



The epiphyseal scar joint line distance and age are important factors in determining the optimal screw length for medial malleoli fractures



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ABSTRACT

Aim: The screw length is important to achieve a stable fixation for medial malleoli fractures. We aimed to evaluate the optimal screw length for different age groups in surgically treated medial malleoli fractures. The second aim was to identify the utility of the distance of epiphyseal scar to joint line or joint line to medullary space for assessment of screw length.

Material method: 368 X-rays and computed tomography (CT) images of ankle joints were retrospectively evaluated for optimal screw length, epiphyseal scar to joint line distance, joint to medullary space distance. The mean screw length for each decade was calculated. The correlations of screw length with age, screw length with distance of epiphyseal scar to joint line, and screw length with distance of joint line to medullary space were evaluated.

Results: The optimal screw length was obviously decreased in patients in 61–70 and >70 years old group ($p=0.002$). As the distance of epiphyseal scar from joint line was increased, the optimal length of screw was also increased ($p=0.001$). The distance of epiphyseal scar from joint line was decreased by age ($p=0.011$).

Conclusion: The optimal screw length was decreased by age and the epiphyseal scar to joint line distance could be a clue for optimal screw length in medial malleoli fractures.

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Introduction

Bimalleolar fractures are one of most common surgically treated fractures of ankle joint. The general outcome of surgically treated bimalleolar fractures is good. AO guidelines for bimalleolar fractures recommend one or two partially threaded spongy screws for medial malleoli fixation according to the size of the distal part of fracture [1]. However, shortcomings of this fixation method are related to the lack of secure purchase within the distal tibial metaphysis. Such screws must be long enough for the threads to pass fully beyond the fracture plane, however, screws of excessive length in the distal tibia gain poor purchase in the sparse cancellous bone of the metaphysis, especially in older patients [2]. Excessive length of screw may also result in entrapment in the medulla of the tibia [3]. The epiphyseal scar of distal tibia is the most dense part of distal metaphysis of the tibia. 92.72% of females and 92.95% of males retained some remnant of the epiphyseal scar at the distal tibia [3]. The correlation between aging and the distal epiphyseal

scar is shown by Davies et al [3]. By the age, the epiphyseal scar gets smaller in width but its correlation of distance to ankle joint is unknown [3].

The non-union rate of medial malleoli fractures can be up to 7% of instable bimalleolar fractures and age is a major risk factor for these non-unions [4]. Beside age, the stability of fixation on the fracture site is also important. For a secure fixation, Parker et al. suggested purchasing of the screw threads within the radiodense epiphyseal scar [5]. They recommended to use 30 mm 4.0 AO lag screw instead of 40 mm 4.0 partially threaded lag screw. But, in general practice, it is not always possible to use 30 mm screw due to the size of the fracture fragment [5]. All threads have to pass fracture plane for secure compression of fracture sides.

By the age, the medullary space of tibia enlarges and trabecular structure of metaphysis is lost [6]. So the compression force of screws on the fracture plane decline in patients with elderly age. The optimal screw length has to be long enough to pass all threads across the fracture line, but not too long to be entrapped in the medulla of the distal tibia.

Institutional board review has been obtained prior to the study.

In this study, we aimed to put forward the optimal screw length for different ages in surgical management of medial malleoli fractures. The second aim was to identify the utility of the distance of epiphyseal scar from joint or joint to medullary space distance

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for assessment of screw length. With these evaluations, we could also make assessment about joint line–epiphyseal scar distance with age.

Material methods

Digital image archive of our hospital was retrospectively evaluated for CT scans of the ankle. Images of patients with fractures, tumours, and deformity were excluded from the study. A total consecutive CT image of 368 ankles of 368 patients included in the study between 01.01.2017 to 31.12.2017. All images were taken by same CT scanner (Philips Ingenuity Core 128 CT scanner, Amsterdam, Holland). All measurements were performed by an orthopaedic surgeon (SG) using Infinitt PACS, which is an image display and visualization programme (Guro-gu, Seoul, Korea). The measurement accuracy was 0.1 mm in linear values.

On CT images, a virtual medial malleoli fracture line was generated that mimics Lauge–Hansen supination external rotation fracture which is the most common type of bimalleolar fracture [7]. A virtual screw length from the tip of medial malleoli to the medullary space of the tibia that is vertical to fracture line was recorded in the coronal plane at the level of tip of the medial malleoli (Fig. 1). On CT images, the joint line to medullary space is evaluated on midsagittal cross sections. The medullary space reference point was accepted as the Hounsfield unit of 1 cm diameter circle that had 'zero' value on average in the medulla which represented water density in that circle. Hounsfield units, a parameter generated from standard CT, are related to the density of the structure of interest [8]. On the plane X-rays of the same patient images, also the joint line to epiphyseal scar distance is obtained at the middle of ankle joint on antero-posterior plane.

Because the optimal treatment choice for medial malleoli fracture could be different in a patient with open physis, we included patients over 16 years old to study. Patients were categorized according to their age groups as <20, 21–30, 31–40, 41–50, 51–60, 61–70, and >70. This grouping was made in order to provide optimal screw size for decades.

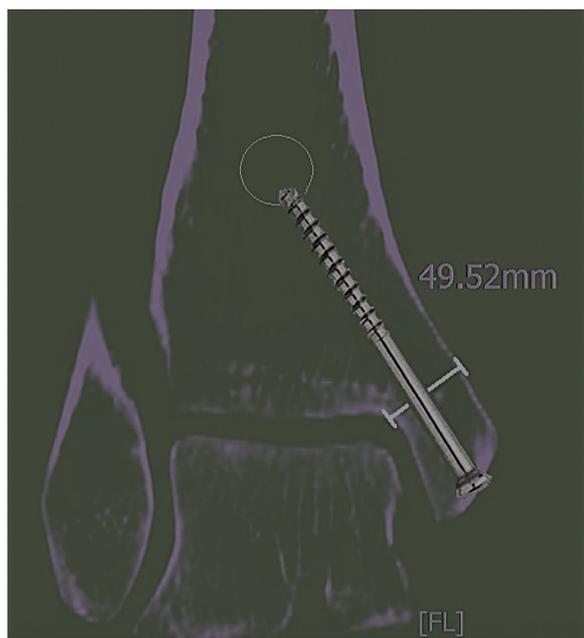


Fig. 1. The assessment of virtual screw size. The grey line at medial malleolus represent the fracture line. The circle represent the medullary space of distal tibia with zero haunsfield unit. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

Mean screw lengths for all age groups were calculated. The correlation of age groups with screw length, epiphyseal scar to joint line distance with screw length, and screw length with distance from joint line to medullary space were measured. The alteration of epiphyseal scar with age was also assessed.

Statistical analysis

The mean, standard deviation, median minimum, maximum, frequency and ratio values were used as the descriptive statistics of the data. The distribution of variables was measured using the Kolmogorov–Smirnov test. In the analysis of the quantitative data one-way ANOVA with post-hoc LSD test was used. For correlation analysis, a Pearson correlation analysis was performed. The level of significance was defined as $p < 0.05$. SPSS 20.0 software (Chicago, IL) was used for all analyses. Due to the retrospective design of the study, no power analysis was made before the study to calculate the sample size, but retrospective analysis of our results gave a %99 power when α was set to 0.05 and standard effect size was set to 1.5.

Results

231 male and 137 female patients with a total 368 CT images and plane radiographies were evaluated. The mean age was 34.02 (± 15.89) years. The mean screw length was 49.53 ± 7.59 (Table 1)

The screw length was significantly decreased as the age increased ($p = 0.002$). By post-hoc LSD test, we observed that this decrease was prominent in age groups at 61–70, and >70 (Table 2).

There was a significant correlation between screw length and epiphyseal scar to joint distance ($p = 0.001$). As the epiphyseal scar to joint distance increased, the screw length increased (Fig. 2).

There was an inverse correlation between age and epiphyseal scar to joint distance. The epiphyseal scar to joint distance decreased by age ($p = 0.011$) (Fig. 3). The screw length was correlated with joint line to medullary space distance ($p < 0.001$) (Fig. 4).

Discussion

The most important finding of our study was that there was an obvious decrease in the length of screw for patients over 60 years with surgically treated medial malleoli fractures. In a cadaver study, Parker et al. investigated the compression force in the fracture line that was fixed by either partial or full threaded 4.0 mm \times 45 mm and 4.0 \times 30 mm partially threaded screws. They found that the screws that engaged the epiphyseal scar had more compression force on fracture line than that entered the medullary region. They recommended to use 4.0 mm \times 30 mm partially threaded and 4.0 mm \times 45 mm fully threaded screws in medial malleoli fractures [5].

When the lag screw fixation was not enough for stabilization, especially in osteoporotic patients, bicortical fixation with 3.5 mm

Table 1
The mean screw length in each decades.

Age groups	n	Mean	\pm	SD
16–20	98	50.39		7.06
21–30	84	49.65		6.77
31–40	74	49.37		6.99
41–50	50	51.01		8.53
51–60	35	49.26		8.32
61–70	16	45.48		5.56
>70	11	41.58		11.11
Total	368	49.53		7.59

Table 2

The comparison of screw length between age groups. The bold p scores represents the statistical significance.

Age groups	<20	21-30	31-40	41-50	51-60	61-70	>70
<20	–	0.502	0.375	0.632	0.440	0.015	<0.001
21-30	0.502	–	0.817	0.306	0.795	0.040	0.001
31-40	0.375	0.817	–	0.230	0.940	0.058	0.001
41-50	0.632	0.306	0.230	–	0.286	0.010	<0.001
51-60	0.440	0.795	0.940	0.286	–	0.092	0.003
61-70	0.015	0.040	0.058	0.010	0.092	–	0.180
>70	<0.001	0.001	0.001	<0.001	0.003	0.180	–

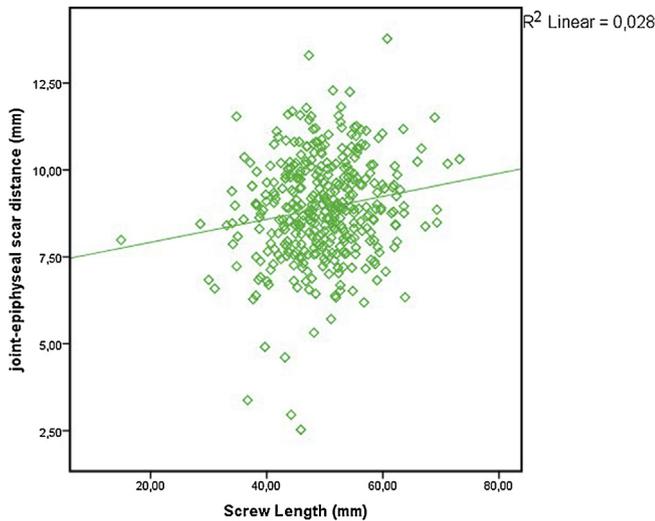


Fig. 2. The correlation of epiphyseal scar joint distance with screw length.

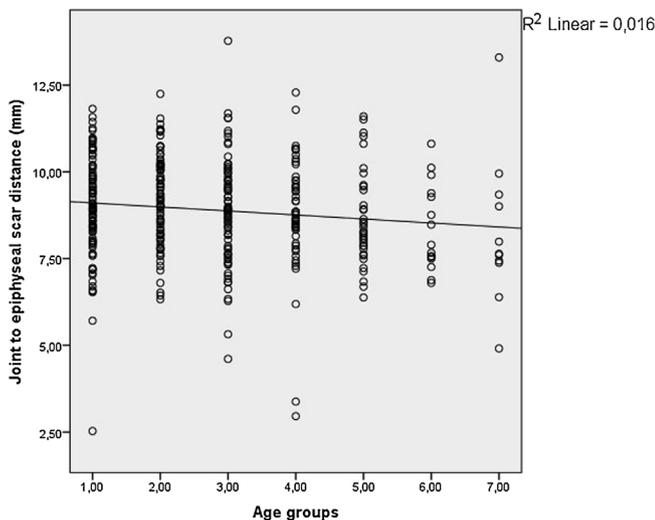


Fig. 3. The correlation between age and epiphyseal scar to joint distance. Age groups 1–7 represents >10 to >70.

fully threaded screw was recommended in biomechanical studies [9,10]. 3.5 mm bicortical screw was superior in resistance to translation and had more pull out force, but the screw length could be challenging during operation. In a medial malleoli fracture that's at the level of ankle joint line and parallel to joint line; a screw, that is vertical to fracture line like AO 44-B2 type, can be entrapped in medulla of tibia, because the direction of screw could not reach to lateral cortex of tibia, or needed screw length could be longer than screws on a standard AO 3.5 mm screw set. Although

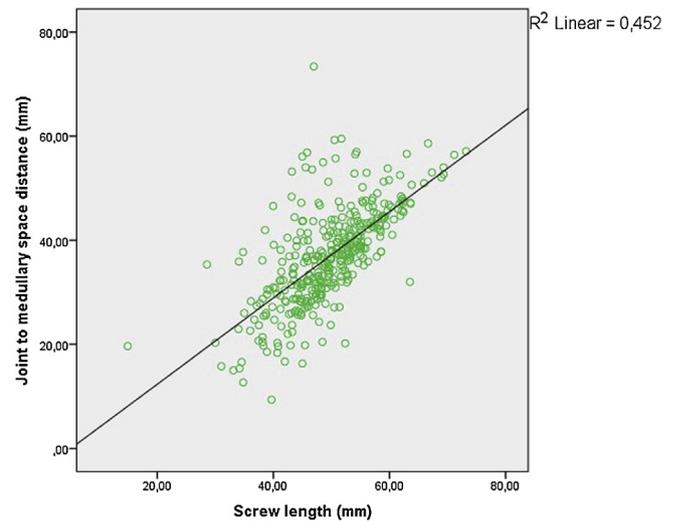


Fig. 4. The correlation between screw length and joint to medullary space distance.

the created fracture line was slightly oblique from the superior medial border of ankle joint just like AO 44-A2, which corresponded to the shortest distance from the tip of medial malleoli to lateral cortex, they had to use 75 mm screw length [9].

The second important finding of our study was the association between the distance of epiphyseal scar from joint line with screw length. This showed us that epiphyseal scar joint line distance which could be measured from a plain radiograph could give us clue about the possible screw length. In a cadaver study, Parker et al. also suggested to engage the screws into the epiphyseal scars where had most dense bone of distal tibia metaphysis [5]. Especially in patients with epiphyseal scar joint distance under 9 mm, surgeon should be more alert that longer lag screws might not increase the compression and a new strategy should be determined for smaller screws or longer bicortical screws if possible.

The fusion of epiphyseal scar of tibia can be used for age estimation between 20 to 50 years old [11]. But it is relation with distance from joint line has not been clearly demonstrated yet. We have showed that there is an inverse relation of age and joint line to epiphyseal scar distance. Although the correlation was poor, it was significantly important. A large cohort study could be designed for further investigation.

Another important finding of our study was that joint line to medullary space distance was directly related to screw length. Surgeons should be alert that if the medullary space extends to distal metaphysis, the screws used in fixation of malleoli could be entrapped in medulla and the compression force on the fracture plane could decrease.

There were limitations of our study. Firstly, this was a virtual study on CT images and plain radiographs of patients with no fracture at ankle joint. In a patient with ankle fracture it could be difficult to achieve a true mortise and lateral view. The second limitation was that all measurements were made in assessment of supination external rotation injury which is the most common fracture type, but in different fracture types, different screw sizes could be needed for secure fixation. The strong side of our study was the number of cases. As our hospital is in a metropolitan city with different nationality, we believe that the sample could represent the population.

Conclusion

The epiphyseal scar joint line distance could be a clue for optimal screw length in medial malleoli fractures. In patients over

60 years old, a longer lag screw could not be a solution for secure fixation. Shorter screws that engaged in epiphyseal scar could be more appropriate for elderly patients in medial malleoli fixation.

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