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Surgical Outcomes and Complications of Hand and Foot Polydactyly in Children: A Systematic Review

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Abstract

Background: Polydactyly is a heterogeneous congenital limb anomaly in children affecting the hand or foot. Surgical management aims to restore function, alignment, stability, and acceptable appearance, but outcomes may vary according to anatomical subtype and reconstructive complexity. This systematic review evaluated surgical outcomes and complications of pediatric hand and foot polydactyly.

Methods: PubMed, Scopus, Web of Science, Embase, and Google Scholar were searched for studies published from January 2010 through January 2026. Eligible studies included original clinical research involving children with congenital hand and/or foot polydactyly undergoing surgical treatment and reporting functional, aesthetic, or complication-related outcomes. Two reviewers independently extracted data and assessed methodological quality using design-appropriate tools. Due to substantial clinical and methodological heterogeneity, findings were synthesized narratively.

Results: The search identified 2,123 records. After duplicate removal and screening, 96 articles underwent full-text assessment, of which 84 were excluded. Twelve studies were included in the qualitative synthesis. Overall, surgical correction generally resulted in favorable functional and aesthetic outcomes. However, residual or recurrent deformity, malalignment, instability, stiffness, scar-related problems, wound complications, infection, pain, and neurovascular symptoms were reported. Some patients required secondary corrective surgery. Outcomes appeared to be influenced by anatomical subtype, reconstructive complexity, relative development of duplicated digits or rays, and surgical technique. Hand and foot procedures demonstrated distinct functional priorities, limiting direct comparison of outcomes.

Conclusions: Surgical treatment generally provides favorable outcomes in children with hand and foot polydactyly, but residual deformity and postoperative complications remain clinically relevant. An individualized, anatomy-based reconstructive strategy is preferable to a universal operative approach. Prospective multicenter studies with standardized outcome measures and long-term follow-up are needed.

Key Words: Foot Polydactyly; Hand Polydactyly; Polydactyly; Pediatric Surgery; Surgical Outcomes.

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1- INTRODUCTION

Polydactyly is one of the most common congenital limb anomalies in children and is characterized by the presence of one or more supernumerary digits in the hand or foot. Its clinical presentation is highly heterogeneous, ranging from a small, rudimentary accessory digit to complex duplications involving bones, joints, tendons, ligaments, neurovascular structures, and surrounding soft tissues (1). Polydactyly may occur as an isolated anomaly or as part of a broader genetic or syndromic condition. Anatomically, it is commonly classified as preaxial, postaxial, or central according to the location of the duplicated digit. This phenotypic diversity has important implications for treatment because the anatomical characteristics of the duplicated structures, rather than the presence of an additional digit alone, largely determine the appropriate reconstructive strategy (2).

Surgical management is generally considered when polydactyly causes functional impairment, progressive deformity, difficulty with footwear or hand use, or unacceptable cosmetic appearance. However, the primary objective of surgery is not simply excision of the accessory digit. Successful reconstruction requires restoration of appropriate skeletal alignment, joint stability, soft-tissue balance, tendon function, and satisfactory appearance while preserving the greatest possible functional potential of the remaining digit or ray (3). These considerations are particularly important in children because surgical reconstruction must accommodate ongoing skeletal growth and changes in functional demands. Consequently, an apparently satisfactory early postoperative result may not necessarily represent a durable long-term outcome (4).

The surgical approach varies considerably according to the anatomical subtype and complexity of the deformity. In hand polydactyly, particularly radial polydactyly, treatment may involve excision of one duplicated digit combined with reconstruction of collateral ligaments, tendons, joints, or other soft-tissue structures (5). More complex duplications may require procedures tailored to the relative size and function of the duplicated digits rather than simple removal. In foot polydactyly, surgical decision-making may similarly involve excision of an accessory digit or ray, correction of angular deformity, reconstruction of the first or affected ray, and soft-tissue balancing. Thus, differences in surgical technique may reflect underlying anatomical complexity and should be interpreted within the context of the specific polydactyly subtype (6).

Although surgical correction generally produces favorable functional and cosmetic results, postoperative complications remain clinically important. Reported complications include residual or recurrent angular deformity, joint instability or stiffness, malalignment, scar-related problems, infection, wound complications, nail abnormalities, pain, neurovascular symptoms, and the need for revision surgery (7). In addition, some complications may become apparent only during subsequent growth. The distinction between early postoperative complications and growth-related or late deformities is therefore particularly relevant when assessing the effectiveness and durability of surgical treatment in children (8).

Despite the substantial clinical literature on pediatric polydactyly, the available evidence remains fragmented and heterogeneous. Studies differ considerably in patient selection, anatomical classification, surgical techniques, outcome definitions, and duration of follow-up. Functional outcomes are also inconsistently assessed, with some studies emphasizing range of motion or strength,

whereas others primarily report radiographic alignment, cosmetic appearance, parental satisfaction, pain, or postoperative complications (9). Furthermore, previous reviews have often focused on a specific anatomical subtype or a single treatment strategy, limiting their ability to provide an integrated assessment of outcomes across both the hand and foot. These differences make direct comparison of surgical approaches challenging and hinder identification of factors that may influence postoperative success or complications (10).

A comprehensive synthesis of the pediatric evidence is therefore needed to clarify the overall effectiveness and safety of surgical treatment for hand and foot polydactyly. Accordingly, this systematic review aims to evaluate surgical outcomes and complications following operative treatment of polydactyly in children, incorporating evidence from both the hand and foot. We specifically sought to characterize the surgical approaches used across different anatomical subtypes, assess functional, radiographic, and aesthetic outcomes, determine the spectrum and frequency of postoperative complications, and identify factors associated with unfavorable outcomes or secondary surgical intervention. By integrating these findings, this review seeks to provide clinically relevant evidence to support individualized surgical decision-making and highlight areas requiring more standardized outcome assessment and higher-quality prospective research.

2- METHODS

This systematic review was designed to comprehensively evaluate surgical outcomes and postoperative complications of hand and foot polydactyly in children. The review was conducted in accordance with established methodological principles for systematic reviews and reported according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) 2020 guidelines (11). The review focused on published evidence describing the surgical management of pediatric polydactyly, with particular emphasis on postoperative functional and aesthetic outcomes, complication profiles, the need for revision surgery, and factors potentially associated with treatment success or adverse outcomes.

The literature search covered studies published from January 2010 through January 2026. This broad timeframe was selected to capture the evolution of surgical approaches to pediatric polydactyly, including changes in operative techniques, reconstructive strategies, perioperative management, and approaches to postoperative assessment. Because polydactyly encompasses a heterogeneous group of congenital limb anomalies involving both the upper and lower extremities, studies addressing hand and/or foot polydactyly in pediatric populations were considered eligible when they provided relevant surgical outcome or complication data.

To enhance methodological transparency and minimize the potential for selection and reporting bias, predefined eligibility criteria were established before study selection. Data were systematically extracted regarding patient characteristics, type and anatomical distribution of polydactyly, surgical technique, age at surgery, follow-up duration, functional and cosmetic outcomes, postoperative complications, recurrence or residual deformity, and the requirement for additional or revision procedures. Where sufficient information was available, outcomes were considered separately for hand and foot polydactyly and according to the underlying anatomical subtype or surgical approach.

The review protocol was developed in accordance with systematic review

methodology. “The protocol was prospectively registered in PROSPERO (CRD420261484862). Registration was intended to promote methodological transparency, reduce the risk of selective reporting, and establish the review objectives and eligibility criteria before completion of the evidence synthesis. In addition to protocol registration, the review adhered to PRISMA 2020 recommendations, and detailed information regarding the search strategy, study selection process, data extraction, assessment of methodological quality or risk of bias, and methods of evidence synthesis was documented to facilitate reproducibility.

2-1. Information Sources

To identify relevant evidence, a systematic literature search was conducted across five major electronic databases. The search included PubMed, Scopus, Web of Science, Embase, and Google Scholar, which were selected because of their broad coverage of biomedical, surgical, orthopedic, and pediatric research. These databases were systematically searched to retrieve studies addressing the surgical management, clinical outcomes, and postoperative complications of hand and foot polydactyly in children. The use of multiple databases was intended to maximize the retrieval of potentially eligible studies and reduce the likelihood of missing relevant evidence published across different medical and surgical disciplines.

2-2. Search Strategy

A comprehensive search strategy was developed and tailored to the specific indexing requirements of each database. Relevant keywords, controlled vocabulary terms, and Boolean operators (AND/OR) were combined to identify studies investigating surgical treatment and postoperative outcomes of hand and foot polydactyly in children. The search strategy incorporated terms related to the condition, pediatric population, surgical intervention, treatment outcomes, and postoperative complications to maximize the retrieval of potentially eligible studies. The search strategies were adapted appropriately for PubMed, Scopus, Web of Science, Embase, and Google Scholar. The detailed search strategies for each database are presented in Table 1.

2-3. Eligibility Criteria

The eligibility criteria were predefined according to the PICO framework to ensure a focused and reproducible study selection process.

- **Population (P):** Studies involving children with congenital hand and/or foot polydactyly, without restriction according to sex or specific anatomical subtype. Studies including mixed pediatric and adult populations were considered eligible only when pediatric data could be extracted separately.

- **Intervention (I):** Surgical treatment of polydactyly, including excision or reconstruction of the supernumerary digit and other established operative techniques for correction of hand or foot polydactyly.

- **Comparator (C):** Studies with or without a comparator group were eligible. Where comparative data were available, different surgical techniques, treatment strategies, or relevant clinical subgroups were considered for comparison.

- **Outcomes (O):** Studies were required to report at least one clinically relevant postoperative outcome, including functional outcome, cosmetic/aesthetic outcome, postoperative complications, recurrence or residual deformity, need for revision surgery, patient or parent satisfaction, or other measures of surgical success.

Studies were eligible when they provided original clinical data relevant to the surgical management of pediatric hand or

foot polydactyly. No restriction was imposed on the specific surgical technique or duration of follow-up, provided that postoperative outcomes were reported.

Table-1. Database-specific search strategies.

Database	Search Strategy
PubMed	("Polydactyly"[Mesh] OR polydactyly[tiab] OR polydactyl*[tiab] OR "supernumerary digit*"[tiab] OR "duplicated digit*"[tiab]) AND ("Child"[Mesh] OR "Infant"[Mesh] OR "Adolescent"[Mesh] OR child*[tiab] OR pediatric*[tiab] OR paediatric*[tiab] OR infant*[tiab] OR adolescent*[tiab]) AND ("Surgical Procedures, Operative"[Mesh] OR surg*[tiab] OR excision[tiab] OR resection[tiab] OR reconstruction[tiab] OR correction[tiab] OR ligation[tiab]) AND ("2010/01/01"[Date - Publication] : "2026/01/31"[Date - Publication])
Scopus	TITLE-ABS-KEY (polydactyly OR polydactyl* OR "supernumerary digit*" OR "duplicated digit*") AND TITLE-ABS-KEY (child* OR pediatric* OR paediatric* OR infant* OR adolescent*) AND TITLE-ABS-KEY (surg* OR excision OR resection OR reconstruction OR correction OR ligation) AND PUBYEAR > 2009 AND PUBYEAR < 2027
Web of Science	TS=(polydactyly OR polydactyl* OR "supernumerary digit*" OR "duplicated digit*") AND TS=(child* OR pediatric* OR paediatric* OR infant* OR adolescent*) AND TS=(surg* OR excision OR resection OR reconstruction OR correction OR ligation) AND PY=(2010-2026)
Embase	('polydactyly'/exp OR polydactyly:ti,ab OR polydactyl*:ti,ab OR 'supernumerary digit*':ti,ab OR 'duplicated digit*':ti,ab) AND ('child'/exp OR 'adolescent'/exp OR 'infant'/exp OR child*:ti,ab OR pediatric*:ti,ab OR paediatric*:ti,ab OR infant*:ti,ab OR adolescent*:ti,ab) AND ('surgery'/exp OR surg*:ti,ab OR excision:ti,ab OR resection:ti,ab OR reconstruction:ti,ab OR correction:ti,ab OR ligation:ti,ab) AND [2010-2026]/py
Google Scholar	polydactyly OR "supernumerary digit" OR "duplicated digit" AND (child OR pediatric OR paediatric OR infant OR adolescent) AND (surgery OR excision OR reconstruction OR resection OR ligation) AND (outcomes OR complications OR functional OR aesthetic OR deformity)

2-4. Exclusion Criteria

Studies were excluded if they met any of the following criteria:

1. Population or clinical focus was outside the scope of the review, including studies that focused exclusively on adult patients, non-congenital digital anomalies, or conditions other than pediatric hand or foot polydactyly. Studies in mixed-age populations were excluded when pediatric-specific data could not be separately identified.

2. No relevant surgical intervention or outcome data were provided, including studies that did not evaluate surgical treatment of polydactyly or failed to report postoperative clinical, functional, aesthetic, or complication-related outcomes.

3. The publication did not provide original empirical data, such as narrative reviews, systematic reviews, meta-analyses, editorials, letters to the editor, commentaries, conference abstracts, or expert opinions. Previously published reviews were not included as primary evidence or subjected to outcome extraction.

4. Studies involving non-human subjects or experimental models without applicable clinical data in pediatric patients were excluded.

5. Articles not published in English were excluded because of the predefined language criterion.

6. Insufficient information was available for outcome assessment, particularly when the report did not provide adequate data regarding the surgical procedure, postoperative outcomes, or complications necessary to determine its relevance to the review question.

7. Duplicate publications or overlapping reports from the same study population were excluded, with the most comprehensive or informative report retained for analysis.

2-5. Data Extraction and Management

Data extraction was performed independently by two reviewers using a predefined and standardized data extraction form developed specifically for this systematic review. The following information was collected from each eligible study:

Author/ Year, Anatomical site, Polydactyly type, Study design, Sample, Surgical treatment / comparison, Main postoperative outcomes.

Clinical and Surgical Characteristics type and anatomical classification of polydactyly, age at surgery, surgical technique, type of procedure performed, laterality, and duration of postoperative follow-up.

Outcomes – functional outcomes, cosmetic or aesthetic results, postoperative complications, residual deformity, recurrence, neurovascular or wound-related complications, patient or parent satisfaction, and the need for revision or secondary surgery.

Methodological Characteristics methods used for outcome assessment, measurement instruments or clinical evaluation criteria, and relevant statistical or analytical approaches.

Reference records identified through the database searches were initially organized and screened for duplicate records. Bibliographic information was subsequently managed using reference-management software to facilitate deduplication, citation management, and organization of the retrieved literature. The search strategy was developed based on the predefined research question and eligibility criteria and was independently reviewed by members of the research team to ensure adequate coverage of relevant terminology and concepts.

Any discrepancies between the two reviewers during study selection or data extraction were resolved through discussion and consensus. When consensus could not be reached, a third reviewer was consulted to make the final decision. These procedures were implemented to minimize extraction errors, reduce reviewer-related bias, and maintain consistency and reproducibility throughout the review process.

2-6. Outcome Extraction

Outcomes were extracted as defined and reported in the individual included studies. No standardized outcome definition was imposed by the reviewers, and the original study-specific definitions and assessment approaches were retained wherever reported. Extracted outcomes included surgical success, functional and cosmetic outcomes, postoperative complications, recurrence, range of motion, and other postoperative findings reported by the respective study authors. Because outcome definitions and assessment methods varied across studies, these differences were retained in the data extraction and considered when interpreting the findings and conducting the narrative synthesis.

2-7. Quality Assessment

The methodological quality of the included studies was independently assessed by two reviewers using the standard Newcastle–Ottawa Scale (NOS) for observational studies. All included

studies were non-interventional observational clinical studies; therefore, the NOS was considered appropriate despite differences in the timing and method of data collection. In particular, the study described as having prospective enrollment with retrospective reassessment was considered observational because participants were not prospectively assigned to an intervention and no experimental allocation was performed. The standard NOS was applied without study-specific modification, assessing the relevant domains of study selection, comparability, and outcome assessment. Any disagreements between reviewers were resolved through discussion and consensus, with consultation of a third reviewer when necessary. Quality assessment findings were considered when interpreting the evidence, and studies were not excluded solely because of methodological limitations.

2-8. Data Synthesis

Given the anticipated heterogeneity among the included studies with respect to study design, patient characteristics, types of polydactyly, surgical techniques, outcome definitions, and duration of follow-up, the findings were primarily synthesized using a qualitative narrative approach. This approach enabled systematic comparison and interpretation of the reported surgical outcomes and postoperative complications while accounting for differences in clinical and methodological characteristics across studies.

The extracted data were independently reviewed by two reviewers, who evaluated patterns and similarities across the reported findings. Outcomes were organized into clinically relevant categories, including functional outcomes, aesthetic and cosmetic results, postoperative complications, residual or recurrent deformity, patient or parental satisfaction, and the need for revision or secondary surgery. Where sufficient information was available, findings were further considered according to the anatomical site of involvement (hand versus foot), polydactyly subtype, and surgical technique.

Differences between reviewers in the interpretation or categorization of findings were resolved through discussion and consensus, with consultation of a third reviewer when necessary. Rather than indiscriminately combining clinically heterogeneous outcomes, the synthesis emphasized the direction, consistency, and clinical relevance of findings across studies. Quantitative pooling was considered only when studies demonstrated adequate similarity in population, intervention, outcome definitions, and reporting methods; otherwise, results were summarized descriptively.

The final synthesis therefore focused on identifying consistent patterns in surgical effectiveness, functional and aesthetic recovery, complication profiles, and factors potentially influencing postoperative outcomes in children undergoing surgery for hand or foot polydactyly. Particular attention was given to differences between upper- and lower-extremity procedures and to variations in surgical approaches, while acknowledging the methodological limitations and heterogeneity of the available evidence.

3- RESULTS

The systematic search yielded 2,123 records from the five electronic databases. Following the removal of duplicate records 1,484 unique records were retained for title and abstract screening. At this stage 1,388 records were excluded because they did not meet the predefined eligibility criteria. The remaining 96 articles underwent full-text assessment. Of these 84 studies were excluded for reasons including

inappropriate study design, absence of relevant surgical outcome data, insufficient reporting of postoperative outcomes, overlapping patient populations, or publication types that did not meet the eligibility criteria. Ultimately 12 studies fulfilled all inclusion criteria and were incorporated into the qualitative synthesis. The complete selection process is illustrated in the PRISMA flow diagram (Figure 1).

3-1. Characteristics of the Included Studies

The methodological and clinical characteristics of the 12 included studies are summarized in Table 2. Considerable variability was observed across the studies with respect to study design, patient characteristics, anatomical subtype of polydactyly, operative technique, outcome assessment, and duration of follow-up. The included literature encompassed different forms of hand and foot polydactyly, reflecting the broad anatomical and clinical spectrum of this congenital anomaly. The reported surgical approaches varied according to the anatomical configuration and relative development of the supernumerary and primary digits.

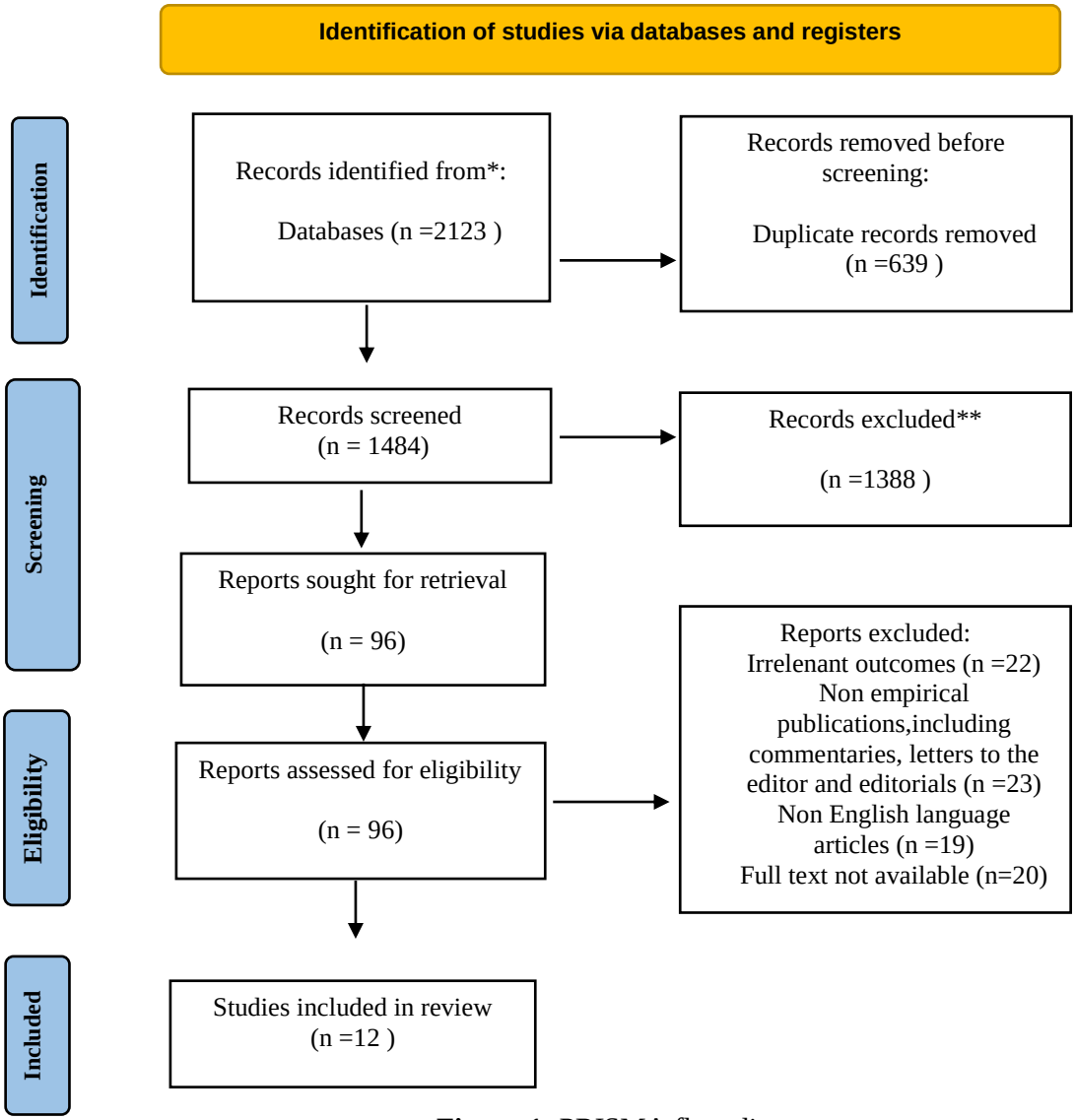


Figure-1: PRISMA flow diagram.

In hand polydactyly, surgical management generally involved excision of the less functional or less developed digit, with reconstructive procedures used when preservation or reconstruction of shared anatomical structures was required. For foot polydactyly, surgical treatment similarly focused on removal of the less dominant ray and preservation or reconstruction of the structurally and functionally preferable digit. These differences in operative strategy contributed substantially to the heterogeneity of reported outcomes.

3-2. Surgical Outcomes

Overall, the available evidence suggested that surgical correction of pediatric hand and foot polydactyly generally produces satisfactory functional and aesthetic results. Most studies reported preservation or improvement of function following correction, although the magnitude and definition of functional improvement differed considerably between studies. Functional assessment was performed using heterogeneous clinical criteria, including range of motion, digit alignment, stability, grip or pinch function, gait-related parameters in foot involvement, and clinician- or parent-reported assessments (12).

For hand polydactyly, favorable functional outcomes were generally associated with successful reconstruction or preservation of the dominant digit and appropriate correction of angular or rotational deformity. Nevertheless, residual malalignment, instability, restricted motion, or persistent deformity were reported in a subset of patients. Recent systematic evidence focusing on pediatric preaxial hand polydactyly similarly demonstrates substantial variability in long-term outcomes and highlights bone-related complications as an important contributor to suboptimal thumb function (13).

In foot polydactyly, most reports described satisfactory postoperative function and the ability to use conventional footwear. However, residual aesthetic deformity remained a relatively important concern. Previous evidence focusing on lower-extremity postaxial polydactyly has reported generally favorable long-term functional outcomes but identified residual deformity, including residual valgus, as an important postoperative issue (14).

3-3. Postoperative Complications

Postoperative complications varied substantially among the included studies. The reported adverse outcomes included residual deformity, malalignment, recurrence or persistence of deformity, scar-related problems, wound complications, infection, neurovascular symptoms, stiffness, pain, and the need for secondary corrective surgery. The frequency of individual complications could not be directly compared across all studies because definitions, follow-up periods, and methods of outcome assessment were inconsistent (15).

The available evidence suggests that complications were influenced not only by the surgical procedure itself but also by the anatomical subtype of polydactyly, complexity of reconstruction, age at surgery, relative development of the duplicated digits, and the presence of associated structural abnormalities. In particular, procedures requiring reconstruction of shared bones, joints, tendons, or soft tissues appeared to carry a greater potential for residual functional or structural abnormalities than simple excision procedures (16).

Evidence from studies of ulnar/postaxial hand polydactyly further illustrates the importance of surgical technique in postoperative morbidity. A systematic review comparing suture ligation with surgical excision found substantial heterogeneity but reported higher

complication rates with ligation in the largest comparative cohort. Similarly, a subsequent systematic review and meta-analysis reported pooled adverse-event rates of approximately 22% following ligation versus 1% following surgical excision, although the underlying studies were predominantly observational and had important methodological limitations. These findings support the interpretation that the choice of technique may influence postoperative morbidity, although direct comparisons across different forms of polydactyly should be made cautiously (8).

3-4. Residual Deformity and Aesthetic Outcomes

Aesthetic outcome represented an important component of treatment success, particularly because surgical correction of polydactyly is frequently undertaken during childhood with the expectation of achieving both functional restoration and an acceptable external appearance. Most included studies reported generally favorable cosmetic results; however, residual angular deformity, contour abnormalities, scar visibility, and incomplete correction were described in a proportion of patients (17).

The occurrence of residual deformity appeared to be particularly relevant in anatomically complex forms of polydactyly in which the duplicated digits shared skeletal or soft-tissue structures. In such cases, achieving an optimal cosmetic appearance while maintaining adequate stability and function may require more extensive reconstructive procedures and, in some patients, secondary correction (18).

3-5. Revision and Secondary Surgery

The requirement for additional surgery was reported inconsistently across the included studies. Where secondary procedures were described, they were generally undertaken to address residual deformity, malalignment, instability, functional limitation, or unsatisfactory cosmetic appearance. The reported need for revision surgery therefore appeared to represent both a measure of postoperative complication and an indicator of the limitations of the initial reconstructive procedure (19).

The available literature emphasizes that revision rates should be interpreted in the context of follow-up duration. Some residual deformities may become clinically apparent only with growth, particularly in children undergoing reconstruction of duplicated skeletal structures. Consequently, studies with shorter follow-up may underestimate the eventual frequency of secondary correction (20).

3-6. Differences Between Hand and Foot Polydactyly

The synthesis indicated clinically meaningful differences between hand and foot polydactyly. Hand surgery primarily emphasized preservation of fine motor function, digit stability, range of motion, alignment, and thumb or finger function, whereas surgical correction of foot polydactyly placed greater emphasis on weight-bearing function, footwear compatibility, alignment, and cosmetic contour (21).

Despite these differences, both groups demonstrated a common pattern: overall favorable surgical outcomes accompanied by a variable risk of residual deformity and postoperative complications. The heterogeneity of anatomical classifications and operative techniques prevented reliable direct comparison of complication rates between hand and foot procedures (2).

3-7. Overall Synthesis

Taken together, the evidence indicates that surgical treatment is an effective approach for correcting pediatric hand and foot polydactyly, with most children achieving satisfactory functional and aesthetic outcomes. However, the

results should not be interpreted as evidence of uniformly uncomplicated recovery. A clinically relevant proportion of patients may develop residual deformity, scar-related concerns, functional limitations, or other postoperative complications, and some require subsequent corrective surgery (22).

The principal limitation of the available evidence was substantial clinical and methodological heterogeneity. Differences in polydactyly classification, surgical techniques, outcome definitions, follow-up duration, and reporting practices limited the feasibility of direct quantitative comparison across studies (23). Moreover, much of the available evidence is based on retrospective observational studies or case series, which limits causal inference and increases susceptibility to selection and reporting bias. These considerations support cautious interpretation of the pooled evidence and highlight the need for prospective studies using standardized functional, aesthetic, and patient-reported outcome measures (24).

4- DISCUSSIONS

This systematic review demonstrates that surgical treatment of pediatric hand and foot polydactyly is generally associated with favorable functional and aesthetic outcomes, but the available evidence does not support the assumption that correction is uniformly uncomplicated or that a single operative strategy is appropriate across all anatomical subtypes. The central finding of this review is that postoperative outcome appears to be determined less by the mere removal of the supernumerary digit than by the quality of anatomical reconstruction. Preservation of the dominant digit, restoration of axial alignment and joint stability, appropriate management of shared skeletal and soft-tissue structures, and maintenance of a satisfactory contour are therefore more meaningful indicators of surgical success than excision alone.

Anatomical complexity is a major determinant of outcome

Polydactyly is not a single surgical entity. Preaxial, postaxial, and central duplications differ substantially in their skeletal anatomy, soft-tissue relationships, functional requirements, and reconstructive demands. This distinction provides an important explanation for the heterogeneity observed among the included studies. In particular, preaxial hand polydactyly may involve duplication or partial duplication of phalanges, metacarpals, joints, tendons, ligaments, and neurovascular structures. Consequently, the technical challenge is frequently not removal of one digit but reconstruction of a stable, well-aligned, and functional remaining digit (17, 24).

This interpretation is supported by contemporary evidence. A recent systematic review of long-term outcomes following surgery for pediatric preaxial hand polydactyly identified substantial numbers of postoperative complications and additional procedures, with skeletal abnormalities representing an important component of adverse outcomes. Earlier clinical literature has similarly shown that postoperative function and appearance vary according to the complexity of the duplication, with more complex anatomical patterns generally associated with less predictable outcomes. Thus, anatomical classification should not merely serve as a descriptive variable; it should be considered a prognostic variable and a determinant of surgical strategy (25).

Surgical success should be defined by reconstruction rather than excision

A clinically important implication of the present findings is that simple removal of the less developed digit should not automatically be equated with successful treatment. In complex duplications,

inadequate correction of angular deformity, instability, tendon imbalance, or abnormal joint morphology may leave the child with a residual deformity despite technically successful excision (8, 26).

For hand polydactyly, this issue is particularly relevant to thumb duplication. The objective of reconstruction is to create a stable thumb with appropriate length, alignment, motion, strength, and appearance. Existing evidence indicates that residual angulation and structural abnormalities may adversely affect both functional and cosmetic outcomes, while postoperative instability and pain can lead to later revision surgery (27, 28).

The same principle applies to foot polydactyly, although the functional priorities differ. In lower-extremity disease, preservation of an appropriately aligned ray, adequate weight-bearing, comfortable shoewear, and acceptable foot contour are fundamental. A systematic review of postaxial foot polydactyly found generally excellent long-term functional outcomes but persistent concerns regarding residual deformity and aesthetic appearance, demonstrating that apparently successful functional correction does not necessarily imply complete anatomical correction (29).

Complications reflect both technique and patient selection

The complication profile identified in this review should be interpreted in relation to both surgical technique and underlying anatomy. Residual deformity, malalignment, scar-related problems, pain, stiffness, wound complications, and secondary procedures were reported across the literature, but their frequency varied substantially (17, 30).

Evidence from postaxial ulnar hand polydactyly provides an instructive example. A systematic review comparing suture ligation with surgical excision found substantial heterogeneity but reported a complication rate as high as 23.5% with ligation compared with 3% following surgical excision in the largest cohort. More recent meta-analytic evidence similarly found adverse events to be substantially more frequent after ligation than surgical removal, although the certainty of these comparisons was limited by high risk of bias and heterogeneous outcome definitions (26, 31).

These findings suggest that the intervention itself may influence postoperative morbidity, but they should not be extrapolated to all forms of polydactyly. A pedunculated type B ulnar duplication is fundamentally different from a complex preaxial thumb duplication or central foot polydactyly. Therefore, the appropriate clinical question is not simply "Which procedure has the lowest complication rate?", but rather "Which procedure is most appropriate for the specific anatomical configuration while minimizing residual deformity and preserving function?"(8, 29)

Residual deformity may be more clinically important than early complications

One of the most relevant patterns emerging from the evidence is the distinction between early perioperative complications and late structural complications. Wound problems or infection may be readily identifiable during the early postoperative period, whereas angular deformity, instability, abnormal growth, or dissatisfaction with appearance may become apparent only after months or years (24).

This is particularly important in children because the operated limb continues to grow. A reconstruction that appears satisfactory immediately after surgery may subsequently demonstrate residual angulation or altered joint mechanics. Contemporary evidence in preaxial hand

polydactyly has reported persistent angular deformity and other structural abnormalities during longer-term follow-up, while lower-extremity literature has similarly identified residual valgus as an important late outcome (17).

Accordingly, postoperative surveillance should not be limited to wound healing or early range of motion. Long-term alignment, joint stability, growth-related changes, function, and patient or parental satisfaction are essential components of outcome assessment. This also explains why studies with short follow-up may underestimate the true burden of postoperative morbidity (32).

Functional and aesthetic outcomes should be evaluated together

The present review further suggests that functional and aesthetic outcomes are closely interconnected rather than independent endpoints. A residual angular deformity may compromise both mechanical function and appearance, while an aesthetically unsatisfactory reconstruction may generate dissatisfaction despite acceptable objective function (28).

This relationship is particularly relevant in pediatric hand surgery, where residual deformity can affect grasp, pinch, joint mechanics, and appearance simultaneously. In foot polydactyly, the relationship is similarly important because residual widening, valgus deformity, abnormal contour, or scar formation may influence both footwear and cosmetic satisfaction. Existing lower-extremity evidence demonstrates that although difficulties with mobility and footwear are relatively uncommon after appropriate correction, residual aesthetic deformity remains a meaningful postoperative issue (17).

Therefore, future studies should avoid defining "success" exclusively through surgeon-assessed function. A more clinically meaningful framework would combine objective functional assessment, radiographic alignment, complication rates, revision surgery, and patient- or parent-reported satisfaction (8).

Hand and foot polydactyly should not be pooled indiscriminately

An important methodological implication of this review is that hand and foot polydactyly should be considered related but distinct surgical conditions. The functional requirements of the thumb or fingers differ fundamentally from those of the toes and weight-bearing rays. Consequently, pooling all surgical outcomes into a single estimate risks masking clinically important differences (33).

For the hand, relevant outcomes include digit stability, range of motion, pinch and grasp, alignment, and tendon function. For the foot, appropriate outcomes include weight-bearing, gait, footwear tolerance, pressure distribution, residual deformity, and cosmetic appearance. The existing literature on lower-extremity postaxial polydactyly has specifically emphasized residual deformity, scar cosmesis, mobility, and shoe wear as outcome domains, supporting the need for anatomy-specific assessment (34).

This distinction should also influence future meta-analyses. Rather than treating polydactyly as one homogeneous condition, evidence synthesis should be stratified by anatomical location, preaxial versus postaxial versus central classification, and complexity of duplication (35).

The evidence does not establish a universal optimal surgical technique

Despite generally favorable outcomes, the current literature remains insufficient to establish one universally superior surgical technique. The main reason is not necessarily that surgical methods are ineffective, but that comparisons are

frequently confounded by case selection. More complex deformities are likely to receive more extensive reconstruction, whereas simpler duplications may be treated with limited excision. Comparing complication rates between these groups without accounting for baseline anatomical complexity can therefore produce misleading conclusions (32).

This problem is evident in the literature on ulnar polydactyly, where systematic reviews have demonstrated potentially lower complication rates following surgical excision than ligation but have simultaneously emphasized substantial heterogeneity and limitations in the underlying evidence. Similarly, contemporary evidence on preaxial polydactyly indicates that outcomes vary according to the underlying anatomical classification, supporting an individualized rather than uniform surgical approach. Thus, the available evidence supports anatomy-driven reconstruction rather than procedure-driven treatment algorithms (30).

Clinical implications

From a clinical perspective, the findings support a treatment pathway beginning with detailed anatomical characterization rather than immediate selection of an operative technique. Preoperative assessment should determine which duplicated digit or ray is functionally dominant, evaluate skeletal and joint anatomy, identify shared tendons and soft tissues, and assess alignment and stability (26).

The surgical objective should then be the preservation or reconstruction of the most functional anatomical unit while minimizing residual deformity. In the foot, the decision should additionally consider weight-bearing mechanics, footwear, and the preservation of an appropriately positioned ray (17). For complex central foot polydactyly, published surgical descriptions similarly emphasize the preservation of the best-aligned digit, correction of alignment, soft-tissue stabilization, and adequate coverage. Importantly, families should be counseled that a favorable immediate postoperative appearance does not eliminate the possibility of later residual deformity or revision. This is particularly relevant in complex duplications in which growth may reveal abnormalities not apparent at the time of primary reconstruction (31).

Strength of the evidence and implications for interpretation

The principal limitation of the current evidence base is its methodological heterogeneity. Differences in study design, anatomical classification, surgical technique, outcome definitions, and follow-up make direct comparison difficult. The literature also contains a substantial proportion of retrospective cohorts and case series, increasing susceptibility to selection bias, incomplete follow-up, and inconsistent outcome reporting. Similar limitations have been identified in previous systematic reviews of pediatric polydactyly (23).

Another important issue is the lack of standardized definitions for complications and revision surgery. A residual deformity identified radiographically is not necessarily equivalent to a clinically symptomatic deformity requiring intervention. Likewise, a planned secondary reconstruction should not be classified in the same manner as an unplanned revision for surgical failure. Overall, the available evidence does not support a universally superior surgical technique for pediatric hand or foot polydactyly. Surgical selection should therefore be individualized according to anatomical characteristics, functional requirements, associated deformities, and anticipated cosmetic outcomes (36).

Table-2. Characteristics and Surgical Outcomes of Included Studies on Pediatric Hand and Foot Polydactyly.

Author/ Year	Anatomical site	Polydactyly type	Study design	Sample	Surgical treatment / comparison	Main postoperative outcomes
Almeida 2017 (26)	Hand	Preaxial/radial	Retrospective clinical study	109	Surgical reconstruction	Residual deformity, alignment, functional and aesthetic outcomes
Monjardino 2023 (24)	Hand	Radial/preaxial thumb duplication	Retrospective cohort	11	Excision and reconstruction	Tada, Horii and Tien scores, ROM, stability, alignment, cosmetic/functional satisfaction
Ganju 2024 (29)	Hand	Postaxial type B	Retrospective cohort	258	Ligation vs surgical excision	Pain, sensitivity, scar, residual nubbin, complications
Cordray 2025 (8)	Hand	Postaxial type A	Multicenter retrospective cohort	64	Reconstructive surgery	Complications, scar assessment, aesthetics, PROMIS, patient-reported outcomes
Banala 2026 (27)	Hand	Postaxial type B	Retrospective cohort	620	Office vs OR excision	Surgical outcomes, complications, treatment setting
Young 2026 (36)	Hand	Mixed	Retrospective national database study	3,880	Surgical correction vs suture ligation	Postoperative complications, treatment patterns, timing
Zeniya 2025 (17)	Foot	Postaxial	Retrospective chart review	25	Excision with emphasis on collateral ligament reconstruction	Long-term alignment, stability, postoperative outcomes
Farr 2021 (32)	Foot	Preaxial, central and postaxial	Prospective enrollment with retrospective reassessment	52	Resection	VAS, PODCI, ASK, AOFAS, radiographs, pedobarography, complications, revision
Kubat 2018 (30)	Foot	Preaxial & postaxial	Retrospective cohort	48	Surgical excision/reconstruction	Long-term clinical outcome, functional/aesthetic result, comparison by age at surgery
Burger 2020 (28)	Foot	Preaxial, Type IV & VI	Retrospective comparative study	14	Medial vs lateral hallux excision	Plantar pressure, foot function, aesthetics, PROMs, reoperation
Rae Ko 2021 (37)	Foot	Postaxial fifth-toe polysyndactyly	Retrospective cohort	90	Medial duplicated-toe excision + dorsal rectangular flap	Surgical outcomes, complications, predictive factors, cosmetic results
Soo Jin Woo 2021 (23)	Foot	Postaxial polysyndactyly	Retrospective case-control study	38	Fifth vs sixth toe excision	Forefoot width, toe length, alignment, complications, cosmetic satisfaction

Future studies should therefore distinguish between minor postoperative events, persistent structural abnormalities, symptomatic complications, growth-related deformity, and unplanned reoperation. The heterogeneity also explains why the findings of this review should be interpreted primarily as evidence of consistent clinical patterns rather than precise estimates of treatment effect. The literature provides reasonable support for the effectiveness of surgical correction but

substantially weaker evidence for the superiority of one technique over another.

4-1. Future Research Priorities

Future research should move beyond retrospective descriptions of surgical experience toward prospective, multicenter studies using standardized classifications and outcome measures. At a minimum, studies should report the anatomical subtype, operative technique, age at surgery, follow-up duration, functional outcome, aesthetic outcome, complications, and revision surgery using predefined definitions. Long-term follow-up is particularly important because the ultimate outcome of pediatric reconstruction may only become evident with skeletal maturation. In addition, incorporation of validated patient- and parent-reported measures would provide information that surgeon-based assessments alone cannot capture.

Most importantly, future comparative studies should stratify patients according to anatomical complexity before evaluating surgical techniques. This would allow researchers to determine whether differences in outcomes are attributable to the procedure itself or simply reflect differences in the underlying deformity.

4-2. Limitations

This review has several limitations. First, the included studies were heterogeneous in terms of study design, polydactyly subtype, surgical techniques, outcome definitions, and follow-up duration, limiting direct comparison across studies. Second, most available evidence was derived from retrospective or observational studies, which may be susceptible to selection and reporting bias. Third, postoperative complications and functional and aesthetic outcomes were not assessed using uniform or validated measures across studies. Finally, the relatively limited number of eligible studies and variability in reporting reduced the feasibility of robust quantitative synthesis and limited the certainty of conclusions regarding the superiority of specific surgical techniques**.**

5- CONCLUSION

This systematic review indicates that surgical treatment of hand and foot polydactyly in children generally provides favorable functional and aesthetic outcomes, but the available evidence also demonstrates a clinically relevant risk of residual deformity, postoperative complications, and secondary procedures. The variability of outcomes across studies appears to be driven largely by differences in anatomical subtype, complexity of duplication, surgical technique, and duration of follow-up rather than by the presence of polydactyly alone.

The findings support an individualized, anatomy-based surgical approach, in which preservation of the most functional digit or ray, restoration of alignment and stability, and achievement of an acceptable long-term appearance are prioritized over simple excision of the accessory digit. Because current evidence is predominantly observational and characterized by heterogeneous outcome definitions and follow-up periods, definitive superiority of one surgical technique cannot be established.

Future prospective, multicenter studies using standardized anatomical classifications, validated functional and patient-reported outcomes, clearly defined complication and revision criteria, and long-term follow-up are needed. Such evidence would facilitate more reliable comparison of surgical strategies and support the development of evidence-based, subtype-specific treatment algorithms for pediatric hand and foot polydactyly.

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8- DATA AVAILABILITY

All data analyzed in this study were extracted from previously published studies, which are cited in the manuscript. No new datasets were generated. Therefore, data sharing is not applicable.

9 - CONFLICTS OF INTEREST

The authors declare that they have no competing interests.

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