Intra- and interobserver repeatability of radiographic measurements in hallux surgery

Improvement and validation of a method

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ABSTRACT – **To test the hypothesis that the reproducibility of radiographic measurements of the first metatarsophalangeal angle and the intermetatarsal angle I–II can be increased by exact guidelines, we calculated the intra- and interobserver reliability of both methods. 4 independent observers (2 senior residents and 2 orthopedic trainees) evaluated 50 pre- and 50 postoperative plain dorsoplantar radiographs with their method of preference and then with Mitchell et al.'s method (1958).**

The mean intraobserver coefficient of repeatability for the metatarsophalangeal angle improved from 5.9° to 4.2°and for the intermetatarsal angle I-II, from 4.4° to 2.8°. The interobserver coefficient of repeatability improved from 6.5° to 5.0° for the metatarsophalangeal angle, and from 4.9° to 3.6° for the intermetatarsal angle I-II. This improvement in measurement accuracy was more marked for postoperative measurements, due to deformation of the metatarsal after the osteotomy which made it more difficult to find the longitudinal axis of the metatarsal. The improvements in the accuracy of measurements were also greater in the two inexperienced observers, since their measurements differed more when they had no exact guidelines for their drawings.

Measurements of the first metatarsophalangeal angle and the intermetatarsal angle I-II on plain dp radiographs are regarded as a standard in preoperative planning and in the evaluation of hallux surgery. Despite the importance of these measurements, the methods to evaluate the two angles are not very accurate (Schneider and Knahr 1998). We found only one article dealing with the reproducibility of these angles and it describes an unacceptably high interobserver error (Resch et al. 1995).

Our hypothesis was that measurement reproducibility can be increased by exactly defining how to draw the line representing the longitudinal axis of the first metatarsal. To test this hypothesis, we compared the Mitchell et al.'s method (1958), considered as most suitable for all types of hallux surgery (Schneider and Knahr, 1998), with radiographic measurements made in accordance with personal preferences.

Material and methods

We used 100 randomly selected plain dorsoplantar forefoot radiographs (50 preoperative, 50 after a distal chevron-type osteotomy) for our measurements. 4 independent clinicians (2 senior residents experienced in foot surgery and 2 trainees) were asked to draw the longitudinal axis of the first proximal phalanx, the axis of the first and that of the second metatarsal on all 100 radiographs. The first 2 measurement cycles were made with no instructions about how to draw the lines. The second 2 measurement cycles were made with Mitchell et al.'s method (1958) in which one draws a line connecting the center of the articular surface of the metatarsal head and the center of the proximal articulation as the longitudinal axis of the first metatarsal. The first metatarsophalan-

Interobserver and intraobserver limits of agreement with their upper and lower 95% confidence limits, based on repeated measurements of the metatarsophalangeal angle and the intermetatarsal angle I–II. The results are given separately for all radiographs ("all"), preoperative radiographs alone ("pre") and postoperative radiographs alone ("post")

	Interobserver limits of agreement		Intraobserver limits of agreement					
	All observers		Experienced residents		Inexperienced trainees		All observers	
	w/o guideline	with guideline	w/o guideline	with guideline	w/o guideline	with guideline	w/o guideline	with guideline
Metatarsophalangeal angle								
Lower limit of agreement								
all	**–6.8** –7.1/–6.4	**–6.3** –6.6/–6.1	**–4.8** –5.5/.4.1	**–4.2** –4.7/–3.7	**–5.9** –6.6/–5.1	**–4.2** –4.7/–3.7	**–5.4** –5.9/–4.8	**–4.2** –4.6/–3.8
pre	**–7.1** –7.6/–6.6	**–6.5** –6.9/–6.1	**–3.9** –4.8/–3.0	**–3.8** –4.4/–3.1	**–6.0** –7.1/–5.0	**–4.6** –5.4/–3.7	**–5.2** –5.9/–4.5	**–4.2** –4.7/–3.7
post	**–6.3** –6.8/–5.9	**–6.1** –6.5/–5.8	**–5.5** –6.6/–4.5	**–4.6** –5.4/–3.8	**–5.6** –6.7/–4.5	**–3.8** –4.4/–3.2	**–5.6** –6.3/–4.8	**–4.2** –4.7/–3.7
Upper limit of agreement								
all	**6.5** 6.2/6.9	**4.1** 3.9/4.4	**6.4** 5.7/7.1	**4.0** 3.5/4.5	**6.2** 5.5/7.0	**4.2** 3.7/4.7	**6.3** 5.8/6.8	**4.1** 3.7/4.4
pre	**6.0** 5.5/6.5	**4.5** 4.1/4.9	**6.5** 5.6/7.4	**3.6** 2.9/4.2	**5.6** 4.6/6.6	**4.8** 4.0/5.7	**6.2** 5.5/6.9	**4.2** 3.7/4.7
post	**6.9** 6.5/7.4	**3.7** 3.3/4.1	**6.1** 5.1/7.2	**4.4** 3.6/5.2	**6.8** 5.7/7.9	**3.5** 2.8/4.1	**6.5** 5.7/7.2	**3.9** 3.4/4.4
Intermetatarsal angle I–II								
Lower limit of agreement								
all	**–4.9** –5.1/–4.6	**–3.4** –3.6/–3.2	**–3.3** –3.9/–2.9	**–2.8** –3.1/–2.4	**–5.0** –5.6/–4.4	**–2.7** –3.0/–2.3	**–4.2** –4.6/–3.9	**–2.7** –3.0/–2.5
pre	**–4.8** –5.1/–4.5	**–3.5** –3.8/–3.2	**–2.5** –3.2/–1.9	**–3.2** –3.8/–2.7	**–4,7** –5.5/–4.0	**–2.7** –3.3/–2.2	**–3.8** –4.8/–3.3	**–3.0** –3.4/–2.6
post	**–4.8** –5.1/–4.4	**–3.2** –3.4/–3.0	**–3.9** –4.6/–3.2	**–2.3** –2.7/–1.9	**–5.2** –6.2/–4.3	**–2.5** –3.0/–2.1	**–4.6** –5.2/–4.0	**–2.4** –2.7/–2.14
Upper limit of agreement								
all	**4.8** 4.6/5.1	**3.8** 3.7/4.0	**4.2** 3.7/4.7	**2.8** 2.4/3.1	**4.9** 4.3/5.7	**2.9** 2.6/3.3	**4.6** 4.2/5.0	**2.9** 2.6/3.1
pre	**3.9** 3.6/4.3	**4.3** 4.0/4.5	**4.4** 3.8/5.0	**3.1** 2.6/3.7	**4.0** 3.3/4.8	**3.5** 2.9/4.0	**4.4** 3.9/4.9	**3.3** 2.9/3.7
post	**5.5** 5.2/5.9	**3.4** 3.2/3.6	**3.8** 3.1/4.5	**2.4** 2.0/2.8	**5.6** 4.7/6.6	**2.3** 1.9/2.7	**4.7** 4.2/5.3	**2.4** 2.1/2.6

geal angle and the intermetatarsal angle I–II were measured on these drawings by only one senior resident (WS) to reduce the error. We used Bland and Altman's method (1986) to calculate the coefficient of repeatability between interobserver and intraobserver measurements.

Results

The mean values of the preoperative metatarsophalangeal angle were 32°, when no instructions were given for drawing the axis of the first metatarsal, and 28°, using Mitchell et al.'s method (1958). The mean postoperative values of the metatarsophalangeal angles were 10° and 9.4°, respectively. The mean values of the preoperative intermetatarsal angle I–II were 16° without the guideline and 13° with the above-mentioned method. The postoperative intermetatarsal mean values were 6.7° and 6.0°, respectively.

For all pre- and postoperative metatarsophalangeal angles, the interobserver coefficient of repeatability was 6.5° when no instructions were given

for drawing the longitudinal axis of the first metatarsal versus 5.0° using a guideline. As regards the preoperative radiographs alone, the improvement was from 5.5° (without the guideline) to 4.9° (using the guideline) and the postoperative radiographs, the improvement was 6.6° to 4.8°. We found an improvement in the interobserver coefficient of repeatability for the intermetatarsal angle I–II from 4.9° to 3.6°, when the calculation included all radiographs, 4.1°–3.7°, for the preoperative radiographs alone, and 4.9°–2.9° for all postoperative radiographs.

The intraobserver coefficient of repeatability for the total of all pre- and postoperative metatarsophalangeal angles was 5.9° when no instructions were given about drawing the longitudinal axis of the first metatarsal versus 4.2° using Mitchell et al.'s method. As regards the preoperative radiographs alone, we found an improvement from 5.5° (without the guideline) to 4.1° using the guideline as well as in the postoperative drawings from 6.0° to 4.1°. The intraobserver coefficient of repeatability for the intermetatarsal angle I-II improved from 4.4° to 2.8° when all radiographs were included, from 3.9° to 2.3° for the preoperative radiographs alone, and from 4.5° to 2.4° for all postoperative radiographs.

For pre- and postoperative metatarsophalangeal angles without guidelines, the intraobserver coefficient of repeatability was 5.7° for the residents, and 6.2° for the trainees. With a guideline, these values decreased to 4.1° and 4.2°, respectively. For preoperative radiographs alone, the improvement was from 5.2° to 3.6° using the guideline for residents, and from 5.8° to 4.5° for trainees. For postoperative drawings, the improvement was from 5.7° to 4.5° for the residents and 6.3° to 3.7° for the trainees. The intraobserver coefficient of repeatability for the intermetatarsal angle I–II improved from 3.8° to 2.8° for the residents and from 5.0° to 2.8° for the trainees, when all radiographs were included.

Discussion

The first metatarsophalageal angle (the "hallux valgus" angle) and the intermetatarsal angle I-II are used to make decisions about forefoot surgery (Bordelon 1987, Mann 1990, Mann and Coughlin 1993). They also form part of most scores used to evaluate the results of foot surgery (Bonney and MacNab 1952, Sherman et al. 1984, Steinböck and Leder 1988, Geissele and Stanton 1990, Shankar et al. 1991). In a review of the literature, we found only one paper that dealt with interobserver variability of metatarsophalangeal and intermetatarsal angles (Resch et al. 1995) which had noted poor repeatability of these measurements. We tested the hypothesis that intra- and interobserver repeatability can be improved by using guidelines for the angular measurements. We compared measurements made routinely by clinicians who had received no particular instructions and were planning and evaluating hallux valgus surgery to those made with a method regarded as entirely appropriate in most clinical settings (Schneider and Knahr 1998), described by Mitchell et al. (1958). This method defines a line connecting the center of the articular surface of the metatarsal head and the center of the proximal articulation as the longitudinal axis of the first metatasal.

Without a guideline, we found poor intra- and interobserver repeatability for pre- and postoperative radiographs. These values are similar to those reported by Resch et al. (1995), and unacceptable for measurements of small angles. The mean value of the metatarsophalangeal angle was found by Hardy and Clapham (1951) to be 16° and 12.0° by Steel et al. (1980); for the intermetatarsal angle I–II, the same authors noted mean values of 8.5° and 7.0°, respectively.

By exactly defining the longitudinal axis of the first metatarsal, we improved the intra- and interobserver repeatability of the metatarsophalangeal angle and intermetatarsal angle I-II before and after surgery. The effect was more marked for postoperative measurements because in distal metatarsal osteotomies, the longitudinal axis of the first metatarsal becomes more difficult to see with an increase in the amount of lateral displacement of the distal fragment. Presence of deformation of the first metatarsal will affect all types of osteotomies and bunionectomies and was described by Resch et al. (1995) for closing wedge osteotomies. When we compared the accuracy of measurements made by the two experienced foot surgeons and the two orthopedic trainees, we found that the latter

had benefited more from the exact measurement guidelines.

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