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# Lesser Toe PIP Joint Resection Versus PIP Joint Fusion: A Randomized Clinical Trial

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**Abstract**

**Background:** It is unclear whether proximal interphalangeal joint (PIPJ) resection or fusion leads to superior clinical outcome in patients undergoing hammertoe surgery. The purpose of this study was to prospectively evaluate a series of patients undergoing this surgery.

**Methods:** Patients with one or more toes with rigid PIP flexion deformity were prospectively enrolled. These patients were randomly assigned to undergo either PIPJ resection or PIPJ fusion. In addition to the PIPJ procedure, a metatarsophalangeal joint (MTPJ) release was performed if deemed necessary. Follow-up was up to 1 year postoperatively. Twenty-six patients (39 toes) were included in the PIPJ resection group and 29 (50 toes) in the PIPJ fusion group.

**Results:** Thirty-four underwent an MTPJ release. No significant difference in foot outcome scores (American Orthopaedic Foot & Ankle Society scale, the Foot Function Index, and visual analog scale pain) could be detected after 1-year follow-up. A statistically significant difference was found regarding the toe alignment in the sagittal plane in favor of PIPJ fusion.

**Conclusions:** Our randomized controlled study did not show any clinical outcome difference between PIPJ fusion and PIPJ resection. Both procedures resulted in good to excellent outcome in pain and activity scores.

**Level of Evidence:** Level II, lesser quality RCT or prospective comparative study.

**Keywords:** forefoot disorders, hallux disorders, outcome studies, pip flexion deformity, treatment, fusion, resection

## Introduction

The incidence of lesser toe deformities in the general population reported varies from 2% to 20%.[9,10] There is an ongoing debate regarding the definition of lesser toe deformities.[26,27] In the present study, a claw toe was defined as a flexion deformity of the proximal interphalangeal joint (PIPJ), with a hyperextension deformity of the metatarsophalangeal joint (MTPJ).[27] Operative procedures of lesser toes are among the most common operative interventions within general orthopedic practice.[13] Although various treatment options have been reported, usually the rigid PIPJ deformity is corrected through either resection or fusion.[4,8,11,14,17,29] These procedures do not differ much except for the resection of the proximal end of the middle phalanx. However, these procedures both have advantages and disadvantages. The MTPJ deformity is most commonly corrected through joint release, frequently with additional extensor tendon lengthening or tenotomy.[8,11,13,14,22]

Many different operative procedures of lesser toe deformities can be found in the literature. However, these lack methodological quality and comparative design with divergent outcomes.[14] Moreover, there is no international consensus on the operative treatment of lesser toe deformities. No previous randomized trials have been performed comparing 2 frequently performed interventions for PIPJ deformity, resection, and fusion. The goal of the present study was to compare the effectiveness of PIPJ resection with PIPJ fusion among a population with rigid PIP flexion deformity with a randomized prospective study.

## Methods

### *Study Population*

Patients were prospectively enrolled in 3 institutions in the Netherlands and Belgium. These institutions consisted of the University Hospitals Leuven (B), Sint Maartenskliniek (NL), and Isala hospital (NL). Approval for this study was

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obtained from the local ethics committees and the patients were recruited after taking their written informed consent.

All patients had one or more rigid PIP flexion deformities with extension deformity of the MTPJ, resulting in metatarsalgia and, commonly, with painful callosities on the dorsal aspect of the toes. These deformities, with a flexion deformity of the PIPJ with hyperextension deformity (extension contracture) of the MTPJ, were defined as claw toes in the current study.[27] Hallux valgus was not an exclusion criterion. The other inclusion criteria were as follows: age between 18 and 85 years and mental competence. All subjects had undergone unsuccessful conservative treatment for a minimum of 6 months.

Patients were excluded in case of (1) previous ipsilateral forefoot surgery; (2) simultaneous operative intervention on the same foot during the same session other than forefoot surgery; (3) specific comorbidity (ie, arterial insufficiency, complex regional pain syndrome, diabetes mellitus, neuropathy, generalized joint disease, and/or an active infection); and (4) pre-existent impaired mobility which would hamper postoperative rehabilitation (eg, hemiplegia).

The patients were interviewed and examined by orthopedic surgeons at the outpatient clinic before their inclusion. The actual inclusion and follow-up visits, following a standard protocol, were performed by independent researchers.

## Study Design

The current study had a prospective design with random allocation of eligible patients to undergo either PIPJ resection or fusion. The randomization was carried out according to an allocation concealment mechanism. One independent person sequentially assigned different subjects to the different interventions, by means of block randomization (10 subjects per block), using www.randomization.com. These data were recorded in nontransparent envelopes.[28] The allocation sequence was concealed to the participating physicians and researchers. Before the operative treatment, the surgeon received an envelope that was opened in the operating room that revealed the treatment.

## Outcome

The clinical data collected were: demographic data, medical history, comorbidity and ASA classification.[2] Follow-up was at 2 weeks, 6 weeks, 3 months, and 1 year postoperatively. Two specific foot outcome measures were applied: the American Orthopaedic Foot & Ankle Society scale (AOFAS) and the Foot Function Index (FFI).[5,15,18] The Dutch version of the FFI was divided into a pain subscale (section B; consisting of 9 items) and an activity scale (section C; 9 items). Pain was assessed by a visual analog scale (VAS 0-10). Physical examination was performed focusing on details of the forefoot deformity, the alignment, the plantar fat pad, and mobility of the hallux and lesser MTP joints.

Standardized weight-bearing radiographs (anterior-posterior [AP] and sagittal plane) were obtained preoperatively, after 6 weeks and 1 year postoperatively. These were evaluated using the method of Sung et al, also evaluating (non) union of the PIPJ.[29] The alignment (AP and sagittal) of the PIPJ of the operated ray was measured. If several rays were operated on, only the second ray was measured. On the AP view, the angle was defined as positive if the deviation of the ray was lateral to the axis of the metatarsal, and negative if the deviation was medial. Because of overprojection, the alignment of the MTPJ could not be measured. All measurements were performed by the same author.

## Operative Techniques

The operative procedures were discussed and practiced in detail during a cadaveric session, aiming at reduction of performance bias throughout the course of the study. If an operated toe in the present study exhibited an extension contracture at the MTPJ, an MTPJ release was performed in addition to the PIPJ procedure. All procedures were performed in accordance with the methods described by Louwerens et al.[21]

*PIPJ resection.* A dorsal longitudinal incision was used and the extensor tendon and joint capsule was also divided. Hohman retractors were shifted over the bone under the tendon and positioned around the phalanx just proximal to the joint on both sides. The head of the basal phalanx was resected, using either a bone cutter or an oscillating saw. Usually the resection height of this condylectomy was about 6 to 10 mm. The foot was positioned in simulated "standing position," and if tension and persistent malalignment were present, more bone could be resected. It was also determined if the basal phalanx was well aligned at the level of the MTPJ, without extension due to extension contracture of the MTPJ and/or contracture of the extensor tendon(s). In case of contracture, a dorsal capsulotomy of the MTPJ and extensor tendon lengthening were performed. If persistent subluxation occurred, a plantar release was conducted, using a McGlamry rasp. If necessary because of contracture of the flexor tendons, a flexor tenotomy was performed. A 1.0- to 1.25-mm K-wire was drilled through the center of the articular surface of the middle phalanx retrograde through this phalanx and the distal phalanx, holding the DIP joint in neutral position, exiting centrally at the apex of the toe. Hereafter, the K-wire was drilled forwards through the proximal phalanx as centrally as possible. With the foot in standing position and the MTPJ held in neutral position (slight extension, equal angle as the adjacent normal MTP joints), the K-wire was drilled across the MTPJ into the metatarsal bone.

*PIPJ fusion.* The approach was identical to that of the PIPJ resection. In general, less bone was removed from the distal part of the basal phalanx. The articular surface of the middle phalanx was also resected. Preferably, the cut surfaces on

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**Table 1.** Demographic Data.

| | Total | PIPJ Resection | PIPJ Fusion | *P* Value |
|---|---|---|---|---|
| n | 55 | 26 | 29 | |
| Gender (male/female) | 12/43 | 6/20 | 6/23 | .83 |
| Age (y), M (SD) | 62 (9) | 61 (9) | 63 (9) | .50 |
| Height (cm), M (SD) | 170 (10) | 172 (11) | 169 (11) | .31 |
| Weight (kg), M (SD) | 80 (15) | 86 (12) | 75 (12) | .004 |
| Side (left/right) | 25/30 | 12/14 | 13/16 | .80 |
| ASA classification (1), (I/II/III) | 22/28/5 | 8/16/2 | 14/12/3 | .33 |

Abbreviations: ASA, American Society of Anesthesiologists; M, mean; PIPJ, proximal interphalangeal joint; SD, standard deviation.

both sides were made at the level of metaphyseal cancellous bone with its optimal bone healing properties. The amount of bone resected depended on the amount of deformity. The more deformity, the more bone needed to be removed in order to obtain realignment. In case of contracture, a dorsal capsulotomy of the MTPJ and extensor tendon lengthening were performed. If persistent subluxation occurred, a plantar release was conducted, using a McGlamry rasp. If necessary because of contracture of the flexor tendons, a flexor tenotomy was performed. The technique of K-wire fixation started as described for PIPJ resection; however, at the moment the wire was drilled into the basal phalanx, the cut surfaces were compressed to ensure good bony contact.

*Postoperative treatment.* A dressing was applied for 2 weeks. Starting postoperatively, patients were permitted to fully weight bear on a forefoot-relieving shoe for a duration of 6 weeks. After 2 weeks, the stitches were removed. The K-wires were removed after 4 to 6 weeks. At that time, the patients received instructions on how to mobilize and exercise the MTPJ. Subsequently, the patients were permitted to fully weight bear on their own shoes.

### *Statistics*

A 2-way analysis of variance (ANOVA), with between-factor surgery (fusion or resection) and within-factor measurement time (preoperative and 3 and 12 months postoperative), was used to indicate differences in outcome factors AOFAS, FFI B, FFI C, and VAS pain. The primary end point was defined as the AOFAS score after 1 year of follow-up. When a significant main measurement factor was found, a Bonferroni post hoc test was used to indicate which measurement times were significantly different.

Because a large number of subjects underwent an additional hallux valgus correction, a second statistical analysis was performed to indicate the effect of the hallux valgus correction. For this, a 3-way ANOVA was performed, with between-factors surgery (fusion or resection) and hallux (correction or no correction) and within-factor measurement time (preoperative and 3 and 12 months postoperative).

Concerning the radiologic outcome parameters, a 2-way ANOVA with between-factor surgery (fusion or resection) and within-factor measurement time (preoperative and 3 and 12 months postoperative) was used. The level of significance was set at $P < .05$

## Results

Twenty-six persons (39 toes) were included in the PIPJ resection group and 29 (50 toes) in the PIPJ fusion group (period of enrollment from 2008 until 2013). Thirty-four patients underwent an MTPJ release; 19 of these were among the PIPJ resection group. In the complete population, 53 second rays were operated on. In all patients, the second ray was corrected with or without additional rays, except for 2 persons who underwent correction of a third and fourth ray. We decided to include these 2 patients in the statistical analysis because these followed the same research protocol and were of additional value to the number of included patients. Additional 2-way ANOVA did not indicate that exclusion of these 2 patients would influence the outcome. The details of the study population per surgery group are shown in Table 1. There were no significant differences between the 2 groups for all subject characteristics, except for weight. There were complete data of 47 patients after 3 months and 51 patients after 1-year follow-up. There was no significant difference in numbers of first-ray surgery, between groups.

Figure 1 shows the mean and standard deviation of the outcome factors for both groups at preoperation and 3 and 12 months postoperation. The 2-way ANOVA revealed a main effect for measurement time for all outcome parameters ($P < .0001$). A significant improvement in all outcome scores between preoperation and 3 months postoperation and between preoperation and 12 months postoperation for both groups was found. The outcome scores between 3 and 12 months postoperation were not significantly different. With the numbers available, no main effect between groups could be detected (AOFAS $P = .46$, FFI B $P = .25$, FFI C $P = .90$, VAS pain $P = .71$). Additionally, no interaction effects could be demonstrated ($P$ values were $>.42$).

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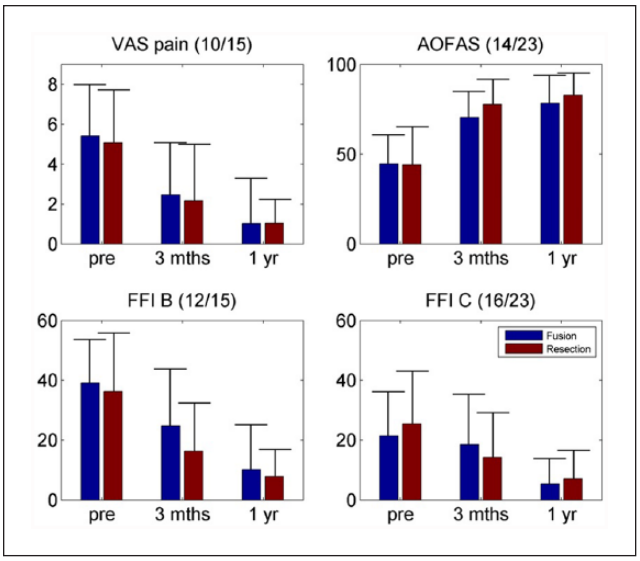



**Figure 1.** The course of the different outcome scores within time and comparison between the 2 groups. In parentheses is the number of patients per group (resection/fusion) with complete follow-up data per specific outcome score.

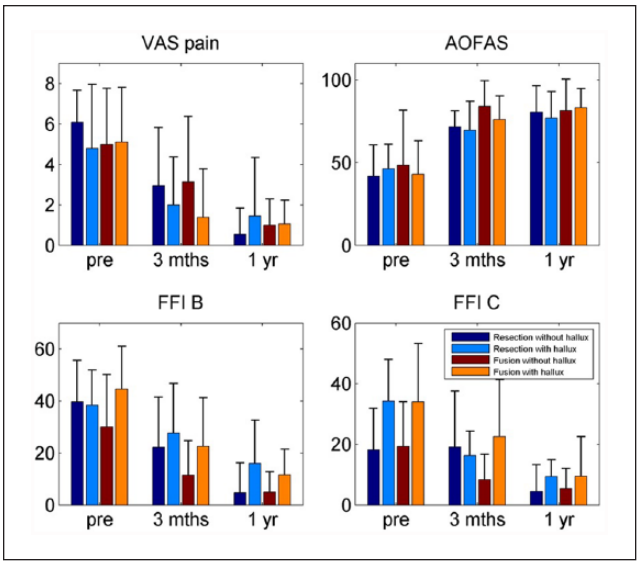



**Figure 2.** The course of the different outcome scores within time and comparison between the 2 groups, with influence of hallux correction or no hallux correction.

In the second statistical analysis, the effect of the first ray correction was evaluated, by adding first ray or no first ray correction as an extra factor (3-way ANOVA). Figure 2 shows the mean and standard deviation of the various outcome scores during the study, for the different groups. The 3-way ANOVA revealed a significant main effect of hallux (correction or no correction) for FFI B ($P$ = .046) but no significance for FFI C ($P$ = .056). No main effect could be demonstrated for AOFAS ($P$ = .74) and VAS pain ($P$ = .42). The patients with a first ray correction had a higher FFI B and FFI C outcome score (3 and 12 months postoperation), compared to the patients without a first ray correction. However, this effect was equal between the 2 groups (PIPJ fusion and PIPJ resection), as indicated by the absence of significant interaction effects. The 3-way ANOVA revealed no interaction between the hallux and the other 2 main effects, intervention and measurement time. Additionally, the other statistical results of the 3-way ANOVA were comparable to the 2-way ANOVA: no significant main effect for intervention (PIPJ fusion or resection), no significant interaction effects, and a significant main effect for measurement time for all outcome parameters.

## Complications

A total of 30 complications in 55 patients were reported. Three patients developed 2 complications. Twelve complications occurred within the PIPJ resection group of 26 persons. Eighteen occurred within the PIPJ fusion group, consisting of 29 persons. There was no significant difference in the number of complications between the 2 groups ($P$ = .38). Eleven K-wire–related problems were reported, of which 9 occurred in one institution ($P$ = .019 in comparison with the 2 other institutions). From this group, 2 patients underwent a reintervention for removal of part of the K-wire (defined as "K-wire" related complication). In another patient, a reintervention was performed to correct a residual toe malalignment (defined as "malalignment"). There were 6 floating toes (4 in resection group), 1 infection, 6 patients with toe malalignment (4 in resection group), 1 recurrence, 1 patient with symptomatic PIPJ pseudarthrosis, 2 patients with a sensory deficit, and 1 patient with superficial skin necrosis with spontaneous recovery.

## Radiologic Outcome

The radiologic outcome parameter alignment of the measured PIPJ for the 2 groups are shown in Table 2, according to the method described by Sung et al.[29] It displays the preoperative comparison of radiologic alignment of the PIPJ in degrees, between the PIPJ resection and fusion group, in the sagittal and AP plane. Subsequently, the postoperative alignment between the 2 groups is displayed. In all patients (except for 2; surgery of third and fourth ray), at least the second ray was operated on; consequently, in these patients the second ray was measured. In case of the other 2 patients, the affected ray was measured. The 2-way ANOVA for the PIPJ alignment in sagittal view revealed a main effect for surgery ($P$ = .02) and measurement time ($P$ < .001) and no interaction effect ($P$ = .07). PIPJ fusion resulted in a better alignment on the sagittal view, compared to PIPJ resection. Regarding the second PIPJ alignment in an AP view, no significant effects

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**Table 2.** Pre- and Postoperative Radiologic Toe Alignment.

| | Preoperation | | 1 Year Postoperation | |
|---|---|---|---|---|
| Alignment of PIPJ of Measured Toe | PIPJ Resection (degrees) | PIPJ Fusion (degrees) | PIPJ Resection (degrees) | PIPJ Fusion (degrees) |
| Sagittal (n = 47), M (SD) | 63 (20) | 60 (16) | 30 (15) | 15 (15) |
| Anteroposterior (n = 51), M (SD) | 3 (12) | −2 (13) | 4 (11) | 2 (8) |

Abbreviations: M, mean; SD, standard deviation.

were found (surgery: $P = .17$; measurement time: $P = .09$; interaction: $P = .38$). There were 7 radiographic nonunions in 29 patients who underwent fusion. One was symptomatic (as described in the Complications section). The 39 toes with intended pseudarthrosis after PIPJ resection had comparable outcome to the 50 toes after fusion. MTPJ release did not influence postoperative sagittal alignment of the PIPJ ($P = .17$ postoperative sagittal alignment between MTPJ release and no MTPJ release).

## Discussion

In the current randomized controlled trial, no difference in clinical outcome between PIPJ resection and PIPJ fusion in patients with rigid PIP flexion deformity was found. The only difference was a greater improvement of sagittal radiologic alignment in the PIPJ fusion group. Most studies with a retrospective design that have been published describe the outcomes of operative correction of lesser toe deformities.[19,23,29] To our knowledge, this is the first randomized trial on this subject, and therefore we have more validity than prior studies. The 3 surgeons followed the same treatment protocol, which was assessed by independent researchers. These could be regarded as the strengths of this study.

Sung et al retrospectively reported outcome after 3 methods of hammertoe correction, including the Weil-Hammertoe-implant.[29] They found no difference between the PIPJ fusion and PIPJ resection arthroplasty group after an average follow-up of 54 months. After PIPJ fusion, their average VAS pain score was 1.9, and after PIPJ resection, 1.0; this result is comparable to the 1-year postoperative VAS scores after both procedures in the present study. The scores demonstrated slightly favorable axial alignment after PIP interpositional implant arthroplasty. A study by Lehman et al after PIPJ fusion defined a satisfied patient as one with an overall AOFAS score of 80 or higher.[20] Coughlin et al reported a mean AOFAS score of 83 after PIPJ fusion and Dhukaram et al a median AOFAS score of 83 after MTP release with PIPJ resection.[8,11] Our data showed similar AOFAS scores after different procedures. One year postoperatively, mean scores of 80.5 (SD = 15.9) after PIPJ fusion without hallux correction and 77.0 (SD = 15.9) after PIPJ fusion with hallux correction were measured. After PIPJ resection without first ray correction, the AOFAS score was 81.5 (SD = 19.1); PIPJ resection with hallux correction showed a 1-year postoperative AOFAS score of 83.3 (SD = 11.7). In the current study, both procedures, irrespective of first ray correction, resulted in satisfied patients with significant pain reduction and results comparable to those reported in literature.

We did find a statistically significant difference between the 2 groups regarding the toe alignment in the sagittal plane. PIPJ fusion resulted in better improvement of sagittal alignment. This could be interpreted as an important factor that could reduce problems over time, as deformity in this plane accounts for most symptoms. The sagittal alignment of the PIPJ was not influenced by MTPJ release. The accuracy of measurement of sagittal alignment yielded complexities in our study (overlapping from other rays), as similarly encountered in other studies.[12,29] This especially accounts for the MTPJ since no current consistent method exists for measuring MTPJ alignment on sagittal plane radiographs. Therefore, we did not include measurement of the MTPJ in our study. Sung et al did not find significant differences in sagittal alignment between PIPJ resection and fusion after an average follow-up of 53.8 months in a retrospective study.[29] Various studies evaluated different methods of stabilization of the PIPJ during operative correction of lesser toe deformities, which ultimately should lead to decreased risk of malalignment.[11,20] None of these detected a superior method.

A high complication rate with 30 complications in 55 patients was found in our study. The complication rate after surgery of lesser toe deformities reported ranges from 21% to 56%.[7,12,24,29] Our data showed a relatively high amount of radiologic non-union after PIPJ fusion, but the non-union rarely resulted in pain. This painless non-union is in accordance with several other studies.[1,3,6,8,16] In the current study, the most prevalent complications were K-wire related, which occurred in 11 patients. This is comparable with the numbers for up to 18% of cases in the literature.[25] Most of the K-wire–related complications in our study occurred in the same institution. All perioperative details and treatment protocols were equal in all institutions. A possible explanation could be the drilling of a small-size K-wire across the MTPJ.

This study has several limitations. Although 3 centers were involved in the study, the number of patients who

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could eventually be included over 6 years was disappointing. The existence of PIP flexion deformity is related to all kinds of pathology, but the presence of such pathology was an exclusion criterion in many cases. Inclusion of patients with simultaneous first ray correction could be regarded as a deficiency of our study design. However, lesser toe deformities are often associated with first ray pathology. If the presence of hallux valgus would also have been an exclusion criterion, the period of inclusion would have even been longer. The number of first ray corrections was equally distributed between the 2 groups. The confounding effect of the first ray correction was tested with a 3-way ANOVA test and was not found to influence the results of either resection or fusion. However, patients with first ray correction showed higher FFI B and C scores. Hence, first ray correction resulted in worse FFI scores, without affecting the outcome of different PIPJ procedures. Another drawback of the present study was the missing follow-up data. We chose to only analyze those patients' data that were complete. Two- and 3-way repeated measures did not show any indication that inclusion of a higher number of patients would have led to a significant difference in the results. Finally, the short duration of postoperative follow-up was a limitation.

## Conclusions

Our randomized controlled study did not show any clinical difference between PIPJ fusion and PIPJ resection in the treatment of rigid PIP flexion deformity. Both procedures resulted in good to excellent outcome in pain and activity scores. It remains disputable if better alignment in the sagittal plane would justify greater use of PIPJ fusion.

### Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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