grafting when deemed necessary, and 38% did not use bone grafts at all.[1] Some studies consistently used bone grafts,[2-15] whereas other studies did not use bone graft at all.[16-29] Most of the studies used bone graft in selected patients only. Supporters of bone grafts believe that it could increase stimulation of fracture healing for early full weight bearing,[2,4,8,12,13,14,27,30,31] prevent posttraumatic arthritis,[8] and add mechanical strength to

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avoid significant late collapse.[2-4,7-10,12-14,32] Those opposed to bone grafts stated that the highly vascular calcaneus heals radiographically 4–8 weeks after surgery in the absence of bone graft,[17,18,20,27,33] internal fixation could adequately support the articular surface,[19,21,25,27,34] and bone graft would increase the infection rate, blood loss, and postoperative pain,[21,35,36] and also considered the inherent donor site morbidity and complications of autograft.[37-39] Proponents for each method advocated their point of view strongly, but most of the information was based on personal preference and experience. The purpose of current study was to determine whether there were sufficient objective cumulative data in the literature to compare the two methods and if the bone graft was needed in surgical treatment of intraarticular calcaneal fractures.

We performed a systematic review of the literature addressing the outcomes of intraarticular calcaneal fractures treated by ORIF, with bone grafts and without bone grafts. In the current study, we compared the infection rate, full weight-bearing time, reduction of posterior facet, subtalar fusion rate, reduction of Böhler's angle, and the efficacy outcomes.

Materials and Methods

Study selection

Standard systematic review methods were used. A prospective protocol was written to describe the objectives, search criteria, study selection criteria, data elements of interest, and plans for analysis (See the Appendix). The search of the English language literature spanning 20 years, from January 1990 to December 2010, was conducted. MEDLINE was searched through PubMed with the use of the following search strategies: (calcaneal or calcanea or calcaneum or calcaneus or os calcis or heel bone) in (title) and (fracture or fractures) in (title/abstract). The titles and abstracts were reviewed and the articles of interest were selected for the full text. Other databases like EMBASE and Cochrane database, and the main journals of orthopedics were reviewed through the websites. A manual reference check of all accepted papers and recent reviews was performed to supplement the electronic searches and to identify any additional potentially relevant studies. For the study of interest without information on whether bone graft was used, we contacted the author to confirm it.[24]

For a study to satisfy the criteria for inclusion, the following criteria were considered: (1) the authors should have reported on ORIF of intraarticular calcaneal fractures in adult patients (defined as those of at least 18 years of age), (2) studies with or without bone grafts for all cases or a comparative study, (3) presence of at least 10 patients in the treatment group, and (4) studies with a mean followup time at least of 1 year. The exclusion criteria consisted of the following: (1) studies in which all patients had been treated with only closed or percutaneous reduction, (2) studies that focused on diabetic or osteoporosis or kids or old age populations, and (3) studies in which the patients with and without bone grafts were mixed together. There were two reviewers who had to agree on all accepted and rejected studies. All study designs were eligible, including randomized controlled trials, prospective and retrospective nonrandomized controlled trials, and case series. Multiple publications on the same patient population were pooled as one study (kinship) to the extent possible to avoid double counting of patients. Protocol defined data elements from each eligible study were extracted and confirmed by two researchers. Differences were resolved prior to data entry.

Data sampling

From the studies that were included, the patient characteristics, mean followup time, fracture classification information based on Sanders and/or Essex-Lopresti methods, full weight-bearing time, patient reported outcome scores, infection, posterior facet incongruity and subtalar arthrodesis, and mean Böhler's angle postoperatively and more than 1 year after surgery were recorded. The full weight-bearing information in the study with a definite time was recorded. Infection was defined as superficial and deep infection and osteomyelitis confirmed by using clinical criteria. Superficial and/or deep infection and/or osteomyelitis that developed in the same patient was calculated as one, and infections at a wire insertion site or following open fractures were excluded. Posterior facet incongruity was recorded according to the method used by Paley;[40] grade 2 and grade 3 were defined as postoperative osteoarthritis. The reduction of posterior facet was categorized as good (step <2 mm) and poor (step >2 mm) to include more available data. The overall patient outcomes were summarized using four categories: excellent, good, fair, and poor. The definitions of these four categories were for the most part uniform across studies. The American Orthopaedic Foot and Ankle Society Score (AOFAS) Ankle-Hindfoot Scale (with excellent defined as 90–100 points, good as 75–89 points, fair as 50–74 points, and poor as <50 points) and Creighton-Nebraska Assessment Sheet (with excellent defined as 90–100 points, good as 80–89 points, fair as 65–79 points, and poor as <65 points) were the most commonly used rating system in the studies of calcaneal fractures.[3,5,7,10,11,15,16,18,20,21,24,26,28,41,42] The authors of some studies used different categorizations of overall patient outcomes (e.g. good to excellent results); therefore, in order to include these studies in the analysis, outcomes were combined into two wider categories: good (including

both excellent and good results) and poor (including both fair and poor results).

Statistical methods

All studies included were divided into bone graft group and non-graft group. The patient and classification characteristics in the two groups were tabulated. Data were shown as percentages, as the median and the range, or as the mean and the 95% confidence interval (CI). The number of patients enrolled was used as a denominator in the analysis of patient characteristics and full weight-bearing time. The number of fractures evaluated was used as the denominator in the analyses of classification characteristics and all other outcomes. Data were summarized in two ways. First, raw means and counts were weighted by sample size and calculated for all outcomes. Second, selected efficacy outcomes synthesized random effects meta-analytic pooling group results across studies.[43,44] Group parameters were compared using one-way analysis of variance for parametric data and nonparametric statistics for nonparametric data. A *P* value of less than 0.05 was considered to be significant, using a two-tailed test. All statistical analyses were carried out using SAS 9.1.3 (SAS Institute Inc., Cary, NC, USA) and STATA 7.0 (StataCorp LP, College Station, TX, USA).

Results

Studies and patients

The initial search yielded 506 citations. After screening titles and abstracts, 389 studies were excluded due to non-relative to the topic of current study, and 84 studies were excluded as they were case reports or followup time was less than 1 year or did not use open reduction methods, or were mixed reports. Thirty three full publications met all the eligibility criteria for inclusion into the database;[2-29,41,42,45-47] one of these was identified as kinship study.[46] The final database included 32 primary studies with 1281 fractures [Table 1]. The primary studies contained 4 (12.5%) comparative studies, 13 (40.6%) studies with bone graft, and 15 (46.9%) studies without bone graft. The characteristics of the accepted studies are further detailed in Table 1. The average age in the bone graft group was 42.0 (range, 18–74) years and in the non-graft group was 41.6 (range, 18–75) years. Gender proportions in the two groups were considered to be similar (P=0.49). The average followup time in bone graft group was shorter (median, 30.3 months; range, 4–188 months) than in non-graft group (median, 36.8 months; range, 6–180 months) (P<0.01). In those in which the classification information was reported according to Sanders and Essex-Lopresti methods, there were more type – III fractures (P<0.01) and joint depression type fractures (P=0.03) in the bone graft group [Table 2].

Functional outcomes and complications

The reporting of outcomes was highly variable in both groups of studies; therefore, the analyses performed in the present study were limited. The mean full weight-bearing time in bone graft group was significantly lower (median, 5.4 months; range, 3–9.1 months) compared with the non-graft group (median, 10.5 months; range, 8–12 months). No significant difference was found between the two groups on comparing the good reduction rate and postoperative osteoarthritis rate [Table 3]. The postoperative subtalar fusion rate was 3.9% (95% CI: 1.6–6.2%) in non-graft group and 1.4% (95% CI: 0–2.9%) in bone graft group; no significant difference was found. The infection rate in bone graft group was higher (mean, 8.3%; 95% CI, 2.4–14.1%) compared with non-graft group (mean, 6.3%; 95% CI, 2.1–10.6%), but no statistical significant difference was found. In those in which the reduction of Böhler's angle was reported,[3,7-9,12,19,22-24,26-28,47] the postoperative and more than 1 year Böhler's angles were significantly higher in the bone due to graft groups [Table 4] and the loss collapse after 1 year or more was significantly lower in the bone graft group (mean, 3.7°; 95% CI, 0.9°–6.4°) compared with the non-graft group (mean, 5.9°; 95% CI, 1.0°–10.9°).

Regarding the efficacy outcomes, the mean AOFAS score was significantly lower (mean, 71.4 points; 95% CI, 65.8–76.9 points) in the bone graft group than in non-graft group (mean, 80.5 points; 95% CI, 72.3–88.8 points) (P<0.01); however, the mean Creighton score was significantly higher in the bone graft group (mean, 89.8 points; 95% CI, 83.4–96.4 points) compared with non-graft group (mean, 81.0 points; 95% CI, 79.5–82.6 points) (P<0.01). With the numbers available (less than 60) for other scales, no significant difference could be detected.

In the studies of bone graft group in which excellent, good, fair, and poor categories were used as overall outcome measures [Table 5], the result was excellent in 35% of the patients, good in 40%, fair in 21%, and poor in 4% of the patients. In the non-graft group, the outcomes were excellent in 34%, good in 42%, fair in 14%, and poor in 10% of the patients. No significant difference was found on comparing the four categories of outcome (P>0.05). The pooling of this binary outcome showed that in the studies of bone graft group, 74% of the patients had a good result and 26% had a poor result. In the non-graft group, 76% had a good result and 24% had a poor result. Also, no significant difference was found in comparing the two categories of outcome (P>0.05).

Discussion

The operative treatment of intraarticular calcaneal fractures

Table 1: Demographic data of included studies

Study	Year	Graft	C/F/M	Age (years)	FU (months)	ST	CS	Scale
Johal[9]	2009	Bone cement	23/24/19	39.5	31	ORIF	S	SF-36/VAS
		No	24/28/22	33.6	31			
Bibbo[43]	2006	Bone cement	33/33/23	42.2	23	ORIF	S	NR
		No	11/11/NR	44.6	23			
Kennedy[45]	2003	Allograft	12/12/9	37	48	ORIF	S/E	SF-36/AOFAS
		No	10/10/7	39	48			
Longino[46]	2001	Autograft	20/20/19	40.8	29	ORIF	S/E	SF-36/VAS
		No	20/20/19	41.2	29			
Di Schino[3]	2008	Autograft	16/18/9	35	23	ORIF	S	AOFAS
Jiang[8]	2008	Bone cement	74/74/42	46	15	ORIF	S	Maryland
Huber[7]	2006	Bone cement	21/24/13	44.3	12	ORIF	S	Creighton
Hatzokos[6]	2006	Bone cement	17/22/13	46.2	33	ORIF	E	Paley
Elsner[4]	2005	Bone cement	18/19/13	47	23	ORIF	S	Zwipp
Thordarson[14]	2005	Bone cement	15/15/13	34	13	ORIF	S	NR
Talarico[13]	2004	Bone cement	23/25/19	43.8	24	OREF	S	Maryland
Westphal[15]	2004	Autograft	71/71/64	42	30	ORIF	S	AOFAS/Maryland/SF-36
Kinner[10]	2002	Autograft	20/20/18	53	24	ORIF	S/E	Maryland/Creighton/VAS
Schildhauer[12]	2000	Bone cement	32/36/32	42	21	ORIF	NR	Kerr
Fortina[5]	1998	Bone cement	30/35/NR	46	99	ORIF	AO	Creighton
Chan[2]	1995	Autograft	31/31/28	34	44	ORIF	E	NR
Leung[11]	1993	Autograft	44/44/41	36.3	35	ORIF	E	Creighton
Makki[24]	2010	No	45/47/34	46.4	120	ORIF	S	AOFAS/Kerr/Creighton/SF-36
Grala[20]	2009	No	42/42/34	46	12	ORIF	S	Creighton
Weber[47]	2008	No	50/50/NR	41.3	28	ORIF	S	AOFAS
Kurozumi [22]	2003	No	67/67/58	50.4	20	ORIF	S/E	Laasonen
Huang[21]	2002	No	30/32/23	34	36	ORIF	S	Creighton
Thornes[29]	2002	No	33/33/NR	46.1	43	ORIF	S	Kerr
Geel[19]	2001	No	29/33/22	41	52	ORIF	S	Thordarson
Ebraheim[18]	2000	No	99/106/75	42	29	ORIF	S	AOFAS
Burdeaux[16]	1997	No	53/61/36	49.5	53	ORIF	E	AOFAS
Song[26]	1997	No	25/29/17	41	37	ORIF	S	Creighton
Laughlin[23]	1996	No	31/32/27	36	21	ORIF	S	Maryland
Thordarson[28]	1996	No	15/15/12	35	17	ORIF	S/E	AOFAS
Sanders[25]	1993	No	120/NR	NR	29	ORIF	S	Maryland
Stephenson[27]	1993	No	22/22/20	40	37	ORIF	NR	Other*

C - Cases, F - Fractures, M - Males, FU - Followup, ST - Surgical techniques, ORIF - Open reduction and internal fixation, OREF - Open reduction and external fixation, CS - Classification systems, S - Sanders classification, E - Essex-lopresti classification, AO - AO classification, NR - Not reported, SF-36 - SF-36 Health questionnaire, VAS - Visual analog scale, AOFAS - American orthopaedic foot and ankle society score, *A self-designed outcome scale

Table 2: Study and patient characteristics of two groups

	With bone graft			Without bone graft		
	Study no.	Patient no.	Fracture no. (%)	Study no.	Patient no.	Fracture no. (%)
Total	17	500	523	18	726	758
Male/patients	17	435/543*	-	14	406/518*	-
Mean age (years)	17	42.0	-	17	41.6**	-
Followup (months)	17	30.3	-	18	36.8	-
Sanders classification	12	346	355	16	651	675
II	-	-	162 (45.6)	-	-	404 (59.8)
III	-	-	156 (43.9)	-	-	218 (32.3)
IV	-	-	37 (10.5)	-	-	53 (7.9)
Essex-Lopresti	7	174	184	5	165	173
Tongue	-	-	49 (26.6)	-	-	65 (37.6)
Joint dep.	-	-	135 (73.4)	-	-	108 (62.4)

No - Number, joint dep - Joint depression, *Gender information of excluded patients in two studies were also calculated, and four studies had no gender information, **One study had no age information

with or without bone grafts is still a topic of debate. Some surgeons always use bone grafts and other surgeons do not use them at all. The objective of this study was to compare the outcomes and complication rates of the studies which

Table 3: Functional outcomes and complications of two groups

	FWB time (months)/Pa.	Good re./ frac.	OA/Pa.	Fusion/ frac.	Infection/ frac.
Graft	5.4/219	87/91	50/173	6/400	31/523
Non-graft	10.5/459	369/414	80/216	32/654	32/758
P value	0.000	0.437	0.297	0.061	0.575

Frac - Fractures, FWB time, Pooled mean full weight-bearing time (months), Pa - Patients, OA, grade 2 and 3 osteoarthritis defined by Paley, good re - Reduction of posterior facet less than 2 mm

Table 4: Mean Böhler's angle of two groups

	Post-op. BA (in degree)/frac.	≥1 year BA (in degree)/frac.	BA loss (in degree)/frac.
Graft	28.4/239	25.1/224	3.7/134
Non-graft	27.1/270	24.0/111	5.9/89
P value	0.000	0.001	0.000

Post-op - Postoperative, BA - Böhler's angle, Frac - Fractures

Table 5: Efficacy outcomes: Overall postoperative outcome based on patient assessment

	With bone graft				Without bone graft			
	Study no.	PNO/TPN	% of Pa.	Mean (95% CI) (%)	Study no.	PNO/TPN	% of Pa.	Mean (95% CI) (%)
Overall outcome								
Excellent	10	132/351	37.6	34.4 (23.1–45.6)	12	215/625	34.4	34.1 (27.7–40.5)
Good	10	142/351	40.5	40.3 (28.4–52.1)	12	256/625	41.0	41.5 (33.3–49.7)
Fair	10	68/351	19.4	21.2 (10.8–31.6)	12	75/625	12.0	14.0 (8.9–19.1)
Poor	10	9/351	2.5	4.1 (0.0–9.9)	12	79/625	12.6	10.4 (5.2–15.5)
Overall outcome binary								
Good*	11	299/387	77.3	74.2 (61.5–86.8)	13	488/647	75.4	75.7 (70.0–81.5)
Poor*	11	88/387	22.7	25.8 (13.2–38.5)	13	159/647	24.6	24.3 (18.5–30.0)

*Good included excellent and good results, poor included fair and poor results, Pa. - Patient, No - Number, PNO - Patient number with outcome, TPN - Total patient number, No significant difference was found on comparing the overall outcome and overall outcome binary

always used bone grafts and the studies which did not use bone grafts at all, and to find out if there were differences between the final outcomes. The systematic review of comparing the two methods in treatment of intraarticular calcaneal fractures has not been reported to the best of our knowledge. In order to compare the functional outcomes, we chose the full weight-bearing time, good reduction rate, postoperative osteoarthritis rate, and subtalar fusion rate as the evaluation indicators. This systematic review showed that the patients treated with bone grafts could go back to full weight bearing earlier. However, no significant difference was reached for other indicators. Many studies had reported higher infection rate in the treatment of intraarticular calcaneal fractures with bone grafts and this was also one of the reasons for the authors to propagate no use of the bone grafts.[21,35] According to the present study, no significant difference was found between the patients with bone grafts and without bone grafts on comparing the infection rates. We observed more joint depression and comminuted fractures in the bone graft group, which might be associated with a higher infection rate. Restoration of Böhler's angle was associated with a better outcome.[3,24,40,48-50] We compared the postoperative and more than 1 year (most were the last followup time) and loss of reduction of Böhler's angle of the two groups. It was found that the mean postoperative Böhler's angles were significantly higher and the mean loss of reduction of the angle was significant lower in the bone graft group. The efficacy outcomes in the two groups showed no significant difference while comparing all the categories. For the reported scores, the patients in bone graft group reached a lower mean AOFAS score but a higher mean Creighton score.

The strengths of this study include the clear definition of the research question to reduce bias in the selection of the studies, adherence to an explicit research protocol that was developed prior to the analysis, the comprehensive literature search, consensus between the two reviewers with the entry data elements, and a quality control review of all results. However, despite the strengths of the review process, they cannot overcome the inherent weaknesses in the literature.

The primary limitation of this study was that only four comparative studies with small number of patients were found and the evaluation methods used in the four studies were not uniform. We were only able to perform a pooled meta-analysis across all studies, with many studies being devoid of key data elements. In fact, differences in patient populations and surgeons' experiences may all be partially responsible for heterogeneity among these studies. The fracture information in the two groups also had differences. In future studies, it is important to use uniform evaluation tools and select similar patient populations to make the comparisons easier.

Despite these limitations, this study provides evidence that with bone graft, the treatment of intraarticular calcaneal fractures could restore the Böhler's angle better and prevent the late collapse. Thus, for those patients with intraarticular calcaneal fractures, if the space created after open reduction is large, bone grafts might be considered as a treatment option. Also, the patients with bone grafts could return to full weight bearing earlier. However, the intermediate term efficacy outcomes were similar in the two groups, which means the intraarticular calcaneal fracture patients treated without bone grafts also could reach good functional outcomes.

Appendix

Study protocol

Treatment of displaced intraarticular calcaneal fractures with or without bone grafts: A systematic review of the literature
Hongmou Zhao, MD; Guangrong Yu, MD

Objectives

A systematic review of literature will be made to determine whether there are sufficient objective cumulative data in the literature to compare with bone grafts or without bone grafts in surgical treatment of intraarticular calcaneal fractures, and if the bone graft is needed for these patients.

Search criteria

Language: English.

Time: January 1990 to December 2010.

Design of study: All study designs are eligible, including randomized controlled trials (RTCs), prospective and retrospective nonrandomized controlled trials, and case series.

Database: PubMed, EMBASE, Cochrane.

Main journals: J Bone Joint Surg Am, J Bone Joint Surg Br, J Orthop Trauma, J Trauma.
Study selection methods: From the database results, the titles and abstracts will be reviewed and the high relative articles will be selected for the full text review. Manually check the references of all accepted papers and recent reviews (ZHM, ZJQ).

Data elements of interest

Basic information: Author, publication year, bone grafts, cases number, fracture number, male/female, mean age, followup time, classification systems.

Complications: Infection rate, pain, reduction of posterior facet, subtalar joint osteoarthritis (OA), subtalar joint fusion.

Outcomes: Pre and postoperative Böhler's angle, full weight-bearing time, outcome scales and scores.

These data elements from each eligible study will be extracted and confirmed by two researchers (ZHM, ZJQ). Differences should be resolved prior to data entry.

Inclusion and Exclusion Criteria

Inclusion criteria

1. ORIF of intraarticular calcaneal fractures in adult patients (defined as those of age at least 18 years).
2. With bone grafts or without bone grafts for all cases or a comparative study.
3. At least 10 patients in the treatment group.
4. A mean followup time at least of 1 year.

Exclusion criteria

1. All patients had been treated with only closed or percutaneous reduction.
2. Focused on diabetic or osteoporosis or kids or old age populations.
3. The patients with and without bone grafts were mixed together.
4. Multiple publications on the same patient population (kinship).

Plans for analysis

Raw means and counts will be weighted by sample size and calculated for all outcomes. Efficacy outcomes use random effects meta-analytic pooling group results. Group parameters will be compared using one-way analysis of variance for parametric data and nonparametric statistics for nonparametric data. A *P*-value less than 0.05 will be considered to be significant, using a two-tailed test.

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