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# Relationship Between Proximal Articular Set Angle and Hallux Abducto Valgus

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A study of radiographs from 50 males and 50 females was undertaken to determine whether a relationship existed between the proximal articular set angle and the hallux abductus angle. Gender differences in the relationship were also investigated. The normal range for the proximal articular set angle was –2.6° to 8.6°, with a mean of 5°. There was no significant difference in the mean values between males and females. A positive linear correlation between the proximal articular set angle and hallux abducto valgus deformity was found ($R^2$ = 0.52), suggesting that an increased lateral tilt of the metatarsal head is one of the factors that lead to hallux abducto valgus deformity. The relationship between proximal articular set angle and hallux abducto valgus deformity was similar in males and females and did not account for the increased hallux deformity seen in females. (J Am Podiatr Med Assoc 92(6): 331-335, 2002)

The proximal articular set angle is described as "the angle formed between a line representing the effective articular surface of the first metatarsal head and a perpendicular to a line representing the bisection of the shaft of the first metatarsal" (Fig. 1).[1]

Laporta et al[1] describe the relationship between hallux abducto valgus and the proximal articular set angle, stating that in the normal adult foot the proximal articular set angle is 0° to 8° and is tilted laterally to account for the 0° to 8° adduction of the first metatarsal. The source of the normal range of angles quoted and whether the relationship between the angles has been tested are unclear from the study. Despite this, the authors describe various types of operations that address these abnormal angles when found with a hallux abducto valgus deformity. Other authors have also measured the angle in adult feet. In one study of 41 radiographs of women,[2] the proximal articular set angle ranged from 0° to 15°. Another study[3] found a mean proximal articular set angle of 6° (range, –3° to 26°) in 100 cadavers.

The reliability of the proximal articular set angle measurement has been studied frequently. The radiographic measurement of the proximal articular set angle has been found to differ in value from the intraoperative measurement,[4,5] although a significant positive correlation existed between the measurements ($r$ = 0.6, $P$ < .05).[5] A difference between the radiographic and intraoperative measurements is not surprising, as the radiograph does not show the sagittal plane deviation of the metatarsal and phalanx, and, therefore, the curve of the metatarsal seen may represent the curve across any part of the metatarsal head. For example, if the metatarsal is in a plantarflexed position, the dorsal edge of the metatarsal head will be seen in the anteroposterior radiograph. If the metatarsal is dorsiflexed, the curve across the central area or the plantar edge of the head will be seen. When measuring the curve intraoperatively, the observer can take the reading at any chosen point, which will not necessarily correspond to the same point on the radiograph. It has been found that the sagittal plane deviation does not influence the radio-

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**Figure 1.** Radiograph showing the line representing the effective articular surface and the metatarsal bisection.

graphic findings as much as the varus or valgus rotation of the metatarsal.[6] In a cadaver study,[6] it was found that the usual method of measuring radiographs was not sensitive to the rotation of the metatarsal, although the radiographic measurement had a 95% probability of being within 5° of the true measurement. When measuring intraoperatively, the observer can identify the medial and lateral borders of the bone and therefore can measure the true transverse curvature. On radiographs, the medial and lateral borders may be incorrectly identified because the rotation of the bone is difficult to assess, and the curvature measured will be different. One study[3] has reported that the typical method of measuring the proximal articular set angle produces angles that are within 5° of those produced by a method that adds metal beads to aid identification of the medial and lateral edges of the articular surface on x-rays.

The intraobserver and interobserver reproducibility of the measurements has been tested, with varying results. There seems to be difficulty in establishing which part of the joint surface represents the effective articular surface for some observers but not for others.[7] There is particular difficulty in measuring an articular surface on radiographs, because these show only bone and not articular cartilage. Vittetoe et al[6] found that differences in identifying the articular surface led to good intraobserver reliability but poor interobserver results. Conversely, another study[4] reported good interobserver measures. In one of the largest interobserver tests, 300 practitioners measured a single x-ray.[8] A wide variation in measuring capabilities was reported, but the data were not analyzed in such a way as to prove or disprove a null hypothesis; only trends in the results were considered.

Despite the considerable work undertaken to test the reliability of the measurement technique, the relationship between the proximal articular set angle and the hallux abductus angle has not been studied, to the authors' knowledge. This experiment aimed to identify whether a relationship exists between the proximal articular set angle and hallux abducto valgus deformity and to investigate gender differences in this relationship. Because the interobserver measurement of the angle seems to be suboptimal, only intraobserver data were used.

## Materials and Methods

One hundred radiographs were selected from the collection held at the London Foot Hospital in London, England. All radiographs had been taken at the Royal National Orthopaedic Hospital in London, which uses a standard procedure of placing the beam at 15° to the navicular, 100 cm from the foot. Weightbearing views from 50 males and 50 females were selected. All patients were younger than 40 years and were in good general health to reduce the likelihood of distortion of the image by arthritic changes. Each radiograph was then digitized and analyzed using OSIRIS software (University Hospital of Geneva, Geneva, Switzerland).

On the digitized image, a line was drawn from the medial to the lateral side of the articular surface of the metatarsal head, establishing the parameters of the effective articular surfaces. A second line was drawn from the medial to the lateral side of the base of the metatarsal. The center of this line was found and used to anchor a line bisection that was placed along the shaft of the metatarsal (Fig. 2). The shaft of the proximal phalanx was also bisected.

The angle between the articular surface and the metatarsal bisection line was calculated as the proximal articular set angle. The angle between the metatarsal and phalanx bisection lines was the hallux abductus angle. Each radiograph was measured five times, and the mean of the measurements was used in the analysis of results. A pilot study had been undertaken initially to test the reproducibility of the measurements and the accuracy of using the five repeated measurements.

## Results

The characteristics of the male and female subgroups are given in Table 1. The normal distribution

**Figure 2.** Digitized image of a radiograph with line bisection of the metatarsal shaft and lines across the medial and lateral edges of the articular surface of the metatarsal head, creating the proximal articular set angle (92° – 90° = 2°).

of the data was tested using a one-sample Kolmogorov-Smirnov test. Because all data were normally distributed, parametric analysis was applied.

The mean proximal articular set angle was 4.52° for males and 5.47° for females. A two-tailed *t*-test showed that there was no significant difference in the proximal articular set angle between males and females ($P = .27$). The hallux abductus angle was significantly different between the sexes, with the mean angle being 12.95° for males and 18.28° for females ($P = .001$). The mean proximal articular set angle for subjects without hallux abducto valgus (ie, with a hallux abductus angle of less than 16°) was 5° (range, –2.6° to 8.6°).

Examination of the data shown in Figure 3 suggested that a positive correlation existed between the proximal articular set angle and the hallux abductus angle. Regression analysis demonstrated a significant correlation for the 100 subjects ($R^2 = 0.52$). There seemed to be little difference in the relationship between males and females, and this was confirmed by the regression coefficients for males ($R^2 = 0.52$) and females ($R^2 = 0.55$) (Table 2). Examination of the raw data suggested a threshold for the proximal articular set angle of 7.6°. In the 27 subjects with a proximal articular set angle greater than 7.6°, only 1 had a normal hallux abductus angle. The residual line fit plot suggested that the application of a linear regression plot was suitable (Fig. 4).

The relationship between the proximal articular set angle and age was also considered. The scatterplot shown in Figure 5 suggests that no linear relationship exists. The proximal articular set angle does not seem to change with age.

## Discussion

The findings from this study agree with those from earlier studies regarding the normal range for the proximal articular set angle. Laporta et al[1] had suggested a normal range of 0° to 8°. This study found a range of –2.6° to 8.6° in subjects without hallux abducto valgus deformity. Steel et al[2] found values from 0° to 15° in their population, which closely mirrors the range of –2.6° to 19° found across the group used in this study. The wide range of –3° to 26° found in the cadaver study[3] was not found here, although the mean was similar to that in the present study (6° *versus* 5°).

It was initially hypothesized that if a correlation between the proximal articular set angle and hallux abducto valgus deformity did exist, a large hallux abductus angle may cause increased lateral forces on the metatarsal head and lead to a change in the proximal articular set angle over time. This study did not investigate progression of the angle over time, but it was found that the proximal articular set angle and patient age were not related. However, patient age

**Table 1. Characteristics of the Male and Female Subgroups**

| | | Mean (SE) and Range | | |
|---|---|---|---|---|
| | Total Number | Age (years) | Hallux Abductus Angle (°) | Proximal Articular Set Angle (°) |
| Males | 50 | 30 (1.00)<br>13 to 40 | 12.95 (1.06)<br>–3 to 28 | 4.52 (0.54)<br>–2 to 18 |
| Females | 50 | 29 (1.19)<br>12 to 40 | 18.28 (1.15)<br>4 to 40 | 5.47 (0.67)<br>–2 to 19 |

Abbreviation: SE, standard error.

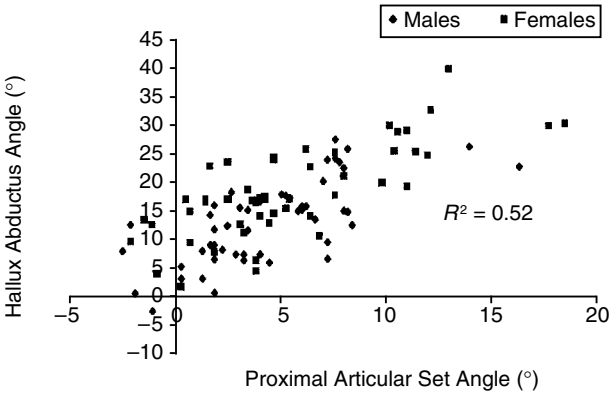


**Figure 3.** Scatterplot showing the correlation between the hallux abductus angle and the proximal articular set angle for males and females.

**Table 2. Regression Analysis Data**

| | All 100 Subjects | 50 Females | 50 Males |
|---|---|---|---|
| *R* | 0.72 | 0.74 | 0.72 |
| $R^2$ | 0.52 | 0.55 | 0.52 |
| $R^2$ adjusted | 0.52 | 0.54 | 0.51 |
| SE | 5.68 | 5.48 | 5.25 |
| *P* value | <.05 | <.05 | <.05 |

Abbreviation: SE, standard error.

was limited to 40 years and younger, and any changes in the proximal articular set angle caused by the hallux abductus angle may be obvious only in patients who have had hallux abducto valgus deformity for a greater length of time. A longitudinal study of hallux abducto valgus deformity and the proximal articular set angle is required to study this. The age of the cadavers used by Richardson et al[3] was not given, but, if typical, they were likely to be elderly subjects with a greater range of hallux abducto valgus deformity or long-standing deformity, which may account for the increased proximal articular set angles found.

## Conclusion

A significant correlation was found between the proximal articular set angle and the hallux abductus angle. It seems from this study that as the angle of the metatarsal head tilts increasingly to the lateral side, the hallux abductus angle increases. In theory, this would not be surprising, as the head of the metatarsal is dictating the direction of the hallux. With lateral deviation of the hallux, the frequently cited soft-tissue imbalances, such as bowstringing of the long tendons, will then bring about further drift of the hallux.[9]

There is no difference in the proximal articular set angle between males and females, and the correlation between the proximal articular set angle and the hallux abductus angle does not vary by gender. The proximal articular set angle may therefore be considered to be associated with hallux abducto valgus deformity, but it does not account for the high prevalence of the deformity in females.[10] Hallux abducto valgus has frequently been thought to be multifactorial, and this study supports such a hypothesis.

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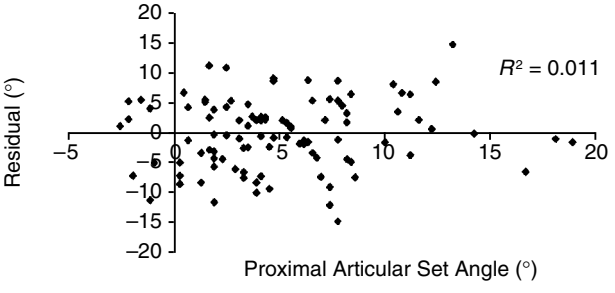


**Figure 4.** Residual plot for the proximal articular set angle correlation.

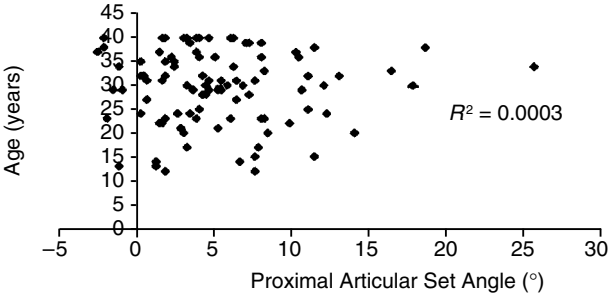


**Figure 5.** Scatterplot showing the relationship between the proximal articular set angle and age for all 100 subjects.

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