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To study outcomes of calcaneus fractures treated by conservative and surgical treatment according to AOFAS scoring system

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Abstract
Introduction: The calcaneus (os calcis) is the largest and most often fractured tarsal bone. It is the major weight bearing osseous structure of the foot and is one of the components of the tri-tarsal articulation and has important functional tasks about normal ambulation. So, any fracture of calcaneus can cause subtalar arthritis and leads to walking on uneven surface extremely painful. Calcaneal fractures account for approximately 2% of all and 60% of all major tarsal fractures, 10% have associated spine fractures and 26% are associated with other extremity injuries. Historically most fractures were treated nonoperatively because open reduction and internal fixation was associated with high complication rates and did not result in significantly improved outcomes. In the last decade, operative management of calcaneal fracture is increasingly preferred over conservative management. The objective of this thesis is to get conclusion which will be useful in selecting treatment in particular case to get maximum good results and improved outcomes.
Aim: To study outcome evaluation of calcaneus fractures treated by conservative and surgical treatment according to AOFAS scoring system.
Materials and Methods: This study was conducted at our institute during the period of February 2014 to November 2015. All patients with displaced intraarticular calcaneum fracture meeting with the inclusion criteria were included in the study. All patients were treated either with conservative or surgical modality. Patients were regularly followed up at every 2 month thereafter. At each visit patients were physically examined regarding the condition of scar, any sign of infection, heel width, subtalar and ankle movement and any other possible complications. Radiological assessment was done for union and subtalar arthritis as well as Bohler and Gissane angle were also measured at each follow up. At final follow up visit patient were also asked about change in occupation and change in shoe size. At final follow up patient functional assessment was done using AOFAS score.
Results and Discussion: In our study for conservative group, excellent as well as good results were found in 31% cases. Unlike, the similar study carried out by Kulkarni *et al.* who found that 66% of cases were in category of excellent as well as good and the similar study carried out by K S leung *et al.* 60 found that 53% cases were in category of excellent as well as good. In our study for operative group, excellent as well as good results were found in 40% cases. Unlike, the similar study carried out by Kulkarni *et al.*, who found that 80% of cases were in category of excellent as well as good and the similar study carried out by K S leung *et al.* who found that 91% cases were in category of excellent as well as good. For percutaneous group, 34% of cases had score in the category of excellent as well as good which was nearly similar to study conducted by Tim scheper *et al.*
Conclusion: In the present case study of 42 patients after evaluation of functional and radiological outcomes of various modalities of treatment by AOFAS Scoring system, it was concluded that the operative management in case of joint depression type calcaneum fracture yields overall better functional outcome compared to conservative treatment. The overall complication rate was almost comparable in conservative as well as operative group. Finally, a larger study with longer follow-up is required to make definitive recommendations.

Keywords: Calcaneus fractures treated, conservative, surgical treatment according, AOFAS scoring system

Introduction
The calcaneus (os calcis) is the largest and most often fractured tarsal bone. It is the major weight bearing osseous structure of the foot and is one of the components of the tri-tarsal articulation and has important functional tasks about normal ambulation. So, any fracture of calcaneus can cause subtalar arthritis and leads to walking on uneven surface extremely painful.

Calcaneal fractures account for approximately 2% of all and 60% of all major tarsal fractures, 10% have associated spine fractures and 26% are associated with other extremity injuries [1, 2]. Fractures of the calcaneus is one injury that has not increased in frequency with the advent of mechanized industry, automobile accidents or even in war. It has been a common, often disabling injury since humans assumed the erect posture and began to defy gravity.

Ordinarily speaking the man who breaks his heel bone is 'done', so far as his industrial future is concerned.

The results of treatment of crush fractures are rotten", the best result that can be obtained from a fracture of the os calcis involving subastragaloid joint is a completely stiff, but painless foot of a good shape with free movement at the ankle joint.

Fractures of calcaneus are “serious and disabling injuries in which the end results continue to be incurably bad”. open reduction of calcaneal fractures in 1931. Despite this, forcible closed reduction with tongs and hammers or traction followed by manual manipulation and casting, were the standard treatments of his time, because of technical problems associated with surgery. During the 1950s, varied techniques were employed, but because subtalar fusion was the easiest to perform, it became the most commonly practiced treatment.

Historically most fractures were treated nonoperatively because open reduction and internal fixation was associated with high complication rates and did not result in significantly improved outcomes. With better understanding of fracture patterns and improved surgical and fixation techniques, there appears to be a renewed interest in the surgical treatment of displaced intraarticular fractures of the calcaneus. Over the last 25 years, however, marked advances in anesthesia, prophylactic antibiotics, computed tomography (CT) scanning, and fluoroscopy have allowed surgeons to improve outcomes when operating on fractures and these techniques have been applied to calcaneal fractures as well. Overall, operative treatment of acute fractures has become the standard of care with many surgeons who have critically evaluated their results and concluded that good outcomes are possible.

In the last decade, operative management of calcaneal fracture is increasingly preferred over conservative management. These operative techniques have its own advantages and disadvantages. However, despite our best efforts and advances in fracture care of calcaneus over the past 100 years, we still have room for improvement.

The assessment of results is done keeping in mind, types of fractures, types of treatment given, residual symptoms, duration of incapability and occupation before and after trauma. The last but not the least, objective of this thesis is to get conclusion which will be useful in selecting treatment in particular case to get maximum good results and improved outcomes. Despite these improvements, it is recognized that operative treatment is still set with difficulties.

Aim

To study outcome evaluation of calcaneus fractures treated by conservative and surgical treatment according to AOFAS scoring system.

Materials and Methods

The following study was conducted at our institute during the period of February 2014 to November 2015. All patients with displaced intraarticular calcaneum fracture meeting with the inclusion criteria were included in the study.

Inclusion Criteria

1. Compound fractures
2. Extraarticular fracture
3. Closed displaced intraarticular fracture of calcaneum
4. Age: 18 years and above
5) Patients with minimum 6 month follow up

Exclusion Criteria

1. Age less than 18 years
2. Pathological fractures
3. Fracture with distal neuro-vascular deficit
4. Fracture which do not satisfy the inclusion criteria

The study was approved by the Ethical and Research Committee. After finding the suitability as per inclusion and exclusion criteria, patients were selected for the study and briefed about the nature of the study, the intervention if any to be carried out and written informed consent was obtained. History were obtained through verbal communication, clinical examination both local and systemic was done. All polytrauma patients were managed initially as per emergency care protocol. Once patients were vitally stable, X-rays were done i.e. calcaneum lateral view and Harris axial view as well as X-ray foot AP and oblique view. According to X-rays, fractures were classified according to Essex-lopresti classification [3] and Bohler [4, 5] as well as crucial angle of Gissane [3, 4] were measured in all patients. If needed as per fracture type, CT scans were obtained as and when feasible economically and fracture were classified according to Sander’s CT classification. Once diagnosis was confirmed, patient was given below knee posterior splint with elevation and analgesics. The further management of fracture was decided after senior consultant’s opinion and treated accordingly.

All patients were treated either with conservative or surgical modality according to following criteria.

Indication for Surgical Treatment

1. All patients with intraarticular fracture involving posterior facet with displacement >2 mm
2. All patients who were surgically fit for surgery
3. All patients who were willing for surgery

Indication for Conservative Treatment

1. All patients who were surgically unfit for surgery because of associated medical comorbidity
2. All patients who were not willing for surgery

All patients who were selected for conservative modality of treatment were given below knee posterior splint until swelling subsided followed by below knee plaster cast with closed manipulation with both palm for the period of 6-8 weeks according to fracture type. They were called for follow up every weekly for 2 weeks followed by every 2 weekly. Rehabilitation was begun usually after 6-8 weeks of immobilization in the form of ankle and subtalar ROM and non-weight bearing exercise for the period of 3-4 months according to fracture type and sign of union on follow up X-rays. After 3-4 month, gradual weight bearing was started to full weight bearing. All patients were called for follow up for minimum 6 months and outcome was evaluated functionally using Creighton Nebraska Scoring system and radiologically by X-rays. Bohler as well as crucial angle of Gissane were measured in all patients.

Those patients who were selected for operative treatment underwent routine pre-operative investigation. After physician’s

cardiorespiratory assessment and anesthetic fitness, patients were posted for planned operative procedure.

The technique used was dependent on type of fracture, quality of bone and soft tissue, and the age and reliability and functional demands of the patients. The following different surgical modalities were used

1. Percutaneous reduction and fixation with either K-wires or CC screw.
2. Close reduction and ST pin incorporation into cast.
3. Open reduction and Plating.

Postoperative Protocol

Injectable antibiotics were given for one day followed by oral antibiotic for 5 days. Stiches were removed after 10 days and below knee cast applied if local condition permited. At 6 weeks X-rays were done after removing below knee cast. Gradual weight bearing was started after 12-16 weeks post operatively to full weight bearing in accordance with pain. Patients were regularly followed up at every 2 month thereafter.

At each visit patients were physically examined regarding the condition of scar, any sign of infection, heel width, subtalar and ankle movement and any other possible complications.

Radiological assessment was done for union and subtalar arthritis as well as Bohler and Gissane angle were also measured at each follow up. At final follow up visit patient were also asked about change in occupation and change in shoe size.

At final follow up patient functional assessment was done using AOFAS score [6].

Results and Observations

All patients meeting with the inclusion criteria and consenting for the study were included in the analysis. Most of the patients were brought to the casualty or admitted through OPD. All patients were assessed and treated according to the fracture configuration, age consideration, general condition and other related factors.

Age Incidence

Table 1: Shows age wise distribution of patients:

Age(years)	No of patients (%)
<20	1 (2%)
21-30	6 (14%)
31-40	21 (50%)
41-50	7 (17%)
51-60	7 (17%)
Total	42 (100%)

Sex Incidence

Table 2: Shows sex wise distribution of patients

Sex	No of patients (%)
Male	34 (81%)
Female	8 (19%)
Total	42 (100%)

Side distribution

Table 3: Shows side wise distribution of patients:

Side	No of patients (%)
Right	17 (40%)
Left	21 (50%)
Bilateral	4 (10%)

Occupational distribution

Table 4: Shows occupation wise distribution of patients:

Occupation	No of patients (%)
Labourer	16 (38%)
Driver	4 (10%)
Farmer	6 (14%)
Housewife	3 (7%)
Other	13 (31%)
Total	42 (100%)

Mode of injury

Table 5: Shows mode of trauma distribution:

Mode of trauma	No of patients (%)
Fall from height	40 (95%)
Domestic fall	1 (3%)
RTA	1 (2%)
Total	42 (100%)

Table 6: Shows fracture classification distribution:

Classification	No of patients (%)
Joint depression type	35 (76%)
Tongue type	11 (24%)
Total	46 (100%)

Method of treatment

Table 7: Shows method of treatment according to fracture classification

Method of treatment		Joint depression type	Tongue type
		No of patients (%)	No of patients (%)
Conservative		17 (37%0	6 (13%)
Surgical	Percutaneous	10 (22%)	5(11%)
	Open	8 (17%)	0 (0%)
Total		35 (76%)	11 (24%)

Injury surgery interval

Table 8: Shows injury surgery interval according to method of treatment:

Injury surgery interval(days)	Orif Percutaneous	
	No of patients (%)	No of patients (%)
<3	0 (0%)	10 (44%)
3 to 6	3 (13%)	3 (13%)
7 to 10	4 (17%)	2 (9%)
>10	1 (4%)	0 (0%)
Total	8 (34%)	15 (66%)

Implant used

Table 9: Shows implant used according to fracture classification:

Implant used	Joint depression type	Tongue type
	No of patients (%)	No of patients (%)
Plate and screw	8 (35%)	0 (0%)
CC screw	6 (26%)	1 (4%)
K- wire	2 (9%)	3 (13%)
ST pin	2 (9%)	1 (4%)
Total	18 (79%)	5 (21%)

Bone graft

Table 10: Shows Bone Graft used in surgical group according to fracture classification:

Bone graft	Joint depression type	Tongue type
	No of patients (%)	No of patients (%)
Yes	2 (9%)	0 (0%)
No	16 (69%)	5 (22%)

Bohler angle

Table 11: Shows Bohler angle comparison at time of injury and final follow-up in conservatively treated fracture

Bohler angle	At the time of presentation	At final follow up
	No of patients (%)	No of patients (%)
<0	2 (8%)	8 (35%)
0 to 10	13 (57%)	9 (39%)
11 to 20	6 (26%)	5 (22%)
21 to 30	2 (9%)	1 (4%)
>30	0 (0%)	0 (0%)
Total	23 (100%)	23 (100%)

Table 12: shows preoperative, postoperative and final follow up Bohler angle comparison in percutaneously treated patients:

Bohler angle	Pre-operative	Post-operative	Follow up
	No of patients (%)	No of patients (%)	No of patients (%)
<0	2 (13%)	1 (7%)	1 (7%)
0 to 10	10 (67%)	6 (40%)	9 (60%)
11 to 20	3 (20%)	4 (27%)	2 (14%)
21 to 30	0 (0%)	3 (20%)	2 (13%)
>30	0 (0%)	1 (6%)	1 (6%)
Total	15 (100%)	15 (100%)	15 (100%)

Table 13: Preoperative, postoperative and final follow up Bohler angle comparison in open reduction group

Bohler angle	Pre-operative	Post-operative	Follow up
	No of patients (%)	No of patients (%)	No of patients (%)
<0	2 (25%)	0 (0%)	0 (0%)
0 to 10	4 (50%)	3 (38%)	4 (50%)
11 to 20	2 (25%)	3 (37%)	3 (38%)
21 to 30	0 (0%)	2 (25%)	1 (12%)
>30	0 (0%)	0 (0%)	0 (0%)
Total	8 (100%)	8 (100%)	8 (100%)

Heel width

Table 14: Shows Distribution of Heel width according to method of treatment

Heel width (mm)	Conservative	Surgical
	No of patients (%)	No of patients (%)
<50	2 (9%)	0 (0%)
51-60	12 (52%)	9 (39%)
61-70	9 (39%)	12 (52%)
>70	0 (0%)	2 (9%)
Total	23 (100%)	23 (100%)

Ankle ROM

Table 15: Shows Distribution of ankle ROM according to method of treatment

		Dorsiflexion				Planter flexion			
		<100	10^0 to 200	>200 to 300	<100	100 to 20^0	200 to 30^0	30^0 to40^0	>40^0
Conservative	No of patients (%)	9 (39%)	14 (61 %)	0(0%)	0(0%)	2 (9%)	9 (39 %)	6 (26%)	6 (26%)
Operative	No of patients (%)	13 (57%)	10 43%	0 (0%)	0 (0%)	3 (13%)	11(48%)	9 (39%)	0 (0%)

Subtalar ROM

Table 16: Shows Distribution of subtalar ROM according to method of treatment and type of classification

		Conservative		Operative		
	Subtalar movement in degree	Joint depress ion type	Tongue type	Joint depression type		Tongue type
				Open reduction	Percutaneous Reduction	Percutaneous Reduction
Inversion	0 to 10	3 (18%)	1 (17%)	3 (37%)	6 (60%)	0 (0%)
	10 to 15	10 (58%)	3 (50%)	3 (37%)	2 (20%)	1 (20%)
	15 to 20	1 (6%)	1 (17%)	1 (13%)	0 (0%)	4 (80%)
	20 to 25	3 (18%)	1 (16%)	0 (0%)	2 (20%)	0 (0%)
	25 to 30	0 (0%)	0 (0%)	1 (13%)	0 (0%)	0 (0%)
Eversion	0 to 10	10 (59%)	3 (50%)	4 (50%)	8 (80%)	3 (60%)
	10 to 15	7 (41%)	2 (33%)	1 (13%)	2 (20%)	1 (20%)
	15 to 20	0 (0%)	1 (17%)	3 (37%)	0 (0%)	1 (20%)
	20 to 25	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
	25 to 30	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)

Complication

Table 17: Shows Distribution of complication according to method of treatment and type of classification

	Conservative		Operative		
	Joint depression type	Tongue type	Joint depression type		Tongue type
			Open reduction	Percutaneous Reduction	Percutaneous Reduction
Superficial					
infection	0 (0%)	0 (0%)	3 (37%)	1 (10%)	0 (0%)
Skin necrosis	0 (0%)	0 (0%)	4 (50%)	0 (0%)	0 (0%)
Peroneal tenosynovitis	8 (47%)	5 (83%)	6 (75%)	5 (50%)	1 (20%)
Subtalar arthritis	8 (47%)	2 (33%)	4 (50%)	4 (40%)	2 (40%)
Calcaneal					
Malunion	12(71%)	3 (50%)	1 (12%)	6 (60%)	3 (60%)
Peroneal					
Subluxation	1 (5%)	0 (0%)	0 (0%)	3 (30%)	0 (0%)

Creighton-Nebraska Score

Table 18: The mean AOFAS Score according to fracture type and method of treatment

Method of treatment	Classification	AOFAS score
Conservative	Joint depression type	68 ± 14.13
	Tongue type	68.5 ± 14.98
Percutaneous	Joint depression type	73.9 ± 7.87
	Tongue type	82.8 ± 6.36
Open	Joint depression type	69.37 ± 12.67

Table 19: Outcome distribution as per AOFAS Score according to fracture type and method of treatment

	Conservative		Operative		
	Joint depression type	Tongue type	Joint depression type		Tongue type
			Open reduction	Percutaneous Reduction	Percutaneous Reduction
Excellent (90 -100)	0 (0%)	0 (0%)	0 (0%)	1 (10%)	1 (20%)
Good (80-89)	5 (30%)	2 (34%)	4 (50%)	1 (10%)	2 (40%)
Fair (6579)	6 (35%)	2 (33%)	0 (0%)	7 (70%)	2 (40%)
Poor (<65)	6 (35%)	2 (33%)	4 (50%)	1 (10%)	0 (0%)
Total	17 (100%)	6 (100%)	8 (100%)	10 (100%)	5 (100%)

Discussion

The calcaneus is the largest and most often fractured tarsal bone. Calcaneal fractures account for approximately 2% of all and 60% of all major tarsal fractures, 10% have associated spine fractures and 26% are associated with other extremity injuries [1, 2].

Earlier these fractures were considered simple and were managed by immobilization and plaster cast and with various manipulative reduction technique but recent advances in understanding of anatomy, good surgical skills and better instrumentation has led to various modalities for the treatment of these fractures.

The present study was done with the following aims and objective: Study the occurrence, mechanism of injury and displacement of various types of calcaneum fracture according to Essex-lopresti classification, study different modalities of the fixations in fractures and to evaluate the outcome of calcaneum fractures treated by conservative and surgical treatment.

Age incidence

The analysis showed that out of 42 patients 50% of the patients were in the age group of 31-40 years with overall average age of 39.78 years which was nearly similar to study conducted by K S leung *et a* [7], Mohamed F *et al.* [8], Tornetta *et al.* [9].

Sex incidence

It was seen that a large majority of patients i.e. 81% were male and 19% were female which was almost similar to study conducted by Tornetta *et al.* [10] and Deniz gulabi *et al.* [11].

Side incidence

The results of the present study found that about 40% of patients had fracture on their right side, similar result was also observed by Tim scheper *et al.* [12] while about 50% of patients had fracture on their left side in present study, and the similar result was also observed by Padmanabh *et al.* [13] in their study.

In our study the percentage of patients having bilateral fracture was found to be 10% which was slightly lesser than the study conducted by Tim scheper *et al.* [12] and Deniz gulabi *et al.* [11].

Mode of trauma

The most common mode of trauma in our study was found to be fall from height, which was similar to study conducted by Mohamed F *et al.* [8], Kulkarni *et al.* [14], Tornetta *et al.* [9] and Tim scheper *et al.* [12].

Type of fracture

In present study out of total 46 fracture, 76% had joint depression type fracture while remaining 24% had tongue type fracture. In the study conducted by Mohamed F *et al.* [8] and Anirudhha *et al.* [15] majority of patients had joint depression type of fracture.

Injury surgery interval

In present study for open reduction group, mean injury surgery interval was 6.87 days with majority having interval in the range of 7-10 days. For percutaneous group mean injury surgery interval was 2.6 days with majority having interval of less than 3 days. It suggests that the cases with poor local condition and significant swelling and which are to be operated by open reduction method, should be operated only after subsidence of oedema and positive wrinkle test. The mean injury surgery interval in the study by Tim scheper *et al.* [12] for percutaneous

treatment was 5 days with the range of 0-17 days while in the study by Mohamed F *et al.* [8] for open reduction internal fixation was 4.83 days.

Bohler angle The mean bohler angle at trauma in conservative group was 7.13 which at final follow-up was 0.08 which indicates further depression of the joint fragment at final follow up. This may be due to early weight bearing, lack of immobilization for the required time due to noncompliance of patients or due to improper selection of patients for conservative management. The mean Bohler angle at trauma in operative group was 3.8 while postoperatively it was 14.82 which indicates improvement in bohler angle in this group but still it was not achieved in normal range in our study so we need improvement in our technique.

Study	Conservative			Operative	
	Pretreatment	Post treatment	Preoperative	Postoperative	Follow-up
Kulkarni *et al.* [14]	14.06	15.2	11	23.66	-
Tim scheper *et al.* [12]	-	-	-2	19	14
Present study	7.13	0.08	3.8	14.82	9.04

Complication

In the present study, the rate of peroneal tenosynovitis and subtalar arthritis was almost similar in both conservative and operative group but it was slightly higher for malunion in cases treated with conservatively compared to cases treated operatively and peroneal subluxation was found to be higher in operatively treated cases compared to conservatively treated cases.

Superficial infection in open reduction group was found in 3 out of 8 patients in our study compared to 4 out of 26 cases in study by Deniz gulabi *et a* [11].

Superficial infection in percutaneous reduction group was found in 1 out of 15 (6.66%) patients in our study compared to 9 out of 61(15%) cases in study by Tim scheper *et al.* [12]. In our study no patient had deep infection or osteomyelitis while deep infection was found in 2 out of 61 cases and osteomyelitis was found in 1 out of 61 cases in the study by Tim scheper *et al.* [12].

Results

As per the results of present study, the AOFAS Score in the category of excellent as well as good was found to be 31% for conservative group and 40% for the operative group, while in the category of fair and poor it was found to be 69% for conservative group and 60% for the operative group. This indicates comparatively better outcome for the operative group.

As per the results of present study, the AOFAS Score in the category of excellent as well as good was found to be in 30% cases of joint depression type fracture treated conservatively while it was found to be in 50% of cases of joint depression type fracture treated with open reduction and internal fixation and in 20% cases of joint depression type fracture treated percutaneously. This suggests that in joint depression type fracture, open reduction and internal fixation gives comparatively better result.

As per the results of present study, the AOFAS Score in the category of excellent as well as good was found to be in 34% cases of tongue type fracture treated conservatively while it was found to be in 60% of cases of tongue type fracture treated surgically. This suggests that in tongue type fracture, surgical treatment gives comparatively better result.

In our study for conservative group, excellent as well as good results were found in 31% cases. Unlike, the similar study carried out by Kulkarni *et al.* [14] found that 66% of cases were in category of excellent as well as good and the similar study carried out by K S leung *et al.* [7] found that 53% cases were in category of excellent as well as good.

In our study for operative group, excellent as well as good results were found in 40% cases. Unlike, the similar study carried out by Kulkarni *et al.*110 found that 80% of cases were in category of excellent as well as good and the similar study carried out by K S leung *et al.* [7] found that 91% cases were in category of excellent as well as good.

For percutaneous group, 34% of cases had score in the category of excellent as well as good which was nearly similar to study conducted by Tim scheper *et al.* [12].

Conclusion

In the present case study of 42 patients after evaluation of functional and radiological outcomes of various modalities of treatment by AOFAS Scoring system, we have arrived at the following conclusions:- The Bohler angle at final follow-up was found to be reduce more in conservatively treated group compared to operatively treated group, which suggests that internal fixation prevents further depression of articular fragment. The main aim of surgical treatment includes precise reconstruction of the articular surface and elevation of the depressed bone fragment with stable fragment internal fixation and bone grafting when required. The operative management in case of joint depression type calcaneum fracture yields overall better functional outcome compared to conservative treatment. In case of joint depression type fracture, open reduction and internal fixation yields comparatively better results than percutaneous reduction. In tongue type fracture, operative treatment yields better results than conservative treatment. The operative treatment yields better results in tongue type fracture compared to joint depression type fracture. The overall complication rate are almost comparable in conservative as well as operative group. Important complications after open reduction and internal fixation are wound complication and infection. This complication rate can be reduced by delaying for surgery till edema reduces and wrinkle sign appears. Finally, a larger study with longer follow-up is required to make definitive recommendations.

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