Does the Addition of Computed Tomography to Computed Radiography Provide More Value to Final Outcomes and Treatment Decisions in Displaced Intra-Articular Calcaneal Fractures?

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Background: *Little is known about the additional prognostic value of computed tomography (CT) in addition to computed radiography in displaced intra-articular calcaneal fractures. The present study was undertaken to examine and compare the final radiographic outcomes and the prevalence of treatment methods of displaced intra-articular calcaneal fractures in patients with preoperative computed radiography alone vs. a combination of computed radiography and computed tomography.*

Material and Method: *Thirty-four patients with 38 displaced intra-articular calcaneal fractures were divided into two groups: a group that was evaluated with computed tomography and computed radiography (17 patients; 20 fractures) and a group that was evaluated with computed radiography alone (17 patients; 18 fractures). Patient demographics, preoperative and postoperative Bohler's angles, and fracture classifications were recorded. Postoperative outcomes were evaluated using calcaneal fracture radiographic scores (modified Zwipp score).*

Results: *The mean age of our patients in the present study was 43.3±12.3 years. The mean age of the patients in the computed tomography group (48.4±11.6 years) was significantly higher than that of the non-computed tomography group (37.6±10.7 years, p = 0.005). The mean follow-up time was 17.4±9.8 months. There was a significantly higher prevalence of open reduction and internal fixation in the computed tomography group versus the non-computed tomography group (p = 0.019). However, there was no significant difference observed for the mean radiographic scores. Postoperatively, outcomes were satisfactory in both groups, although intra-articular alignment was significantly better in the computed tomography group (p = 0.020).*

Conclusion: *The overall outcomes were comparable between the patient groups with computed tomography vs. those without computed tomography, except for the superiority of postoperative intra-articular alignment in patients with computed tomography. Open reduction and internal fixation were more frequently performed in the patients with computed tomography than patients without computed tomography.*

Keywords: *Calcaneus, Fracture, Computed tomography*

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The assessment of calcaneal fractures and the determination of treatment methods conventionally rely on three main approaches: history taking, physical examination, and the use of radiographs, taken in various projections. The standard lateral and axial views according to Harris (calcaneal axial or posterior oblique image) are well known. Lesser known are the oblique views proposed by Broden[1], and Anthonsen[2] and these have been verified as useful for visualizing the extension of the fracture lines in the posterior facet following the injury. However, in the last twenty years, almost all of these views have been substituted by the use of computed tomography (CT)[3]. Previous

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papers have promoted the benefits of using CT in calcaneal fracture cases based on an indirect comparison with the limited image quality of conventional radiography[3,4]. After CT scanning was adopted, the utilization of standard radiographic projections was questioned. One example is the need for an axial view[5]. However, in the early 1990s, Koval and Sanders claimed that, while CT scans had enhanced the management of calcaneal fractures, conventional radiography continues to have an imperative role[6].

Computed radiography (CR) was invented by Fujifilm of Japan in 1983[7]. CR refers to the digital execution, processing, presentation, and storage of radiological images. Its advantages include increased speed and efficiency, as well as improved quality of imaging as compared with conventional radiography. Because CR exposures are digital, they can be post-processed and modified, forwarded using data networks, and archived digitally[8]. By fine-tuning the image's brightness and/or contrast, a wide range of thicknesses can be inspected in a single exposure. This differs from conventional radiography, which may require a different exposure or several film speeds in one exposure to cover a wide thickness range for a component. This innovative imaging plate technology results in consistent, high-quality images[8]. Competition among CR manufacturers has raised the bar and newer CR technologies, with increased detective quantum efficiency and higher spatial resolution, have been developed, making CR a more desirable and affordable diagnostic option.

Although conventional radiography has improved in image quality in its "computerized" form, several clinicians routinely use preoperative CT for intra-articular calcaneal fractures. This is a management trend that has been influenced by previous studies from as early as 1995[3,4]. However, little is known about the additional value of CT scanning in terms of predicting radiographic outcomes and guiding treatment options as compared to the use of "CR" alone in the pre-operative evaluation of displaced intra-articular calcaneal fractures. The primary objective of the present study was to determine the radiographic outcomes as an end-result of displaced intra-articular calcaneal fractures after treatment of patients with preoperative CR or CR with CT scan. The secondary objective was to determine the prevalence of treatment methods of displaced intra-articular calcaneal fractures in patients with pre-operative computed radiography alone vs. computed radiography with an accompanying computed tomography scan.

Material and Method

Study population

During the period of August 2006 to November 2011, a retrospective evaluation was conducted on 40 patients (33 men, 7 women), aged 18 years or older, who had displaced, closed or open, intra-articular calcaneal fractures from traumatic causes, such as: falling from height, falling down stairs, traffic accidents, and low-energy causes that include simple falls. Patients were excluded if they were lost to follow-up after treatment of the fracture, presented with disorders likely to cause pathological fractures (bony metastasis, tumors, Paget's disease), and patients who had no available medical records or previous imaging to review. Of the 40 patients reviewed, four patients (2 men, 2 women) were excluded from the study as they had been lost to follow-up after surgery, and two patients (both male) were excluded as there were no available medical records. This resulted in 34 patients (29 men, 5 women) with 38 fractures in the study. The 34 patients were divided into two groups according to their having or not having preoperative CT scan records: CT group (n = 17 patients; 20 fractures) and non-CT group (n = 17 patients; 18 fractures). The medical records of each patient were reviewed to collect baseline data. This data included age, gender, history of smoking, injured side, trauma mechanism, associated injuries, treatment methods, and period of follow-up. The present study was approved by the ethical committees of our respective institutions.

Assessors

All surgical procedures were completed at our respective institutions by experienced foot and ankle or orthopedic trauma surgeons (CA, KK, IY, and non-author surgeons). Pre-operative two orthopedic physicians who were in training (AA, TH) reviewed CR and CT images (in the CT group). Interobserver reliability was assessed via Pearson's correlation analysis. The techniques used for radiographic measurement are described in the following section. In cases of differences of opinion or uncertainties in the interpretations between observers, a consensus of three experienced foot and ankle surgeons (CA, KK or IY) and one radiologist (WA: blinded to treatment allocation) was undertaken to determine the final value of the radiographic parameters in question.

Radiographic measurements and outcomes

Pre-operative CR (anteroposterior, lateral, axial, oblique, Broden, and/or Anthonsen views of the injured foot (Fig. 1), CT images (Fig. 2) (in the CT group), and pre-operative and postoperative Bohler's angles were measured in every case. Fracture classifications were recorded according to the Essex-Lopresti system[9], the Paley system[10], and the Sanders system (in the CT group)[5]. In the pre-operative phase, fracture severity was determined by the parameters of grading in each fracture classification and by the Bohler's angle. In addition to the Bohler's angle in postoperative imaging evaluations, the CR of all patients was graded according to our calcaneal fracture radiographic scoring system (CFR; Table 1). Our CFR scoring system was modified from the Zwipp radiographic score[11,12]. to decrease CR radiation over-exposure to the non-injured, contralateral calcaneus which necessitated examination by radiography to compare it with the injured calcaneus in the original version[11,12]. CFR was the scoring system used to determine the post-treatment outcomes of calcaneal fractures. The authors set the normal range of the Bohler's angle in accordance with normal ranges, as recorded in previous studies,

Fig. 1 Computed radiographs (CR) of intra-articular calcaneal fracture (left: axial view; right: lateral view).

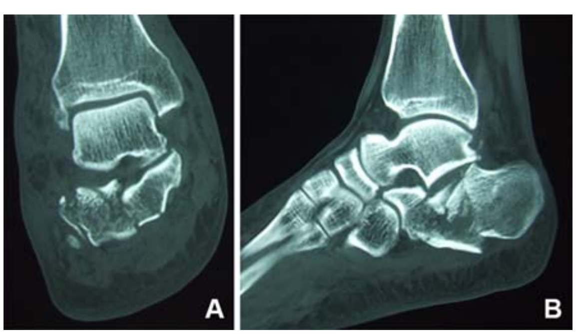

Fig. 2 Computed tomography (CT) images of intra-articular calcaneal fracture (A: semi-coronal view; B: sagittal view).

for comparison between the injured and non-injured extremities[13-15]. As a result, this CFR scoring system can be used to evaluate postoperative results in cases of bilateral calcaneal fractures and there is no need to examine the non-injured radiographically, contralateral extremity in cases of unilateral fractures. This system was also modified to grade the quality of the intra-articular reduction in the initial postoperative period, post-traumatic subtalar arthritis at the final follow-up, and the assessment of the fracture's union after treatment.

Fracture union was graded as follows: (a) abnormal (non-union, delayed union, with a union at time >3 months after treatment, or malunion, with an obvious heel widening or varus/valgus in the axial view at the final follow-up examination); (b) possible abnormal (doubtful heel widening or varus/valgus in the axial view at the final follow-up examination); or, (c) normal union[16,17]. The evaluation of subtalar arthritis at the final follow-up examination was modified from Kellgren-Lawrence's classification of osteoarthritis[18]. This classification was further classified into three groups: (a) definite arthritis (subtalar joint space narrowing, gross subchondral bone cyst-sclerosis, and osteophyte formation, Kellgren-Lawrence grade II-IV); (b) possible arthritis (uncertain subchondral bone sclerosis, and joint space narrowing, Kellgren-Lawrence grade I); and, (c) a normal calcaneus. The CFR scores were in the range of 3-12 on the scale and weighted in accordance with the Zwipp score (grading of total scores: 11-12, Excellent; 9-10, Good; 6-8, Satisfactory; <6, Poor) (Table 1). The best possible score was 12. In addition, the histories of postoperative bone mineral density tests were collected for the study population.

Statistical methods

To assess the differences between the groups, the quantitative data were analyzed using the Student's t-test (normality) or the Mann-Whitney U test (non-normality). Qualitative data were analyzed using the χ^2 test. A *p*-value <0.05 was considered statistically significant. Pearson correlation analysis was used to determine the correlation between patient age and CFR score via Pearson's correlation coefficient (r). Statistical analysis was performed using SPSS version 13.0 software program (SPSS, Chicago, IL, USA).

Results

Baseline characteristics

The relevant clinical variables for each group are summarized in Table 2. The mean age was 43.3$\pm$12.3

Table 1. Calcaneal fracture radiographic (CFR) scoring system, modified from Zwipp radiographic score

Score	0	1	2	3
Quality of reduction	-	Poor (intra-articular stepping/gap >3 mm)	Fair (intra-articular stepping/gap 2-3 mm)	Good-excellent (intra-articular stepping/ gap <2 mm)
Postoperative Bohler's angle	<0°	0-9°	10-19°	≥20°
Fracture union	-	Abnormal[a]	Possible abnormal[a]	Normal
Post-traumatic subtalar arthritis	-	Definite[b]	Possible[b]	Normal

[a]Abnormal: non-union, delayed union (union at time >3 months after treatment) or malunion (obvious heel widening or varus/ valgus in axial view); Possible abnormal: doubtful heel widening or varus/valgus in axial view. [b] Evaluation of subtalar arthritis, modified from Kellgren-Lawrence classification of osteoarthritis. Definite: subtalar joint space narrowing, gross subchondral bone cyst-sclerosis, osteophyte formation (Kellgren-Lawrence grade II-IV); Possible: doubtful subchondral bone sclerosis, joint space narrowing (Kellgren-Lawrence grade I).

Table 2. Baseline clinical characteristics

	CT Group (n = 20 fractures)[a]	Non-CT Group (n = 18 fractures)[a]	*p*-value
Age (years[b]) (%)	48.4±11.6	37.6±10.7	0.005
<45	9 (45)	14 (77.8)	0.039
≥45	11 (55)	4 (22.2)	
Sex (%)			
Male	16 (80)	17 (94.4)	0.188
Female	4 (20)	1 (5.6)	
Mean follow-up time (months[b])	15.9±10.5	19.4±8.4	0.262
History of smoking (%)			
Yes	8 (40)	7 (38.9)	0.944
No	12 (60)	11 (61.1)	
Injured side (%)			
Right	10 (50)	10 (55.6)	0.732
Left	10 (50)	8 (44.4)	
Trauma mechanism (%)			
Falling from height	13 (65)	15 (83.3)	0.223
Motorcycle accident	1 (5)	2 (11.1)	
Car accident	3 (15)	0 (0)	
Low-energy trauma	3 (15)	1 (5.6)	
Associated musculoskeletal injury[c] (%)			
None	17 (85)	15 (83.3)	0.731
Other site of foot	1 (5)	0 (0)	
Other site of lower limb (non-foot)	1 (5)	1 (5.6)	
Spine	0 (0)	1 (5.6)	
Combined injury (spine/other limb injury)	1 (5)	1 (5.6)	
Treatment methods (%)			
ORIF[d]	12 (60)	4 (22.2)	0.019
1. locking plating	9 (45)	1 (5.6)	
2. Non-locking plating	3 (15)	3 (16.7)	
Percutaneous fixation	8 (40)	14 (77.8)	
1. Screw fixation	8 (40)	4 (22.2)	
2. Pin fixation	0 (0)	10 (55.6)	

[a] Numbers and percentages are calculated for fractures rather than patients; [b] Mean ± standard deviation; [c] Associated injuries were treated by other orthopedic trauma surgeons with appropriate treatments; [d] Open reduction and internal fixation

years (range: 18-76 years). The mean follow-up time was 17.4±9.8 months (range: 2-36 months). There were no significant differences between the groups with respect to gender, smoking history, side of injury, trauma mechanism, associated injuries, and follow-up time (p>0.05). However, the mean age of the patients in the CT group (48.4±11.6 years) was significantly higher than that of the non-CT group (37.6±10.7 years, p = 0.005) (Table 2). There was a significant prevalence of open reduction and internal fixation (ORIF) in the CT group, as compared to the non-CT group (p = 0.019). Multivariate analysis confirmed that ORIF treatments (p = 0.015) and patient age ≥45 years (p = 0.027) were significantly higher in the CT group than in the non-CT group.

Radiographic data

Of the 38 fractures in the 34 patients, the mean preoperative Bohler's angle was measured at 4.5±14.3°. The fractures in each group were classified in accordance with the Essex-Lopresti system(9) and the Paley system(10), as shown in Table 3. In the CT group, there were no significant differences in the frequency of CT investigations at several different points in time (p = 0.06). Sanders system[5] classifications were: grade I: 0 (0%); IIA/IIB/IIC: 1 (2.6%), 2 (5.3%), 4 (10.5%); IIIAB/IIIAC/IIIBC: 5 (13.2%), 3 (7.9%), 2 (5.3%); IV 2 (5.3%); unclassified 1 (2.6%). Overall, there were no

Table 3. Radiographic data and satisfactory and unsatisfactory outcomes

	CT Group (n = 20 fractures)[a]	Non-CT Group (n = 18 fractures)[a]	p-value
Preoperative Bohler's angle[b]	3.5±17.7	5.7±9.6	0.652
Postoperative Bohler's angle[b, c]	23.0±10.1	24.4±7.7	0.642
Bohler's angle change (pre-and-postoperative)	20.7±16.5	18.7±11.1	0.674
Essex-Lopresti system			
- Tongue-type	12 (60%)	13 (72.2%)	0.428
- Joint depression	8 (40%)	5 (27.8%)	
Paley system-			
- A: two-part shear fracture	2 (10%)	0 (0%)	0.121
- B1: tongue-type with displacement	6 (30%)	10 (55.6%)	
- B2: tongue-type with comminution	6 (30%)	3 (16.7%)	
- C1: central depression with displacement	1 (5%)	4 (22.2%)	
- C2: central depression with comminution	3 (15%)	1 (5.6%)	
- D: extensive comminution	2 (10%)	0 (0%)	
CFR score[b, d]	10.8±1.4	10.4±1.9	0.565
Radiographic grading[e]			
- Excellent (11-12)	13 (65%)	12 (66.7%)	0.710
- Good (9-10)	5 (25%)	4 (22.2%)	
- Fair (6-8)	2 (10%)	1 (5.6%)	
- Poor (<6)	0 (0%)	1 (5.6%)	
Postoperative intra-articular alignment			
- Excellent: no gap/stepping	14 (70%)	4 (22.2%)	0.020
- Good: gap/stepping 0.1-1.9 mm	5 (25%)	8 (44.44%)	
- Fair: gap/stepping 2-3 mm	1 (5%)	5 (27.8%)	
- Poor: gap/stepping > 3 mm	0 (0%)	1 (5.6%)	
Malunion[f]	2 (10%)	1 (5.6%)	0.612
Post-traumatic subtalar arthritis			
- Definite	4 (20%)	3 (16.7%)	0.594
- Possible[g]	1 (5%)	0 (0%)	

[a] Numbers and percentages are calculated for fractures rather than for patients; [b] Mean ± standard deviation; [c] Bohler's angle was measured at final follow-up; [d] CFR: calcaneal fracture radiographic score; [e] Radiographic grading according to total scores from the CFR score; [f] Malunion (obvious heel widening or varus/valgus in the axial view); Possible abnormalities: doubtful heel widening or varus/valgus in the axial view; [g] Possible subtalar arthritis: doubtful subchondral bone sclerosis, joint space narrowing (Kellgren–Lawrence grade I)

significant differences in the mean pre-operative Bohler's angles and the prevalence of the types of fractures between the CT and non-CT groups, as measured by the Essex-Lopresti and Paley systems ($p>0.05$, Table 3).

Regarding the postoperative outcome at the last follow-up, the mean CFR score was 10.6 ± 1.6, which is graded as "good overall". The interobserver reliability of the CFR, given that Pearson's correlation coefficient (r) was 0.88 ($p = 0.001$), was the strongest correlation. The Pearson correlation analysis revealed that the CFR score did not significantly correlate with patient age (r = 0.186, $p = 0.263$). There were no significant differences in the mean postoperative Bohler's angle, degree of Bohler's angle change (pre-and-postoperative), or the CFR score between the CT and non-CT groups ($p>0.05$, Table 3.). Regarding the subcategory of radiographic outcomes, the quality of reduction was significantly better for patients in the CT group than those in the non-CT group ($p = 0.020$). However, there were no significant differences for any of the other outcomes (fracture union, subtalar arthritis, and Bohler's angle) between the two groups (Table 3). BMD tests were performed on only 2 of the patients (5.9%) out of the total study population. T-scores were -2.7; -3.6 and -1.4; -1.5 for the lumbar and hip areas in the first and second patients, respectively.

Discussion

In the present study, the authors compared the use of preoperative CR versus CR with CT on patients who had displaced intra-articular calcaneal fractures. Open reduction and internal fixation were more frequently performed in the computed tomography group, relative to the non-computed tomography group. However, the overall outcomes were comparable between the two groups, with the exception of the superiority of postoperative intra-articular alignment in the computed tomography group.

In our current practice in level-1 trauma centers at university-based hospitals, surgeons continue to favor ORIF when pre-operative data regarding fracture configuration can be determined from CT. To include several configurations of intra-articular calcaneal fractures[19,20], this data is consistent with the current trends for the promotion of ORIF for the treatment of these fractures[21]. Many surgeons are of the opinion that a better anatomical reduction leads to a superior outcome[21]. This treatment rationale has been partially confirmed by the findings in this study; most notably, where postoperative intra-articular alignment is significantly better for patients in the CT group. As earlier stated, these patients have a higher incidence of ORIF treatment than patients in the non-CT group. At this point, the present study has shown that, although the non-CT group had resulted in a lesser number of ORIF treatments, there were no significant differences between the two groups in terms of end-result and radiographic outcomes. Some of these results present as rates of post-traumatic subtalar arthritis, malunion, postoperative Bohler's angle, and total CFR scores at the final follow-up. This means that patients without pre-operative CT, and a lower chance of treatment with ORIF, may not always have poorer end-results as compared to patients with preoperative CT and a likely higher chance of the choice of ORIF treatment. This can be explained in several ways. First, the end results of the treatment of a displaced intra-articular calcaneal fracture are not solely dependent on the anatomical reduction of the subtalar joint. Irreversible destruction to the articular cartilage of the subtalar joint may occur at the time of the initial trauma[22]. Thus, post-traumatic subtalar arthritis may still develop in cases where anatomical reduction has occurred[16]. Second, although ORIF treatment is believed to produce better anatomical reduction of calcaneal fractures and the subtalar joint, several reports of non-ORIF treatment have been shown to produce favorable results in terms of subtalar joint realignment or other end-results, such as an acceptable rate of developing subtalar arthritis or other anatomical restorations when compared with ORIF treatment[21,23,24]. When combined, the addition of CT to CR may guide surgeons in performing more ORIF procedures, but this does not necessarily provide a better prognostic value of end results than with CR alone.

This relative lack of additional prognostic value, in terms of predicting the final outcome, may originate from the improvement in image quality due to the advanced technology of CR and its abilities to: post-process, modify, forward and access using data networks, and archive the images digitally[8]. The technician or interpreter is able to adjust image brightness and/or contrast. This is unlike conventional radiography, which may be limited in the scope of post-processing and image quality adjustment. This innovative imaging plate technology results in consistent, high-quality images[8]. Competition among manufacturing companies has led to the development of newer CR technologies with increased detective quantum efficiency (DQE) and higher spatial resolution. These newer CR techniques can help physicians interpret fracture imaging details, such as: intra-articular fracture lines, fragments of the fracture, fracture displacement, and soft-tissue shadows - all much better than in conventional radiographs. In addition, the cost of CR x-rays in this field, excluding the cost of interpretation by the radiologist, is about $30 USD (four projections), while a CT scan is approximately nine times the cost at $267 USD[25]. Moreover, there is rising concern about the levels of radiation exposure from CT. A combined axial and coronal CT, performed with 5 mm contiguous cuts, delivers a dose of 3.4 rad (0.034 Gy) and an axial examination, performed with 1.5 mm contiguous cuts, from which both sagittal and coronal views can be reconstructed, delivers 2.6 rad (0.026 Gy)[3]. It is evident that the five-position conventional film examination delivers the lowest radiation dose; measured to be 0.1 rad (0.001 Gy), this is 26-34 times lower than the radiation dose from CT[3]. Achieving better detective quantum efficiency with newer CR technologies can decrease the radiation doses necessary to produce quality diagnostic images and this is safer for the patient[26]. Thus, physicians may have to evaluate the benefits that can be attained from using preoperative CT, as compared to using only CR. We have shown that CT, when added to CR, does not provide added prognostic value to the end-result, as compared to the use of CR alone. It does, however, subject the patient to additional radiation exposure.

There were some limitations in the present study. The first limitation was that we primarily focused on the radiographic outcomes as the end-point results. Indeed, there was no correlation between the radiographic outcomes and the clinical results. Further studies are required to clarify the prognostic significance of the addition of preoperative CT with CR, as compared with the use of CR alone in terms of both clinical and radiographic outcome predictions. Second, our findings found that CT offered a better postoperative reduction. However, all of these procedures were performed by different surgeons and this could be simply demonstrating a difference in individual surgical expertise. Therefore, the CT value might be needed to re-validate for this conclusion. Third, based on the limitations of retrospective design, there was a significant difference in the mean ages of the patients in the two groups. The decision-making data regarding pre-operative CT and complications were inadequate and therefore unreported. In addition, the patient selection may have some limitations from the retrospective design. However, there were no significant differences in the pre-operative parameters of fracture severity, such as pre-operative Bohler's angle, Essex-Lopresti types, and Paley classification (Table 3). Fourth, the minimum follow-up times were less than 6 months in 2 patients and were too short to observe post-traumatic arthritis following the surgery. The authors realize that their findings are reported with the limitations of the retrospective study design, but we are confident that the information contained in this report may be helpful in the development of a prospective study that considers the addition of CT to CR for pre-operative evaluation of displaced intra-articular calcaneal fractures as compared to using only CR for pre-operative evaluation.

Conclusion

The overall outcomes were comparable between the patient groups with computed tomography and those without computed tomography, except for the observed superiority of postoperative intra-articular alignment in patients evaluated with computed tomography. Open reduction and internal fixation were more frequently performed in the patients with computed tomography than patients without computed tomography were.

Potential conflicts of interest

None.

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การตรวจเอกซเรย์คอมพิวเตอร์ที่เพิ่มมาจากการตรวจเอกซเรย์ทั่วไปแบบภาพดิจิตอลให้ประโยชน์ต่อการตัดสินใจและผลการรักษาในกระดูกส้นเท้าหักแบบแตกเข้าข้อหรือไม่?

ชญานิน อ่างทอง, เอกพงศ์ อธิคมชัยวงศ์, อิจิโร่ โยชิมูระ, คาซูกิ คานาซาว่า, ทศ หาญรุ่งโรจน์, วิรณา อ่างทอง, โทโมโนบุ ฮากิโยะ, อาคิโนริ ทาเคยามะ, มาซาโตชิ ไนโตะ

วัตถุประสงค์: *ข้อมูลจำกัดที่บอกถึงประโยชน์ของการตรวจเอกซเรย์คอมพิวเตอร์ที่เพิ่มมาจากการตรวจเอกซเรย์ทั่วไป แบบภาพดิจิตอลในการพยากรณ์โรคของผู้ป่วยกระดูกส้นเท้าหักแบบเข้าข้อ การศึกษานี้มีวัตถุประสงค์เปรียบเทียบผลการรักษาโดยรวมและความชุกของวิธีการรักษาระหว่างกลุ่มผู้ป่วยกระดูกส้นเท้าหักแบบเข้าข้อที่ได้รับ และไม่ได้รับการตรวจเอกซเรย์คอมพิวเตอร์เพิ่มมาจากการตรวจเอกซเรย์ทั่วไปแบบภาพดิจิตอล*

วัสดุและวิธีการ: *การวิจัยนี้ประกอบด้วยผู้ป่วย 34 รายที่มีกระดูกส้นเท้าหักแบบเข้าข้อ 38 แห่งโดยได้รับการแบ่งเป็น 2 กลุ่ม ได้แก่ กลุ่มที่ได้รับ (ผู้ป่วย 17 ราย กระดูกหัก 20 แห่ง) และไม่ได้รับการตรวจเอกซเรย์คอมพิวเตอร์ (ผู้ป่วย 17 ราย กระดูกหัก 18 แห่ง) เพิ่มมาจากการตรวจเอกซเรย์ทั่วไปแบบภาพดิจิตอล ตามลำดับข้อมูลพื้นฐานรวมทั้งข้อมูล ทางรังสีวิทยาได้รับการบันทึก จากฐานข้อมูลส่วนของผลการรักษาได้รับการประเมินโดยใช้เกณฑ์การประเมินทางรังสีวิทยาของกระดูกส้นเท้าหัก ซึ่งประยุกต์จากเกณฑ์ของ Zwipp*

ผลการศึกษา: *ผู้ป่วยมีอายุเฉลี่ย 43.3±12.3 ปี ได้ติดตามผลการรักษาของผู้ป่วยเป็นระยะเวลาเฉลี่ย 17.4±9.8 เดือน อายุเฉลี่ยของผู้ป่วยในกลุ่มที่ได้รับการตรวจเอกซเรย์คอมพิวเตอร์เพิ่มนั้น (48.4±11.6 ปี) มีมากกว่ากลุ่มผู้ป่วยที่ไม่ได้รับการตรวจเอกซเรย์คอมพิวเตอร์เพิ่มอย่างมีนัยสำคัญ (37.6±10.7 ปี, $p = 0.005$) ความชุกของการผ่าตัดยึดตรึงกระดูกแบบเปิดนั้นมีมากกว่าอย่างมีนัยสำคัญ ในกลุ่มผู้ป่วยที่ได้รับการตรวจเอกซเรย์คอมพิวเตอร์เพิ่ม ($p = 0.019$) แต่ไม่พบความแตกต่างอย่างมีนัยสำคัญในปัจจัยอื่น ๆ รวมทั้งค่าเฉลี่ยโดยรวมของคะแนนการประเมิน ทางรังสีวิทยาหลังการรักษาระหว่าง 2 กลุ่ม อย่างไรก็ตามค่าเฉลี่ยส่วนย่อยในด้านการจัดเรียงกระดูกหักที่ผิวข้อ ของกลุ่มผู้ป่วยที่ได้รับการตรวจเอกซเรย์คอมพิวเตอร์เพิ่มนั้นมีค่าสูงกว่ากลุ่มผู้ป่วยที่ไม่ได้รับการตรวจเอกซเรย์คอมพิวเตอร์เพิ่มอย่างมีนัยสำคัญ ($p = 0.020$)*

สรุป: *ผลการรักษาโดยรวมในทั้ง 2 กลุ่มไม่มีความแตกต่างอย่างมีนัยสำคัญ ยกเว้นค่าเฉลี่ยส่วนย่อย ในด้านการจัดเรียงกระดูกหักที่ผิวข้อของกลุ่มผู้ป่วยที่ได้รับการตรวจเอกซเรย์คอมพิวเตอร์เพิ่มนั้นมีค่าสูงกว่า ส่วนวิธีการรักษาพบว่าความชุกของการผ่าตัดยึดตรึงกระดูกแบบเปิดนั้นมีมากกว่าอย่างมีนัยสำคัญในกลุ่มผู้ป่วยที่ได้รับการตรวจเอกซเรย์คอมพิวเตอร์เพิ่มเติม*