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Review Article

# Mobility of the First Ray in Patients With or Without Hallux Valgus Deformity: Systematic Review and Meta-Analysis

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ABSTRACT

The hypermobility theory of the first ray is the reason for the popularization of procedures such as the modified Lapidus procedure involving arthrodesis of the first tarsal–metatarsal joint for correction of hallux valgus deformity. Although many studies have involved motion of the first ray in hallux valgus patients, the presence and clinical significance of hypermobility in the first ray remains controversial. We performed a systematic review and meta-analysis to evaluate the difference in the first ray range of motion between patients with or without hallux valgus deformity. The databases used for the present review included Ovid EMBASE, Ovid MEDLINE, CINAHL, and the Cochrane Database. We searched for comparative studies that had evaluated the motion of the first ray in patients with or without hallux valgus. After screening for inclusion and exclusion criteria, we identified 3 studies that were relevant to our study question. All 3 studies showed more first ray motion in the hallux valgus group. Our quantitative synthesis showed a mean difference in the range of motion of the first ray of 3.62 mm (95% confidence interval 2.26 to 4.98) between those with and without hallux valgus deformity. Thus, we found statistically significantly increased first ray motion in patients with hallux valgus deformity compared with those without hallux valgus deformity. However, the clinical significance of this small amount of increased sagittal plane motion as a response to or a cause of hallux valgus remains unanswered.

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Hypermobility of the first ray in hallux valgus (HV) deformity has been described and studied by many investigators (1). Despite the recent interest in frontal plane deformity of the first metatarsal with HV, the instability has predominantly been studied in the sagittal plane and, to a lesser extent, the transverse plane (2,3). Because of the malalignment in HV, it has been suggested that the stability of the first ray is compromised. It has been hypothesized that the malaligned peroneus longus, plantar fascia, and plantar ligamentous structures all lose their mechanical advantages, with the result that the first ray becomes more unstable (4–7). Some have also postulated that, in contrast, the hypermobility can be a causative factor for the development of HV. Procedures such as the modified Lapidus arthrodesis of the first tarsometatarsal joint have gained in popularity in part owing to the belief that a hypermobile first ray should be stabilized and that is best achieved with this procedure (8–13). However, the concept of hypermobility in the first ray in HV remains controversial.

We performed a systematic review and meta-analysis to compare the amount of sagittal plane motion in the first ray in patients with and without HV deformity. We evaluated whether the increased sagittal plane motion in the first ray is unique to patients with HV.

## Materials and Methods

Sagittal plane range of motion of the first ray in patients with or without HV was compared using a systematic review of previous human research and a meta-analysis of the aggregated data. Only peer-reviewed reports were considered for inclusion. The measurement of interest was the range of motion in millimeters of the first ray in the sagittal plane at the level of the metatarsal head.

An electronic data search was conducted in March 2017 using a keyword search strategy. The keywords used for this search are listed in Table 1. The databases used for the present review included Ovid EMBASE, Ovid MEDLINE, CINAHL, and the Cochrane Database. No language restriction was set. Google Translate (available at: translate.google.com) was used for the translation of foreign languages for screening purposes, if necessary. Only comparative studies were then selected from the pool of studies.

The initial screening of the titles and abstracts was performed by the primary author (N.S.). Each of us then read the remaining reports in their entirety for the final

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**Table 1**
Terms used for electronic search (≥1 term from each group was required to be in a study's keywords for a study to be retrieved)

| Group |
|---|
| 1 |
| Hypermobility |
| Mobility |
| Range of motion |
| Displacement |
| Motion |
| Flexibility |
| 2 |
| Hallux valgus or HV |
| Hallux abductovalgus or HAV |
| Bunion |
| 3 |
| First ray |
| Metatarsal |
| Tarsometatarsal |
| Metatarsophalangeal |
| Hallux |
| Big toe |
| Great toe |

selection according to our inclusion and exclusion criteria to be included for the final analysis. Disagreements were discussed among us until an agreement was reached. The inclusion and exclusion criteria are listed in Table 2. The characteristics of each study and the potential biases were evaluated and discussed.

To maintain consistency, only those studies using a mechanical device, described by Klaue et al (14), to measure the first ray sagittal plane mobility were included in the study. The device was selected over other methods of measurement because of its tested validity, repeatability (15), and popularity in first ray mobility research. The device is made from a rigid ankle-foot orthosis connected to a forefoot plate with a first ray cutout and a dorsally attached micrometer. The foot is secured in the ankle-foot orthosis with the ankle in a neutral position and the first ray hanging off the forefoot plate in the cutout. With the lesser metatarsal secured on the forefoot plate, the first ray is then dorsally displaced by an investigator. The micrometer, which is located on the dorsal side of the first metatarsal head, measures the dorsal displacement of the first ray in millimeters.

For each study under consideration, we abstracted the number of subjects with or without HV and the mean and standard deviation of the displacement of the first ray in millimeters measured using the Klaue device. Using RevMan, version 5.1 (Review Manager, The Nordic Cochrane Centre, The Cochrane Collaboration, 2011; Copenhagen, Denmark), the mean difference and 95% confidence interval of the first ray mobility in patients with and without HV was computed using a random effects model. Random effects were selected over fixed effects after we reviewed the included studies. When the 95% confidence interval of the cumulative mean difference did not include 0, it was considered statistically significant. Study heterogeneity ($I^2$) was also computed using RevMan, version 5.

## Results

Our original search identified 54 reports through EMBASE, MEDLINE, CINAHL and the Cochrane Database (Fig. 1). After our initial title and abstract screening, the number had been reduced to 13. After reviewing these 13 reports in their entirety, 10 were excluded in accordance with our inclusion and exclusion criteria. Of these 10 reports, 8 had not included the groups (either HV or non-HV) of interest, 1 had not used the Klaue device for measurement, and 1 (16) had a duplicated cohort that had been reported in another study

**Table 2**
Inclusion and exclusion criteria

| Criteria |
|---|
| Inclusion |
| Comparative study measuring first ray mobility in human subjects with and without hallux valgus deformity |
| Primary outcome measure was sagittal displacement of head of first metatarsal in millimeters using Klaue device |
| Exclusion |
| Studies not having a control (non-hallux valgus) group |
| Studies not providing mean ± standard deviation of first ray mobility and sample sizes of each study group |
| Cadaveric studies |
| Studies with duplicated data from other studies included in the present analysis |
| Studies that included subjects who had undergone foot surgery before measurement |

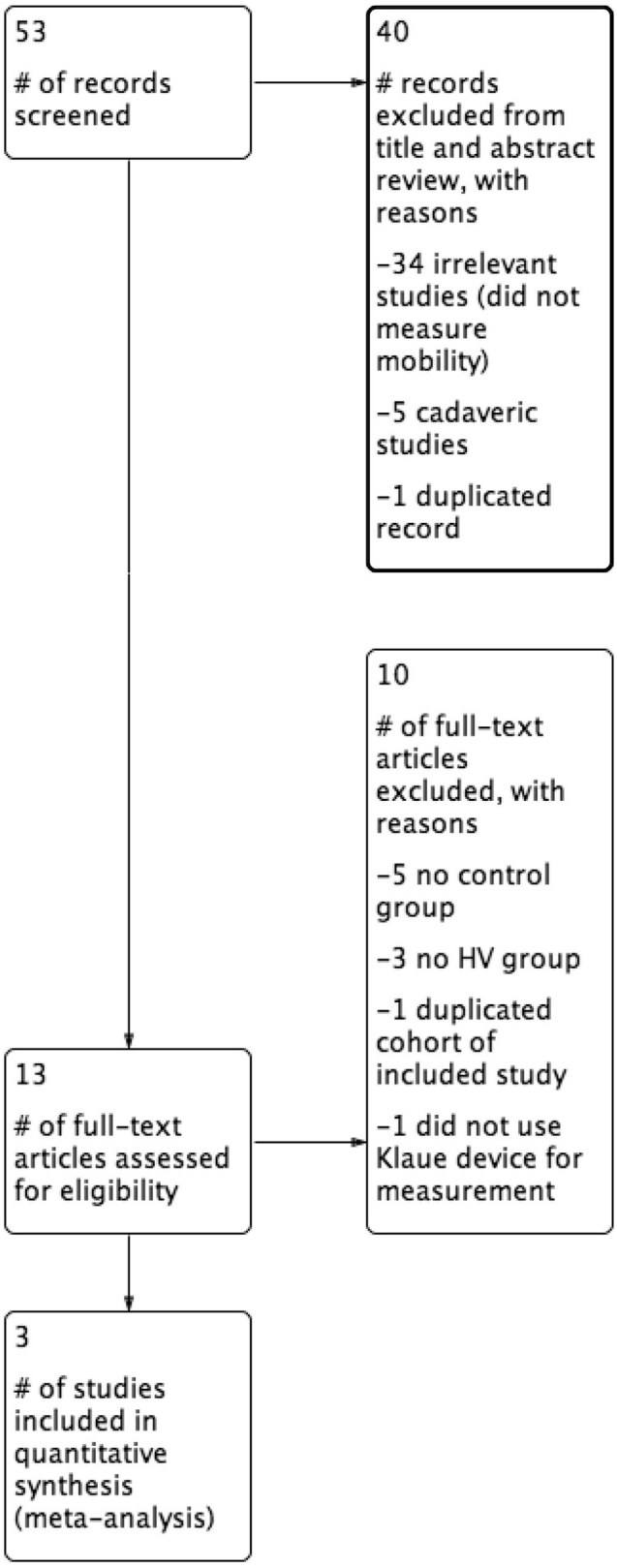


**Fig. 1.** A study flow diagram.