Lesser Proximal Interphalangeal Joint Arthrodesis

A Retrospective Analysis of the Peg-in-Hole and End-to-End Procedures

Bradley M. Lamm, BS*
Carla E. Ribeiro, BS*
Tracey C. Vlahovic, BS*
Anthony Fiorilli, BS†
Gary R. Bauer, DPM‡
Howard J. Hillstrom, PhD§

A retrospective study was performed to compare the prevalence of complications in peg-in-hole and end-to-end arthrodesis procedures. The authors reviewed 177 second, third, and fourth proximal interphalangeal joint fusions for the correction of hammer toe deformities in 85 patients from 1988 to 1998 at the Temple University School of Podiatric Medicine. The average age of the patients was 49 years. Sixteen percent (14) of the subjects were male and 84% were (71) female. Upon follow-up, the fourth digit was generally associated with a greater number of complications for the end-to-end and peg-in-hole procedures, with the second digit being the most common site of fusion. The prevalence of complications was evaluated using contingency table analysis and expressed as a percent of total complications (27%, the end-to-end group; 17%, the peg-in-hole group). A subset of complications deemed clinically relevant was also computed. Similarly, the prevalence of clinically relevant complications for the end-to-end (10%) and the peg-in-hole (9%) procedures was not statistically significant. Therefore, this study showed no statistically significant differences in the total or clinically relevant complications between end-to-end and the peg-in-hole arthrodesis procedures. (J Am Podiatr Med Assoc 91(7): 331-336, 2001)

In 1910, Soule[1] first described the proximal interphalangeal joint arthrodesis of the lesser digits. The head of the proximal phalanx and base of the middle phalanx were resected via a plantar incision. Buried cat-gut sutures were used to reapproximate the subcutaneous structures and a plaster of Paris bandage maintained the digits in extension for 6 weeks. A Kirschner wire was first used by Taylor and Sheffield[2] in 1940 to improve the stability of the fusion site for earlier mobilization and ambulation. Similarly, in 1941, Selig[3] used a Kirschner wire across the arthrodesis site while adding a bend at the distal end of the wire to prevent pin migration.

In 1931, Higgs[4] developed the spike-in-hole arthrodesis procedure, which involves resection of the articular surfaces of the proximal interphalangeal joint. A sharp cone or "spike" was constructed out of the

*Submitted during fourth year, Temple University School of Podiatric Medicine, Philadelphia, PA.

†Submitted during second year, Temple University School of Podiatric Medicine, Philadelphia, PA.

‡Associate Professor, Department of Surgery, Temple University School of Podiatric Medicine, Philadelphia, PA.

§Associate Professor, Department of Orthopedics and Biomechanics, Director, Gait Study Center, Temple University School of Podiatric Medicine. *Mailing address:* Eighth at Race St, Philadelphia, PA 19107.

proximal phalangeal head, which was then inserted into a hole bored in the marrow cavity of the base of the middle phalanx. In 1938, Young[5] improved this procedure by converting the spike into a truncated cone and maintaining the integrity of the central dorsal cortex. In 1983, Schlefman et al[6] modified this technique into what is known today as the peg-in-hole arthrodesis. The authors fashioned a peg out of the dorsal cortex of the proximal phalangeal head, drilled a corresponding hole in the medullary canal of the middle phalangeal base, and used Kirschner wire fixation.

Several fixation methods have been utilized in lesser proximal interphalangeal joint arthrodeses, including the Reese screw with distal threads in the counterclockwise direction and proximal threads in the clockwise direction,[7] Orthosorb (Johnson & Johnson Orthopaedics, Inc, Brunswick, New Jersey) absorbable pin fixation,[8] 26-gauge monofilament wire,[9] and the standard 0.045 or 0.062 Kirschner wire.[10]

In 1984, Martin et al[11] reported a case of pin-tract infection in the fourth toe following trauma to a proximal interphalangeal joint arthrodesis in a 35-year-old man. In addition, in 1987 Reese et al[12] performed 156 digital fusions with Kirschner wire fixation and reported an 18% pin-tract infection rate. The authors presumed that poor hygiene, prolonged duration Kirschner wire fixation, and loosening of the Kirschner wire were the contributory factors.

In 1995, Creighton and Blustein[13] reported using a buried Kirschner wire technique for fixation of the end-to-end arthrodesis. The authors performed this procedure on 30 patients for a total of 46 digits. The second digit was the most commonly fused digit. Sixty-three percent of the digits demonstrated radiographic osseous union or good bone-to-bone apposition. In 33% of the cases (15 Kirschner wires), the buried Kirschner wire extruded through the end of the digit during the postoperative course. In one case, a pin-tract infection was noted, necessitating removal of the Kirschner wire. Seven additional Kirschner wires had to be removed, two as a result of trauma, one as a result of metatarsophalangeal joint space encroachment, and four as a result of sensitivity at the tip of the digit.

Alvine and Garvin[8] reported a fusion rate of 97% with no infections by implementing the peg-and-dowel technique. Two of the 75 procedures resulted in pseudoarthroses, both of which involved the fourth toe. The authors discovered that the fourth toe was technically difficult to fuse due to its small size.

Schlefman et al[6] performed 125 peg-in-hole arthrodesis procedures on 43 patients (34 females, 9 males) that yielded a 100% fusion rate. However, the authors recorded a 16% minor complication rate, including metatarsalgia, reflex sympathetic disorder (which resolved after physical therapy), and postoperative contracture of a scar.

In 1979, Newman and Fitton[14] performed 22 proximal phalangectomies, 56 flexor-to-extensor transfers, 28 end-to-end arthrodeses, 15 end-to-end arthrodeses with single Kirschner wire fixation, and 15 peg-and-socket or spike-in-hole proximal interphalangeal joint arthrodeses as described by Higgs.[4] The average follow-up was 2.6 years and the total fusion rate was 64% of the arthrodesis operations. The authors found an overall complication rate of 10% secondary to medial or lateral deviation of the digit. Patient satisfaction was recorded as a percentage of pain relief. The peg-and-socket arthrodesis was 60% successful in relieving symptoms and the proximal phalangectomy was 80% successful in relieving symptoms.

End-to-End *versus* Peg-in-Hole Techniques

The proximal interphalangeal joint arthrodesis is a popular surgical procedure among foot and ankle surgeons for reducing hammer toes.[15] The two procedures performed most often are the peg-in-hole and the end-to-end arthrodesis, which are comprised of different geometrical constructs.

The end-to-end procedure creates minimal digital shortening[10] and is easy to perform. However, distraction of the distal segment along the Kirschner wire can result in pseudoarthrosis, malunion, delayed union, or nonunion.[16] Furthermore, the distal segment has the possibility of rotating in the frontal plane.[17, 18] According to Monson et al,[16] the end-to-end arthrodesis is the most common procedure for lesser metatarsal proximal interphalangeal joint fusions.

The peg-in-hole construct affords rapid side-to-side osseous union secondary to the increased cancellous bony contact, which augments the construct's inherent stability.[6] Therefore, proper seating of the peg is necessary to obtain good osseous union; otherwise, delayed union or nonunion can result.[6, 16] Schlefman et al[6] reported that the peg-in-hole arthrodesis promotes fast healing and has fewer pseudoarthroses than the end-to-end procedure. The most common postoperative complication was a fractured peg with the middle phalanx overriding the proximal phalanx.[6, 16] Lehman and Smith[19] preferred the peg-in-hole arthrodesis because of its increased rate of fusion and patient satisfaction. However, the peg-in-hole arthrodesis is a more technically difficult procedure to perform and also prolongs intraoperative time as compared with the end-to-end procedure.[6, 16]

The purpose of this study was to compare the nature and prevalence of total and clinically relevant complications seen with the end-to-end and peg-in-hole arthrodesis procedures.

Materials and Methods

The authors reviewed 177 end-to-end and peg-in-hole proximal interphalangeal joint fusions from a total of 85 patients seen at the Foot and Ankle Institute at the Temple University School of Podiatric Medicine in Philadelphia, Pennsylvania, from 1988 to 1998.

Assessment parameters were obtained from postoperative reports, preoperative and postoperative radiographs, and patient demographics. Chart reviews included the type of procedure, date of surgery, number of procedures, the surgical digit, surgical complications, radiographic evidence of healing, and sex and age of the patient.

Preoperative and postoperative radiographs (anteroposterior, lateral, and medial oblique views) were evaluated for alignment, angulation, apposition, rotation, and healing. The authors selected the immediate postoperative radiographs to view the overall alignment of the digits and presence of gapping (with or without pin fixation). Preconsolidation radiographs were reviewed to identify the first sign of trabecular bone crossing the arthrodesis site. Lastly, postconsolidation radiographs were reviewed to assess osseous union and mark the end point of follow-up. The criteria for osseous fusion were based on 1) no gapping at the arthrodesis site, 2) good alignment of the fused digit, and 3) trabeculations crossing the arthrodesis site. A delayed union was defined as any arthrodesis that did not heal within 6 months postoperatively, and a nonunion was defined as any fusion site that did not heal within 9 months postoperatively. Essentially, a nonunion and a pseudoarthrosis are clinically and radiographically indistinguishable. However, the authors recorded these complications as different entities in order to remain consistent with the way they were reported in the medical records. The size and type of fixation were not recorded because of the incompleteness of the postoperative notes.

After collection of the aforementioned parameters, the prevalence of complications (nonunions, delayed unions, pseudoarthroses, malunions, revisional surgeries, infections, and pain) was evaluated using contingency table analysis. The prevalence was expressed as a percent of the total complications and a percent of the clinically relevant complications (ie, a subset of the total complications). These clinically relevant complications included malunions, revisional surgeries, infections, and pain, which were defined as those complications requiring additional therapeutic intervention.

Results

The authors selected a total of 85 patients between the ages of 14 and 82, with an average age of 49 years, who had end-to-end and peg-in-hole procedures. The patient population consisted of 71 females (84%) and 14 males (16%). A total of 177 digital fusions were reviewed: 91 end-to-end and 86 peg-in-hole arthrodeses. Follow-up time for the end-to-end group averaged 8 months. The peg-in-hole group averaged 14 months, resulting in a mean of 11 months for both procedures combined (Table 1).

Approximately 50% of the digital fusions were performed on the second digit and 25% on both the third and fourth digits (Table 2). Table 3 reports the total complications for each digit in both groups. The following complications were observed: nonunions, delayed unions, pseudoarthroses, malunions, revisional surgeries, infections, and pain. The fourth digit was associated with the highest complication rate in both the end-to-end group (43%) and the peg-in-hole group (33%). The authors then excluded those complications that were not clinically relevant (nonunions, delayed unions, and pseudoarthroses). The third digit was associated with the highest complication rate in the end-to-end group (16%) and the fourth digit was associated with the highest complication rate in the peg-in-hole group (17%) (Table 4). Based on the chart review, there were seven nonunions, seven delayed

Table 1. Demographics of Patients

	End-to-End	Peg-in-Hole	Total
Number of patients	48	37	85
Males	8	6	14
Females	40	31	71
Number of digits	91	86	177
Average age (years)	49	49	49
Average follow-up (months)	8	14	11

Table 2. Digits Most Commonly Fused

	End-to-End	Peg-in-Hole
Second	45 (50%)	47 (55%)
Third	25 (27%)	21 (24%)
Fourth	21 (23%)	18 (21%)
Total digits	91	86

Table 3. Digits Associated with Total Complications

	End-to-End			Peg-in-Hole		
	2nd	3rd	4th	2nd	3rd	4th
Nonunions	1	2	4	3	0	2
Delayed unions	4	0	3	1	0	1
Pseudoarthroses	1	1	0	0	0	0
Malunions	0	0	0	0	0	0
Revisional surgeries	2	2	1	0	0	1
Infections	1	1	1	0	0	0
Pain	0	1	0	3	2	2
Total	9	7	9	7	2	6
Complications (%)	20	28	43	15	10	33

Table 4. Digits Associated with Clinically Relevant Complications

	End-to-End			Peg-in-Hole		
	2nd	3rd	4th	2nd	3rd	4th
Malunions	0	0	0	0	0	0
Revisional surgeries	2	2	1	0	0	1
Infections	1	1	1	0	0	0
Pain	0	1	0	3	2	2
Total	3	4	2	3	2	3
Complications (%)	7	16	10	6	10	17

unions, two pseudoarthroses, no malunions, five revisional surgeries, three infections, and one painful digit for the end-to-end group. The peg-in-hole group had five nonunions, two delayed unions, no pseudoarthroses, no malunions, one revisional surgery, no infections, and seven painful digits.

A 27% total complication rate for the end-to-end group and a 17% complication rate for the peg-in-hole group were determined. These data demonstrated a trend of increased complications associated with the end-to-end procedure. However, after chi-square analysis, the percent of total complications between procedures was not statistically significant (χ^2 =1.61, P = .20) (Table 5). The authors then excluded those complications that were not clinically relevant and found that the complication rate for the peg-in-hole group was 9% and the end-to-end group was 10% (χ^2 = 0.15, P = .90) (Table 6). Therefore, the results showed no statistically significant differences in total or clinically relevant complications between the peg-in-hole and end-to-end arthrodesis, despite differences in their structural, technical, and surgical constructs.

Discussion

The digital arthrodesis was most frequently performed on the second digit in middle-aged women, which is consistent with the literature.[6, 9, 11, 12, 20] This retrospective study found that the highest percentage of clinically relevant complications occurred in the third digit for the end-to-end (43%) arthrodesis

Table 5. Total Complications

	End-to-End	Peg-in-Hole
Nonunions	7	5
Delayed unions	7	2
Pseudoarthroses	2	0
Malunions	0	0
Revisional surgeries	5	1
Infections	3	0
Pain	1	7
Total digits	25	15
Complications (%)	27	17

Note: P = .20.

Table 6. Clinically Relevant Complications

	End-to-End	Peg-in-Hole
Malunions	0	0
Revisional surgeries	5	1
Infections	3	0
Pain	1	7
Total digits	9	8
Complications (%)	10	9

Note: P = .90.

and in the fourth digit for the peg-in-hole (17%) arthrodesis. Similarly, Alvine and Garvin[8] studied the peg-in-hole procedure exclusively and reported that the fourth digit was associated with more complications, was technically more difficult to fuse, and frequently resulted in pseudoarthrosis.

Complications found in this study included nonunions, delayed unions, pseudoarthroses, revisional surgeries, infections, and painful digits. Additional complications reported in the literature include metatarsalgia, residual numbness, lack of toe purchase, reflex sympathetic disorder, postoperative scar contracture, deviation of the digit in the transverse plane, shoe wear restrictions, bending of the Kirschner wire, flexion contracture of the distal interphalangeal joint, residual edema, and limited range of motion of the metatarsophalangeal joint.[16]

The results of this study indicate that the end-to-end group (27%) had a higher total complication rate than the peg-in-hole group (17%). According to the literature, the peg-in-hole procedure has been associated with lower complication rates and relatively higher success (fusion) rates compared with the end-to-end arthrodesis. Schlefman et al,[6] Alvine and Garvin,[8] and Lehman and Smith[19] reported successful fusion rates for the peg-in-hole arthrodesis of 100%, 97%, and 95%, respectively. An 83% fusion rate for the peg-in-hole arthrodesis was observed in this study, which is slightly less then the previously mentioned literature. Patton et al[9] and Ohm et al[10] found a 100% fusion rate for the end-to-end approach in contrast to the 73% fusion rate observed in this study for the same procedure. More recently, Creighton and Blustein[13] performed the end-to-end arthrodesis using buried Kirschner wire fixation with a 63% fusion rate. The fusion rates reported in the literature were based on different criteria as well as surgical technique and therefore were difficult to compare.

Side-to-side healing seen in peg-in-hole arthrodesis *versus* the longitudinal healing in end-to-end arthrodesis has been theorized to have less associated complications and a greater chance of osseous union.[6] There is also a preconceived notion that the peg-in-hole procedure is structurally superior to the end-to-end procedure. This theory has been anecdotally described throughout the literature and the authors have confirmed this in a study yet to be published. Since the peg-in-hole arthrodesis is a technically difficult procedure to perform, patients are subjected to longer surgical procedure times with potential increased risk for complications.[6, 16] In reconstructive surgeries of the forefoot, midfoot, or rearfoot, a proximal interphalangeal joint arthrodesis may be ancillary and therefore most surgeons opt to perform an end-to-end arthrodesis, which is easier to perform and less time consuming.

The retrospective design of this study had some limitations. In both the literature and this study, a number of charts had inadequate information for follow-up. For example, postoperative radiographs were missing, postoperative clinical outcomes were not reported, or the type of a given complication was not specified. In this study, those patients were excluded from further analysis; therefore, the 177 digital fusion cases reported all had adequate follow-up data. However, this study found that the end-to-end procedure had almost half the follow-up time (8 months) when compared with the peg-in-hole procedure (14 months). Unfortunately, in a retrospective study, it was not possible to determine why this phenomenon had occurred.

Finally, it is important to make a distinction between the textbook definition of a complication *versus* those that are truly clinically relevant. For example, a delayed or nonunion may be considered a complication, but in most postoperative management of a digital arthrodesis the treatment plan would remain unchanged. Overall, the chi-square analysis yielded no statistically significant difference in the total and clinically relevant complication rates of the end-to-end and peg-in-hole arthrodesis. Therefore, the lack of significant differences in complication rates allows surgeons to base their preference on training and patient need.

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