The Long Term Results of Internal Fixation of Displaced Intra-articular Calcaneal Fractures

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Abstract

One hundred and fourteen displaced intra-articular fractures of the calcaneus (47 tongue type and 67 joint depression type) were treated by open reduction and internal fixation with multiple H plate and were followed-up for an average of 6.75 years. All the fractures healed radiographically in 3 months. Average time for bone healing was 2.25 months for the tongue type and 2.42 months for the joint depression type ($p > 0.05$). Average post operative Bohler tuber angle was 25.05 and 22.71 degrees in the tongue type and joint depression type respectively ($p > 0.05$). All patients could return to work in 8 months. The average time for returning to work was 3.42 months in the tongue type and 4.16 months in the joint depression type ($p < 0.05$). Three calcanei (2.6%) had wound infection. There were significant differences between the two types in degree of residual pain, walking activities and range of subtalar joint movement. There were no significant differences in the ability to work, change of footwear and hind foot swelling. The end functional result was rated as excellent in sixty one (53.5%), good in twenty (17.5%), fair in fourteen (12.3%) and poor in nineteen (16.7%) calcanei. There was significant difference in the satisfactory result (excellent to fair) between the tongue type (91.5%) and joint depression type (77.6%).

Key word : Calcaneal Fracture, Intra-Articular Fracture, Internal Fixation

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Conservative treatment of displaced intra-articular calcaneal fracture has mostly had unsatisfactory results. The patients also had heel pain, subtalar joint arthritis, deformity due to bony impingement under the lateral malleolus, outward shifting of the heel and hind foot valgus.

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Palmer[1] described open reduction and elevation of the depressed fragment of the posterior articular surface and filled the cavity with bone graft. Essex-Lopresti[2] classified the intra-articular fracture of the calcaneus into tongue and joint depression types and suggested closed reduction for tongue type and open reduction for joint depression type. Mc Reynolds[3] treated fracture of the calcaneus with open reduction and internal fixation with staples, using a medial approach. Eberle[4] treated fracture of the calcaneus with open reduction and internal fixation with plate by lateral approach through which the posterior articular facet of the calcaneus could be seen and thereby got better reduction. Stephenson[5] employed a medial approach for body reduction and a lateral approach for joint reduction. Sander [6,7] described CT scan classification and used lateral approach for open reduction and internal fixation with plate. We have treated displaced intra-articular fracture of the calcaneus by open reduction and internal fixation with eleven-hole multiple H plate through a lateral approach for both tongue and joint depression types. Our early[8] and mid-term results[9] were satisfactory. The purpose of this paper was to present the long term results of a series of displaced intra-articular fracture of the calcaneus that were treated with open reduction and internal fixation and to compare the outcomes of results between tongue and joint depression types of fracture.

MATERIAL AND METHOD

One hundred and fourteen displaced intra-articular fractures of the calcaneus (in ninety eight patients) were treated at the Department of Orthopaedic Surgery, Vajira Hospital, between November 1984 and December 1996 with open reduction and internal fixation with eleven-hole multiple H plate through the lateral approach. The follow-up ranged from 2 to 12 years with an average of 6.75 years.

Operative Technique

All fractures were treated with a pre-operative compression dressing and 5 to 14 days of rest with the foot elevated. When the major swelling had subsided, patients were set for surgery. Preoperative antibiotics were administered and a tourniquet was applied. The patient was placed in a lateral decumbent position and an L-shaped lateral approach was used (Fig. 1). The soft tissues were incised, sharply in line with the skin incision, and carried down to the periosteum of the lateral wall of the calcaneus. The flap was retracted gently while subperiosteal dissection was performed along the lateral wall. The peroneal tendon sheath was stripped off the lateral wall of the calcaneus subperiosteally. The calcaneofibular ligament was identified, sharply cut off the calcaneus and retracted anteriorly. The lateral wall was reflected outward to expose the fracture fragments. After clot removal, the depressed posterior facet fragment was elevated and reduced by periosteal elevator until the smooth surface of the posterior subtalar joint was seen and was temporarily fixed with Kirschner wire. The body was reduced and temporary fixation was performed using axial directed Kirschner wires introduced from the heel into the sustentacular fragment. The lateral wall was then reduced along the outer edge of the posterior facet. An eleven-hole multiple H plate was used to maintain the body reduction and buttress the lateral wall. All Kirschner wires were removed and tourniquet was released. Closure was performed over a drain. The leg was placed in a compression dressing. The average operative time was 55 min for each calcaneus. The compression dressing was removed one week post operatively, and active range of motion of the ankle and subtalar joint was begun. The patient was kept nonweight bearing for eight weeks and full weight bearing by three months.

Statistical method

Data are presented as percentages or means (S.D.) as appropriate. Student's *t*-test was used for quantitative variable to determine the significance of differences between means and a p-value of less than 0.05 was taken as statistically significant. Chi square test and Fisher's exact test were used for univariate analysis, a p – value less than 0.05 was considered to be statistically significant.

RESULTS

One hundred and fourteen displaced intra-articular fractures of the calcaneus treated by this technique from November 1984 to December 1996 were available for evaluation. All were closed

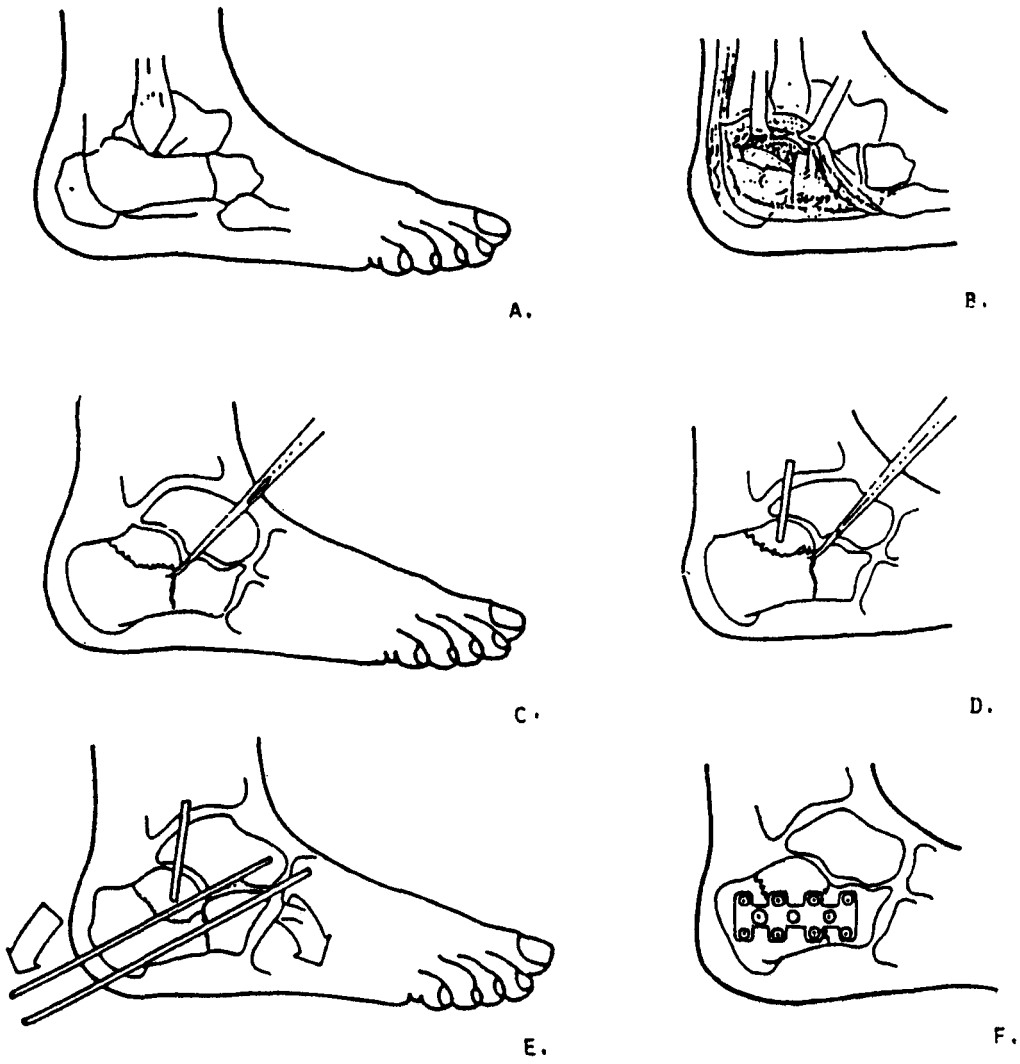

Fig. 1. Operative technique of open reduction and internal fixation

- **A. L-shaped skin incision.**
- **B. Fragments of calcaneal fracture are seen after retracting the flap of skin, peroneal tendon sheath. and calcaneofibular ligament from lateral wall of calcaneus.**
- **C. The depressed posterior articular facet fragment was elevated and reduced by periosteal elevator.**
- **D. Kirschner wire is for temporary fixation of the fragments.**
- **E. The body was reduced and temporary fixation was performed using axial directed Kirschner wires.**
- **F. An eleven-hole multiple H plate was used to maintain the body reduction and buttress the lateral wall.**

fracture. The fractures were classified as tongue type in 47 calcanei and joint depression type in 67 calcanei. The findings were as follows.

1. There was no statistically significant difference in the clinical characteristics (number, age, sex, cause, side and associated fracture)

between the two groups. (tongue type and joint depression type) (Table 1).

2. Bony union (Table 2). All calcaneal fractures healed radiographically in 3 months. Average time for bone healing was 2.34 months. Average time for bone healing for tongue and joint depression type was 2.25 months and 2.42 months respectively. There was no significant difference between the two groups ($p > 0.05$).

3. Infection rate. (Table 2). Three patients (2.63%) developed deep infections, all of which were joint depression type. The hardware was removed after two months and the wounds healed. These three patients were followed for 2, 4 and 9 years respectively. The calcanei healed completely and did not develop osteomyelitis. Thirteen patients (13.26%) had superficial skin necrosis along the incision and the wounds healed completely later.

4. The duration of absence from work (Table 3), All patients could return to work after eight months of treatment. Ten patients with joint depression type were absent from work for eight months, three of them had wound infections, four patients had bilateral calcaneal fractures and three had comminuted fragment of the posterior articular facet. Five patients were absent from work for six months, two patients had bilateral tongue type and three patients had joint depression type, two of which had bilateral calcaneal fractures. Seventeen patients were absent from work for four months. Fifty eight patients were absent from work for three months and eight patents were absent from work for 2.5 months. Average time of absence

Table 1. Characteristics of 98 patients (114 fractures) with displaced intra-articular calcaneal fractures.

Variable	No of fractures	%	Tongue type	%	Joint depression type	%	p-value
Fracture	114		47	41.23	67	58.77	> 0.05
Age (years) Mean ± (S.D.)	30.2 ± 11.25		28.6 ± 11.08		31.5 ± 11.39		> 0.05
Range (years)	17 – 62		18 – 62		17 - 57		
Sex (fractures)							
Male	90	78.95	36	76.6	54	80.6	> 0.05
Female	24	21.05	11	23.4	13	19.4	> 0.05
Cause (patients)							
Fall from a height	75	76.53	29	74.36	46	77.97	> 0.05
Motor-vehicle Accident	23	23.47	10	25.64	13	22.03	> 0.05
Side							
Left	68	59.65	26	55.32	42	62.69	> 0.05
Right	46	40.35	21	44.68	25	37.31	> 0.05
Associated fracture	34	34.69	12	30.77	22	37.29	> 0.05

Table 2. Results of the operations (Mean ± SD).

Variable	Total	Tongue type	Joint depression type	p-value
Bony union (months)	2.34 ± 0.34	2.25 ± 0.3	2.42 ± 0.37	> 0.05
Infection (patients)	3 (2.63%)	0	3 (4.48%)	> 0.05
Duration of absence from work (months)	3.8 ± 1.6	3.24 ± 0.77	4.16 ± 1.88	< 0.05
Post operative Bohler angle (degrees)	23.77 ± 7.03	25.05 ± 7.24	22.71 ± 6.48	> 0.05

Table 3. Duration of absence from work.

Absence from work (months)	Tongue type (patients)	Joint depression type (patients)
8	-	10
6	2	3
4	6	11
3	26	32
2.5	5	3
Total	39	59

from work was 3.8 months. Average time of absence from work of the tongue type was 3.24 months and joint depression type was 4.16 months which was revealed to be significant ($p < 0.05$) (Table 2).

5. Reduction of posterior articular facet of calcaneus. Radiological assessments were made from lateral and axial views of the affected calcaneus, recording the Bohler tuber angle from the lateral radiograph and its width from axial views. Most calcaneal fractures had anatomical reduction of the posterior articular facet from X-ray and CT scan except nine joint depression type fractures and two tongue type fractures which had comminuted fragment and approximate articular reduction could not be achieved. Bohler tuber angle changed from an average of 1.4 degrees pre-operative to 23.77 degrees. The average Bohler tuber angle of the unaffected side was 32.6 degrees. Average post operative Bohler tuber angle for tongue type fracture was 25.05 degrees and for joint depression type fracture 22.71 degrees (Table 2) with no significant difference between the two groups ($p > 0.05$).

6. Range of motion of the subtalar joint (Table 4). All patients had normal movement of the ankle joint. There was no valgus deformity of the hind foot. Thirty two calcanei (28%) had normal movement of the subtalar joint. Twenty two calcanei (19.3%) had the subtalar joint movement more than 60 per cent of normal. Nineteen calcanei (16.7%) had subtalar joint movement more than 40 per cent of normal. Forty one calcanei (36%) had subtalar joint movement less than 40 per cent of normal.

7. For clinical evaluation we used the scoring system of Creigton-Nebraska Health Foundation Assessment sheet for fractures of the calcaneus[10] The results of clinical evalation are shown in Table 5. There were significant differences ($p < 0.05$) between the two groups of patients in degree of pain at rest. and while walking, ability to walk and stand, and range of motion of the subtalar joint. There were no significant differences ($p > 0.05$) in ability to return to their original work, change in shoe size, and the amount of swelling in the hind part of the foot. The total functional results of this operative treatment were good (84.17 points), the tongue type had an average of 88.34 points and joint depression type had an average of 81.24 points, with no significant difference ($p > 0.05$). However, one calcaneus in the joint depression type with poor result underwent subtalar arthrodesis for persistence of pain after the fracture had healed

8. The overall clinical grading of functional results (Table 6). Ninety five calcanei (83.3%) had a satisfactory result (fair to excellent) and nineteen calcanei (16.7%) had an unsatisfactory result. When the two groups were compared, 43 calcanei (91.5%) in the tongue type group had a

Table 4. Range of motion of the subtalar joint.

Range of motion of subtalar joint	Tongue type	%	Joint depression type	%	Total	%
Normal or more than 80% of normal	20	42.55	12	17.91	32	28.07
More than 60% of normal	5	10.64	17	25.37	22	19.3
More than 40% of normal	10	21.28	9	13.43	19	16.67
Less than 40% of normal	6	12.76	21	31.34	27	23.68
No movement	6	12.76	8	11.94	14	12.28
Total	47		67		114	

Table 5. Results of the clinical evaluation by Creigton – Nebraska Health Foundation Assessment sheet for fracture of the calcaneus (Mean ± SD).

Points	Total (n = 114)	Tongue type (n = 47)	Joint depression type (n = 67)	p-value
Pain (30)	27.98 ± 3.79	29.15 ± 2.79	27.16 ± 4.16	< 0.05
Activity (20)	16.84 ± 3.76	17.55 ± 3.34	16.34 ± 4.01	< 0.05
Range of motion (20)	11.36 ± 7.02	12.23 ± 7.28	9.55 ± 6.43	< 0.05
Return to work (20)	18.86 ± 2.96	19.36 ± 2.5	18.51 ± 3.56	> 0.05
Change in shoe size (5)	4.39 ± 1.64	4.57 ± 1.39	4.25 ± 1.78	> 0.05
Swelling (5)	4.74 ± 0.68	4.83 ± 0.56	4.67 ± 1.17	> 0.05
Total (100)	84.17 ± 16.37	88.34 ± 13.52	81.24 ± 17.52	> 0.05

Table 6. The overall clinical grading of functional results.

Results (point)	Tongue type	%	Joint depression type	%	Total	%
Excellent (90-100)	28	59.6	33	49.3	61	53.5
Good (80 – 89)	9	19.1	11	16.4	20	17.5
Fair (65 – 79)	6	12.8	8	11.9	14	12.3
Poor (less than 64)	4	8.5	15	22.4	19	16.7
Total	47		67		114	

satisfactory result and 52 calcanei (77.6%) in the joint depression type group had a satisfactory result. This difference was statistically significant ($p < 0.05$).

DISCUSSION

The treatment of intra-articular fractures of the calcaneus has been controversial. Even-though the fracture line passes through the weight bearing joint, many surgeons prefer conservative treatment because of the complicated calcaneal anatomy and the comminution of the fractures. Later many authors[5,11–14] studied more about the mechanism of injury and the pathoanatomy which has led to growing interest in the surgery of calcaneal fractures. We believe that displaced intra-articular fractures of the calcaneus should be treated on the same principles as other intra-articular fractures ; that is by good anatomical reduction and stable fixation to allow early motion. All patients were operated on within 5-14 days of the fracture. We used the lateral approach of the calcaneus, so we could see and reduce the posterior articular facet of the calcaneus. Open reduction and internal fixation with multiple H plate gave stable fixation, followed by early mobilization. Plate and screws compressed fracture fragments together and supported posterior articular facet, bone graft was unnecessary. This study was started in 1984, when CT scan was not yet used to investigate calcaneal fractures. The study of calcaneal fractures by CT scan [15-17] began in 1985 and CT scan classifications were reported in 1990 by Crosby[10,18] and Sander[6,7]. We started to use CT scan for pre operative analysis in 1986 but we couldn't use CT scan in all calcaneal fractures so we couldn't classify this study by CT scan classification.

When we compared the results of treatment of the tongue and joint depression type, we found that both groups had no significant difference ($p > 0.05$) in characteristics such as sides, age, causes, number of fractures and associated

fractures. It means that the basic population of both groups was similar and thus could not have influenced the results of the treatment. Both groups had bony union in a short time, averaging 2.25 months and 2.42 months respectively which had no significant difference. ($p > 0.05$) Since we could compress the fracture fragments together and decrease the gaps between fragments, bone graft was unnecessary.

Infection rate was low, about 2.63 per cent of the total population, which is the same as the reports of Benirschke[19] and Sangeozan [20]. Infection was found in only 3 calcanei in the joint depression group and no infection was found in the tongue type group. There was no significant difference between the two groups ($p > 0.05$).

Most of the patients could return to work after 4 months of treatment. Fifteen patients (15.3%) were absent from work for 6-8 months. Average time of absence from work was 3.8 months which is less than the study of Leung [14] in which the patients who were operated on were absent from work for an average of 5.75 months. Duration of absence from work of the joint depression type was significantly longer than the tongue type ($p < 0.05$).

Measurement of the range of subtalar joint movement was by the methods described by McMaster[21]. Sixty four per cent of patients had subtalar joint movement more than 40 per cent of normal. They could work and lead a normal life as reported in other articles[5,22-24]. This is attributable to early motion of the ankle joint and subtalar joint.

At the time of the latest follow-up (average 6.75 years) we evaluated the patients using the scoring system of Creigton-Nebraska Health Foundation Assessment sheet for fractures of the calcaneus. The total functional results of both groups had on average good results and there was no significant difference ($p > 0.05$) between the two groups. Sixty one calcanei (53.5%) had excellent results, 20 calcanei (17.5%) had good results, 14 calcanei (12.3%) had fair results and 19 calcanei (16.7%) had poor results. The patients who had poor results included 3 with infected wound, 11 with comminuted fragment of the posterior articular facet. and 5 calcanei (3 joint depression type and 2 tongue type) that had good anatomical reduction of the posterior articular facet. These would be caused by cartilage necrosis of the posterior articular facet from the original injury as reported by Sander[6]. Overall the results were satisfactory (excellent to fair) in 95 calcanei (83.3%) and unsatisfactory in 19 calcanei (16.7%). On comparing the two groups, the tongue type had a satisfactory result in 43 calcanei (91.5%) and the joint depression type had a satisfactory result in 52 calcanei (77.6%). This difference was significant. ($p < 0.05$) It is difficult to compare the results with other series of these fractures that have been reported in the literature because of the lack of a universal classification scheme and evaluation system[5,6,22, 25,26]. The result of operative treatment in every report showed satisfactory results in more than 80 per cent of the cases which is comparable to this report.

SUMMARY

The purpose of open reduction and internal fixation of intra-articular fracture of the calcaneus is to restore normal anatomy and anatomic reduction of the posterior articular facet. Operative treatment of displaced intra-articular fracture of the calcaneus with multiple H plate using a lateral approach allowed early mobilization and weight bearing. Bone healing was good and bone graft was unnecessary. Patients had subtalar joint movement more than 40 per cent of normal. From average follow-up of 6.75 years, we found that this type of operation gave satisfactory results in 83.3 per cent of cases and the tongue type had a significantly better result with respect to pain, activity, range of movement and return to work ($p < 0.05$). We conclude that the tongue type of displaced intraarticular fracture of the calcaneus gives a better long term result than the joint depression type.

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ผลระยะยาวของการรักษากระดูกส้นเท้าแตกเคลื่อนผ่านผิวข้อโดยวิธีการผ่าตัดจัดกระดูกให้เข้าที่และดามด้วยโลหะแผ่น

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ได้ทำการผ่าตัดรักษาผู้ป่วยกระดูกส้นเท้าแตกเคลื่อนผ่านผิวข้อและติดตามผลระยะยาวจำนวน 98 ราย รวมกระดูกส้นเท้าแตกเคลื่อนผ่านผิวข้อ 114 ข้าง โดยวิธีการผ่าตัดจัดกระดูกให้เข้าที่และดามด้วยโลหะแผ่น multiple H plate ขนาด 11 รู ระยะเวลาติดตามผลการรักษานานเฉลี่ย 6.75 ปี พบว่ากระดูกส้นเท้าแตกเคลื่อนผ่านผิวข้อสามารถติดดีทุกรายในเวลา 3 เดือน ระยะเวลาในการติดของกระดูกส้นเท้าแตกเคลื่อนผ่านผิวข้อ ชนิด tongue และชนิด joint depression เฉลี่ยเท่ากับ 2.25 เดือน และ 2.42 เดือนตามลำดับ ($p > 0.05$) การเปลี่ยนแปลงของมุม Bohler tuber angle เฉลี่ยหลังผ่าตัดเท่ากับ 25.05 และ 22.71 องศาตามลำดับ ($p > 0.05$) ซึ่งทั้ง 2 ชนิดไม่แตกต่างกันอย่างมีนัยสำคัญทางสถิติ ผู้ป่วยทุกคนสามารถกลับไปทำงานได้หลังผ่าตัด 8 เดือน ระยะเวลาเฉลี่ยที่ผู้ป่วยกลับไปทำงานของชนิด tongue เท่ากับ 3.24 เดือนและชนิด joint depression เท่ากับ 4.16 เดือน ($p < 0.05$) ซึ่งแตกต่างอย่างมีนัยสำคัญทางสถิติ กระดูกส้นเท้าแตกเคลื่อนผ่านผิวข้อร้อยละ 2.63 มีแผลติดเชื้อโดยเป็นชนิด joint depression ทั้งหมด ผลการใช้งานเมื่อประเมินจากอาการปวด สามารถในการเดินและการเคลื่อนไหวของข้อ subtalar พบว่าทั้ง 2 ชนิดแตกต่างกันอย่างมีนัยสำคัญทางสถิติ ($p < 0.05$) แต่ความสามารถในการทำงาน การเปลี่ยนแปลงขนาดรองเท้าและอาการบวมของส้นเท้าของทั้ง 2 ชนิด ไม่มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติ ($p > 0.05$) เมื่อนำผลรวมของการรักษาทั้งหมดมาแบ่งตาม clinical grading จะได้ผลการรักษาดีมาก ร้อยละ 53.5 ดีร้อยละ 17.5 พอใช้ร้อยละ 12.3 และผลไม่ดีร้อยละ 16.7 ซึ่งกระดูกส้นเท้าแตกเคลื่อนผ่านผิวข้อชนิด tongue จะได้ผลการรักษาเป็นที่พอใจ (ดีมากถึงพอใช้) ร้อยละ 91.5 และชนิด joint depression จะได้ผลการรักษาเป็นที่พอใจร้อยละ 77.6 ($p < 0.05$) ซึ่งแตกต่างกันอย่างมีนัยสำคัญทางสถิติ

คำสำคัญ : กระดูกส้นเท้าแตก, กระดูกแตกเคลื่อนผ่านผิวข้อ, การผ่าตัดจัดกระดูกให้เข้าที่

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