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ORIGINAL ARTICLE
Reconstructive

Lateral Polydactyly of the Foot: Surgical Outcomes Based on a New Classification

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Background: The objective of this study was to propose a novel classification for lateral polydactyly of the foot that integrates both visual appearance and radiographic findings and to delineate surgical techniques and their outcomes based on this classification.

Methods: This study enrolled 148 feet from 126 patients who underwent initial surgery at our hospital between January 2009 and July 2021. The new classification system was derived from visual appearance according to the Hirase classification and radiological bifurcation level (D: distal or middle phalanx, P: proximal phalanx, and M: metatarsal). Incidence rates, surgical procedures, and surgical outcomes were compared across each type.

Results: Morphologically, 25 cases were classified as type A, 43 cases as type B1, and 80 cases as type B2. The branching level was categorized as D in 81 feet, P in 41 feet, and M in 26 feet, with 68 feet (46%) classified as B2-D type. Excision of the sixth toes was performed in all type A cases, whereas the majority of type B cases required excision of the fifth toes. Revision procedures were conducted on 8 feet. Three patients with type A-P classification developed painful hammer toe deformities as a late sequela that necessitated extensor tenolysis and metatarsophalangeal joint contracture release during their school-age years.

Conclusions: The classification system based on the combination of visual appearance and radiological branching level was both straightforward and beneficial for surgical planning and for predicting surgical outcomes and late sequelae. *(Plast Reconstr Surg Glob Open 2025; 13:e6463; doi: 10.1097/GOX.0000000000006463; Published online 21 January 2025.)*

INTRODUCTION

The incidence of polydactyly of the foot in Japan is reported to be 5 per 1000 live births and is occasionally encountered in daily medical practice. Approximately 80% of these cases manifest as lateral polydactyly on the peroneal side.[1,2]

Several studies have explored the classification of lateral polydactyly. Watanabe et al[2] classified various types of foot polydactyly based on the level of duplication. However, distinctions between medial, central, or lateral polydactyly entail different characteristics, thus necessitating varied reconstruction strategies based on the duplicated rays. A classification tailored specifically to lateral polydactyly may be preferable. Konno and Hirase[3] categorized postaxial polydactyly based on syndactyly appearance but overlooked radiographic findings. Their classification later became widely adopted as the Hirase classification. Lee et al[1] classified polydactyly into 7 categories by combining morphological and radiographical findings, with an emphasis on the "origin of the accessory digit," thus complicating the determination of appropriate treatment for each case.

We advocate a simpler classification that can offer guidance to all surgeons in determining a surgical approach

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that ultimately leads to improved outcomes. The objective of treating lateral polydactyly and polysyndactyly extends beyond improving appearance to reconstructing the foot for comfortable shoe wear without pain. Therefore, the selection of the toe to be excised holds significance. This study aimed to propose a straightforward classification of lateral polydactyly of the foot based on a combination of appearance and radiographic findings and to delineate surgical techniques and their outcomes based on this simplified classification.

Takeaways

Question: This study was to propose a novel classification for lateral polydactyly of the foot.

Findings: The classification system based on the combination of visual appearance and radiological branching level was both straightforward and beneficial for surgical planning and for predicting surgical outcomes and late sequelae.

Meaning: We advocate a simpler classification that can offer guidance to all surgeons in determining a surgical approach that ultimately leads to improved outcomes.

MATERIALS AND METHODS

Approval for this retrospective study was obtained from the institutional review board of our hospital. We analyzed data from 148 feet of 126 patients who underwent initial surgery at our facility between January 2009 and July 2021. Among these patients, 61 were male and 65 were female, with 22 patients presenting bilateral involvement. The patients' medical records, surgical records, and radiographic images were retrospectively examined. A positive family history of congenital limb anomalies was noted in 10 patients. Additionally, 12 patients exhibited concurrent anomalies, including bilateral little finger polydactyly in 5 patients, bilateral ulnar polysyndactyly in 2 patients, and various other anomalies such as brachymesophalangy, cutaneous syndactyly of the bilateral ring and little finger, cleft lip, labial fusion, and spina bifida, each in 1 patient. Patient age at the time of surgery ranged from 8 months to 3 years and 6 months. Procedures were performed by three surgeons (authors), who determined the surgical approach for each case. Postoperative follow-up was conducted by the operating surgeons themselves and spanned from 4 months to 16 years and 1 month.

The new classification system relied on both visual appearance and bifurcation level observed on x-ray images, as delineated in Supplemental Digital Content 1. (**See figure, Supplementary Digital Content 1,** which displays a novel classification based on both the visual characteristics according to the Hirase classification and the level of bifurcation observed on x-rays. The horizontal axis represents the appearance categorized by the Hirase classification, whereas the vertical axis illustrates the radiological branching level, **http://links.lww.com/PRSGO/D796**.) The Hirase classification was used for assessment of appearance, distinguishing between type A (without syndactyly), type B1 (syndactyly of the fifth and sixth toes), and type B2 (syndactyly of the fourth to sixth toes). Radiographically, feet branching at either the distal or middle phalanx were categorized as distal type (D), those branching at the proximal phalanx as proximal (P), and those at the metatarsal as metatarsal (M). Each foot was assigned a combined morphological-radiological type, such as B1-D. Subsequently, all feet were retrospectively classified using this new system, and the incidence of each type was documented. Primary surgical techniques and rates of revision were compared between the groups, and the reasons for the revision surgery were investigated.

Occasionally, the phalanges of lateral toes are excessively short, leading to the development of cosmetically displeasing feet. The relative length of the proximal phalanx was calculated as a percentage of the preserved toe length to that of the fourth toe. A "short toe" was defined as having a relative length of less than 50%. The incidence of short toes was compared between each group

Surgical Technique

In type A polydactyly, excision of the sixth toe was performed. A spindle-shaped incision was made at the base of the sixth toe, and the incision was extended proximally to explore the bifurcation site. The abductor digiti minimi was detached from the sixth toe and then sutured back to the fifth ray after complete excision of the sixth ray. A corrective osteotomy was performed in 4 feet with a Y-shaped metatarsal bifurcation (Fig. 1). The skin was trimmed so that the suture line was positioned in the lateral midline.

In type B, excision of the fifth toe was performed in the majority of cases. A typical surgical technique for type B2-D is described in Figure 2. A rectangular skin flap was created over the fifth toe to provide an interdigital space. The bones of the fifth toe, including the nail, were completely resected. If a cartilaginous connection between the fifth and sixth phalanges was present, it was shaved to slim the sixth toe. The medial aspect of the sixth toe was covered with a thinned local skin flap, and surplus skin was grafted if necessary. The lateral aspect of the fourth toe was covered by skin harvested from the excised fifth toe. At the end of the surgery, the fourth and sixth toes were sutured together for 2 weeks to control abduction and rotation deformity of the sixth toe (Fig. 2D). These sutures acted as a splint, which is crucial for achieving well-aligned toes. If the remaining proximal phalanx of the sixth toe was very short, the interdigital space was created deeper than usual to enhance the appearance of the toe.

RESULTS

The numbers of feet in each group are tabulated in Table 1. Morphologically, there were 25 feet of type A (17%), 43 of type B1 (29%), and 80 of type B2 (54%). Radiological branching varied among the morphological types. In type A, 44% of the toes exhibited type A-M branching, whereas 85% of type B2 toes exhibited B2-D branching. "Short toes" were observed in 8 feet; 7 of which were classified as B1-P and 1 as B2-P. There were no occurrences of short toes in type A.

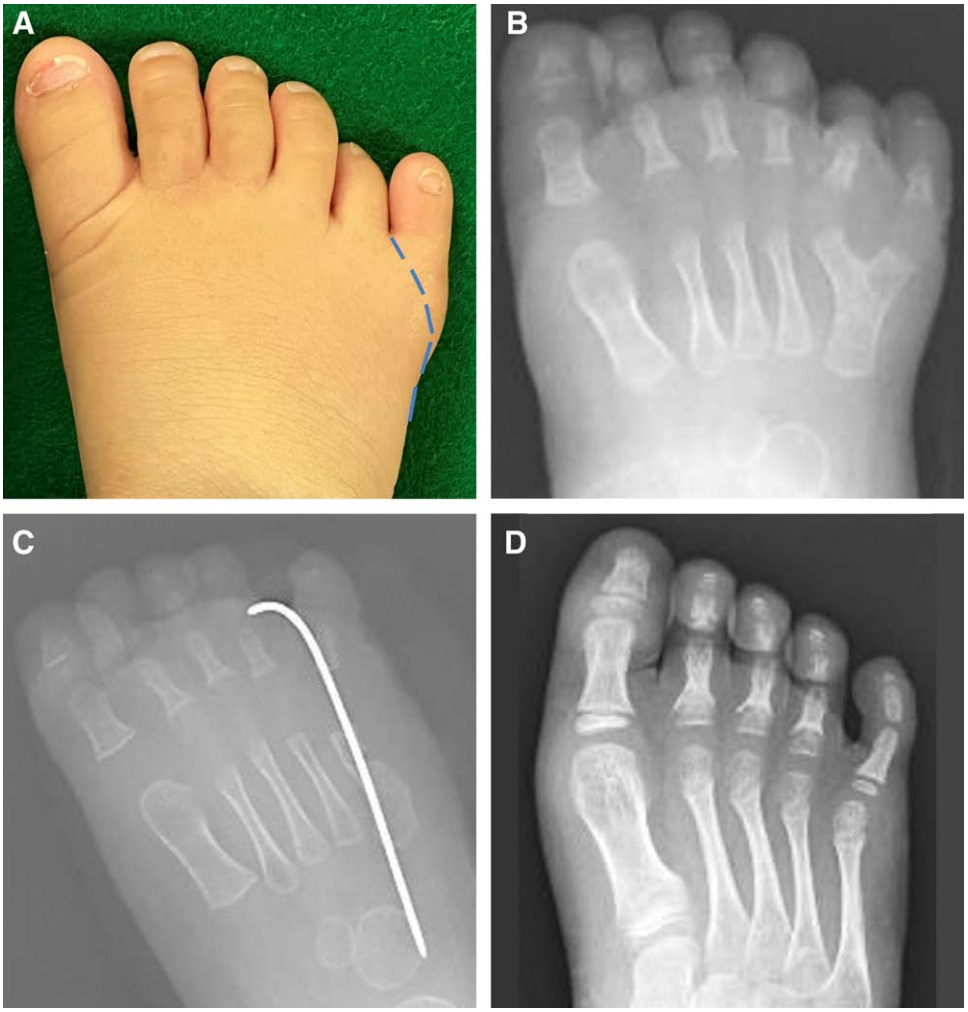

Fig. 1. Representation of a type A-M foot. A, Preoperative appearance. The dotted lines indicate a spindle-shaped skin incision. B, The type A-M foot exhibited Y-shaped metatarsal bifurcation. C, Surgical excision of the sixth toe and corrective metatarsal osteotomy were performed. D, Five years postsurgery, the x-ray revealed favorable alignment of the fifth metatarsal.

Table 2 presents the toes resected in each group. The sixth toes were excised in all type A feet, whereas the fifth toes were excised in all type B2 feet. However, the sixth toe was excised in 3 feet of B1-D and 1 foot of B1-P, in which the fifth ray demonstrated better bony alignment and more aesthetically pleasing nails.

Metatarsal osteotomy was performed in 4 of 11 type A-M feet. In these cases, the fifth metatarsal exhibited a Y-shaped bifurcation. As simple resection of the sixth rays may have led to varus deformity of the remaining metatarsal, initial corrective osteotomy was performed (Fig. 1). None of the type B1 or B2 feet required metatarsal osteotomy.

Revision procedures were conducted in 8 feet (5.3%) of 7 patients (Table 3). Patient age at the time of revision surgery ranged from 2 to 15 years old. Excision of phalangeal remnants was performed in 1 foot (B1-P), and scar excision and deepening of the interdigital space were performed in 2 feet (B2-D and B2-P). Correction of abduction deformity was performed in 1 case of bilateral polydactyly (B1-M and B2-M).

In 3 patients with type A-P, painful hammer toe deformity developed as a late sequela (Fig. 3). All 3 feet had undergone excision of the sixth toes with metatarsal head shaving. Stiffness of the metatarsophalangeal (MTP) joint was observed during follow-up examinations that gradually became symptomatic. Extensor tendon and MTP joint release were performed for these 3 feet at patient ages of 7, 8, and 15 years, respectively.

Three of 8 short toes remained short at the final follow-up, whereas the other 5 toes grew to approximately 60%–70% of the length of the fourth toe. One patient (case 7) underwent revision surgery to deepen the interdigital space at the age of 3 years to improve appearance. (**See figure, Supplementary Digital Content 2**, which displays representation of a type B2-P foot with a short toe [case 7]. A, Preoperative x-ray. The length of the proximal phalanx in the preserved ray, compared with that of the fourth proximal phalanx, is 41%. B, Postoperative x-ray. The fifth toe was excised at 11 months old. C, At the age of 3, the fifth

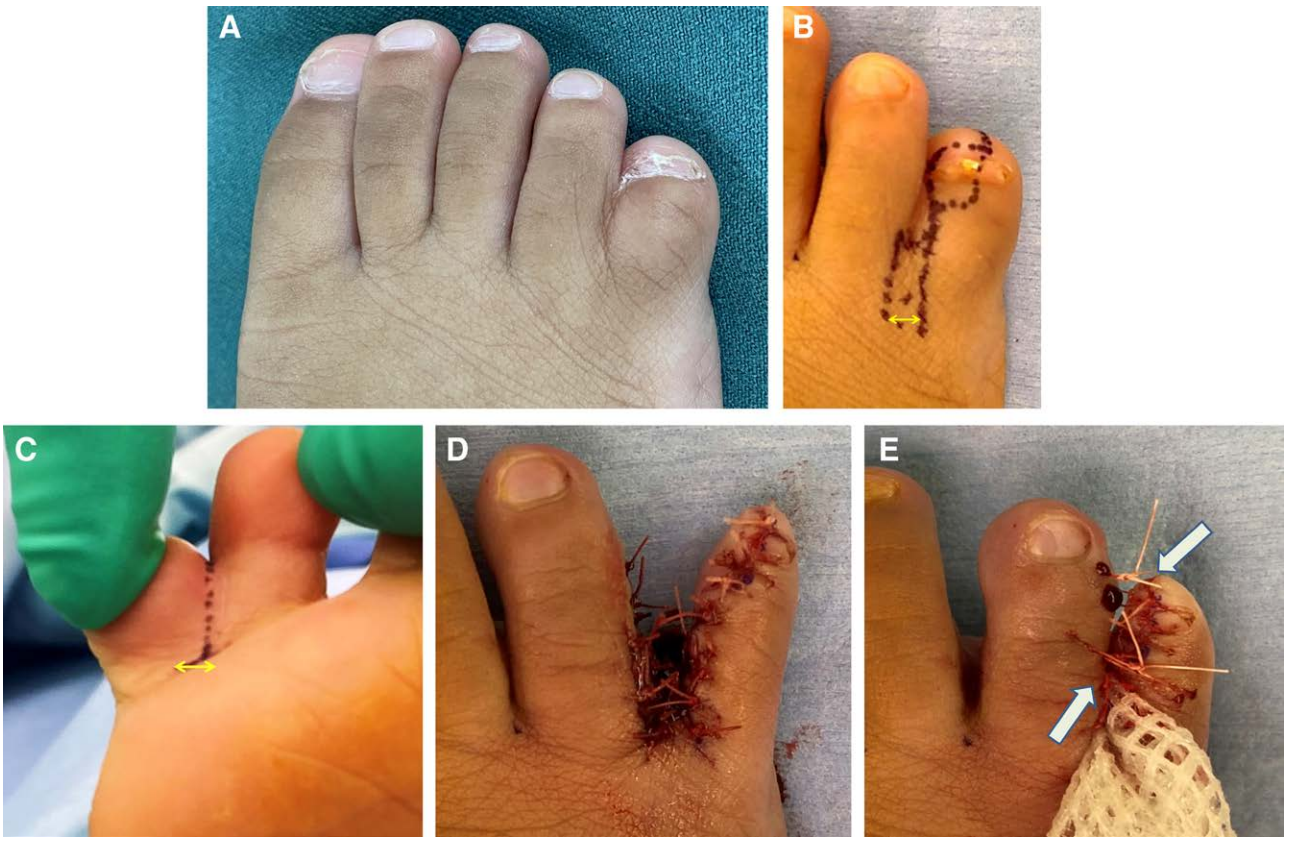

Fig. 2. Surgical techniques for type B2-D. A, Preoperative visual depiction of the toes. Syndactyly was present between the fourth, fifth, and sixth toes. B and C, Creation of a dorsal rectangular skin flap over the fifth toe for interdigital space. The plantar skin incision followed an L-shaped pattern, with the transverse incision at the base matching the width of the dorsal flap (indicated by arrows). D, The sixth toe exhibited abduction after resection of the fifth toe and skin grafting. E, Suturing of the fourth and sixth toes together for 2 weeks to correct rotation and abduction.

Table 1. The Numbers of treated Feet According to New Classification

		Appearance			
		A	**B1**	**B2**	**Total No.**
Branching level	D (Distal)	0	13	68	81
	P (Proximal)	14	19 (7)	8 (1)	41
	M (Metatarsal)	11	11	4	26
	Total No.	25	43	80	148 feet

The figure in parentheses indicates the number of "short toes."

Table 2. The Resected Toes in Each Group

	A: 25 Feet	**B1: 43 Feet**	**B2: 80 Feet**
D (distal)	0	(10/3)	(68/0)
P (proximal)	(0/14)	(18/1)	(8/0)
M (metatarsal)	(0/11)	(11/0)	(4/0)

The numbers of (fifth/ sixth) toes resection.

toe appeared significantly short with keloid formation. Excision of scar tissue and deepening of the interdigital space were performed. D, A photograph at the age of 11. E, The relative length of the proximal phalanx, compared with that of the fourth proximal phalanx, remained at 41% on x-ray, **http://links.lww.com/PRSGO/D797**.)

DISCUSSION

Lateral polydactyly stands as one of the prevailing congenital anomalies encountered in routine clinical practice. Although various classification systems[2,3] have been proposed, none have proven to be sufficiently straightforward or comprehensive for decisively guiding surgical intervention. Although previous studies have explored

Table 3. The Details of Revision Procedures

Case No.	Age at Revision Surgery (y)	Polydactyly Type	Procedure
1	7	A-P	Correction of hammer toe deformity
2	8	A-P	Correction of hammer toe deformity
3	15	A-P	Correction of hammer toe deformity
4	8	B1-P	Excision of remnant
5	3	B1-M, B2-M	Correction of abduction deformity
6	2	B2-D	Deepening interdigital space
7	3	B2-P	Deepening interdigital space

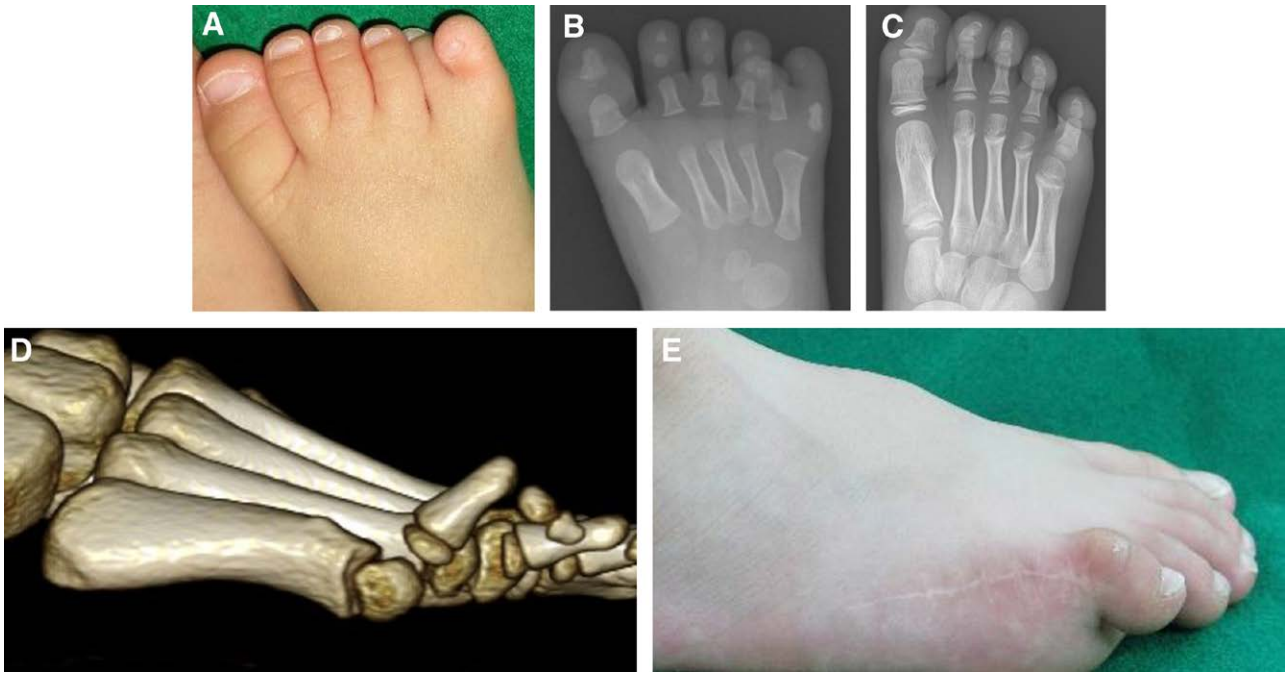

Fig. 3. Case 1 required revision surgery due to painful hammer toe deformity. A and B, Preoperative photograph and x-ray demonstrating type A-P polydactyly. Simple excision of the sixth toe with metatarsal head shaving was performed. C–E, At age 7, the A-P x-ray displayed favorable growth of the fifth ray. The lateral view exhibited hammer toe deformity and painful scarring on the dorsal aspect of the fifth toe.

advanced evaluation and classification methods utilizing artificial intelligence and 3-dimensional imaging,[4,5] we have developed a practical classification system based solely on conventional x-ray images and visual appearance. This classification is both time-efficient and cost-effective, demonstrating significant utility in clinical practice. We contend that a simple classification scheme integrating both visual and radiographic assessments is imperative for effective surgical planning. Preoperative radiographic evaluation is indispensable, particularly in cases involving infants or children. Surgeons must anticipate skeletal growth to ensure not only aesthetically pleasing toes but also functional forefeet devoid of discomfort during adulthood.

Although the morphological Hirase classification is commonly used for determining which toe to excise, it tends to overlook radiographic findings. By incorporating radiographic data, our new classification system delineates distinct characteristics within each subgroup, such as the occurrence of short toes in type B1-P or late hammer toe deformities in type A-P. Notably, we identified several exceptional cases within types B1-D and P; specifically, 4 (14%) of 28 feet required sixth toe removal due to poor alignment observed on x-rays. Despite its simplicity, this new classification system comprehensively encompassed all lateral polydactylies encountered in our study.

Numerous reports advocate for the resection of sixth toes in type A polydactyly,[6] a recommendation supported by our findings. However, within our study cohort, 4 of 11 type A-M feet required metatarsal osteotomy at the initial surgery. Varus deformities were corrected and stabilized using K-wires, obviating the need for revision surgery. Given the tender age of the patients, some degree of remodeling can be anticipated with growth. However, persistent metatarsal angular deformities could lead to toe deviation or plantar protrusion of the MTP joint, potentially resulting in discomfort during weight bearing. Primary osteotomies can be executed through the same incision, with bone healing exhibiting remarkable efficacy in this age group.

Type A-P toes were similarly managed through sixth toe resection, yet 3 of the 14 A-P feet (21%) required revision

surgery due to painful hammer toe deformities. Although the initial procedures were straightforward, stiffness of the fifth MTP joint was noted during follow-up examinations that eventually culminated in hammer toe deformities. The etiology of this deformity remains unclear because it was exclusively observed in type A-P cases. Attention should be directed toward evaluating tendon excursion and MTP joint compatibility during the initial surgery, with meticulous long-term follow-up essential for such patients. Early intervention with passive motion exercises and/or night splints may help prevent this deformity.

Several reports advocate for sixth toe resection and syndactyly separation in type B polydactyly cases,[7,8] aiming to prevent postoperative abduction deformities of the remaining toes. However, we advocate toe resection based on the radiographic findings. Careful examination of radiographs typically reveals superior alignment of the sixth toe in all B2 and the majority of B1 cases. Moreover, resecting the fifth toe offers the added benefit of simultaneously obtaining an interdigital space, with local skin grafting being a viable option. To address sixth toe abduction deformities, we advocate suturing of the preserved toe to the fourth toe for 2 weeks, which is akin to splinting. The majority of our cases demonstrated favorable outcomes, but 1 patient (case 5), who had had bilateral metatarsal branching, needed revision surgery.

We observed instances in which the proximal phalanx exhibited short and delta-shaped deformities in type B-P polydactyly. Preoperatively, 8 of the 27 type B-P polydactyly cases presented with short toes, with 3 cases retaining this trait during follow-up. Although these short toes did not result in functional deficits, they posed cosmetic incongruities. One patient (case 7) required revision surgery to deepen the interdigital space at the age of 3 years to enhance appearance. Although previous studies have proposed intricate reconstruction techniques to lengthen such toes,[9] we adopted a simpler approach, deepening the interphalangeal space during the initial surgery and excising the longitudinal portion of the aberrant physis of the delta-shaped bone,[10] thereby anticipating improved proximal phalanx growth.

Our retrospective analysis revealed a revision rate of 5.3%. With meticulous preoperative planning and precise surgical execution, most deformities can be circumvented, barring cases such as hammer toe deformities. This new classification system can serve as a valuable tool for guiding primary surgery, ultimately fostering the creation of aesthetically pleasing and functional feet.

A limitation of our study lies in its retrospective nature and the inclusion of cases with limited follow-up. Nevertheless, our new classification system offers a simple yet effective framework for surgical planning that minimizes potential pitfalls and facilitates the attainment of aesthetically pleasing, pain-free feet.

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DISCLOSURES

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