Delta Phalanx

Author:

Dr. Monusha Mohan

MS; FNB (Hand & Microsurgery)

Dept of Plastic, Hand and Reconstructive Microsurgery

Ganga Hospital, Coimbatore

Delta phalanx refers to the congenital anomaly of a tubular bone of the hand or foot which commonly has the shape of the Greek capital letter delta- 'Δ'. Its peculiarity lies in the continuous 'C' shaped epiphysis that runs from the proximal to the distal end along its short side. This continuous physis links the proximal and distal epiphyses.

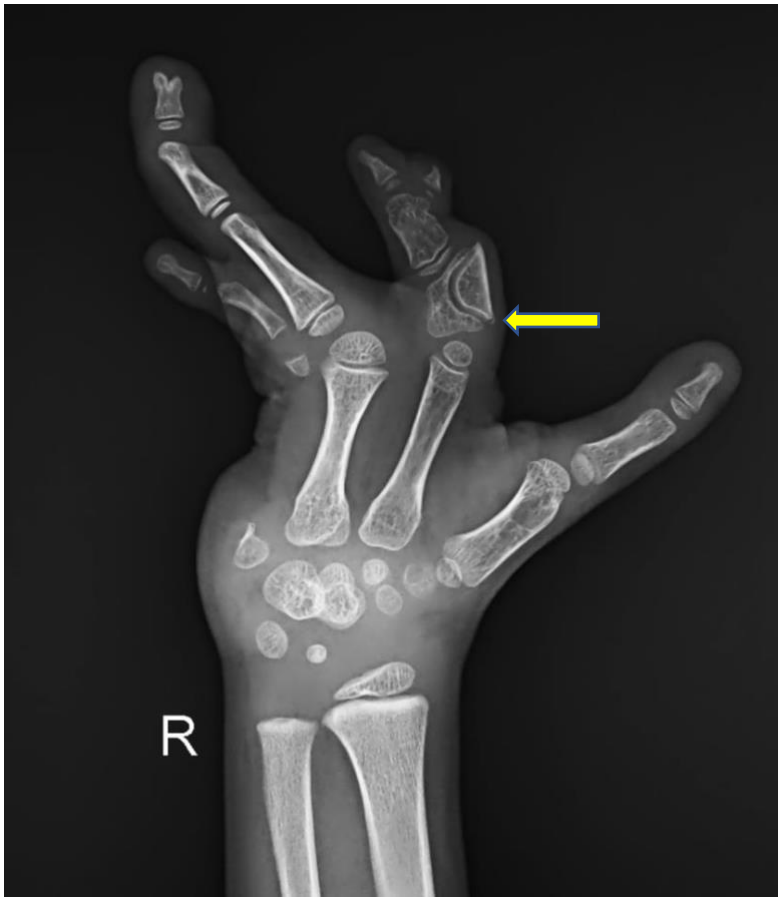

Figure 1: The radiograph shows a delta phalanx in the proximal phalanx of the digit adjacent to the thumb with angulation of the digit towards the C shaped epiphysis.

The term delta phalanx was first used by Blundell Jones in his article published in 1964.[1] The other terms used are longitudinally bracketed diaphysis, longitudinal epiphyseal bracket, congenital triangular bone, or delta bone.[2] Because the deformity has been found also in a metacarpal and metatarsal, the term delta phalanx is questionable and really should encompass any triangular congenital deformity of any bone. Therefore, Flatt believed that one should use the term "delta bone," or "triangular deformity of bone."[3] Light and Ogden believed that the terms “delta phalanx” and “longitudinally bracketed diaphysis” are not appropriate and added three more reasons to those reported by Flatt.[4] They stated that the overall shape may not be triangular, the proximal and distal metaphysis are also involved along with the diaphysis and that it is a longitudinal extension and not completely circumferential. They preferred the term longitudinal epiphyseal bracket.

Etiology

Digital rays are juxtaposed mesenchymal condensations that separate to form individual rays. Then various segments chondrify to produce a cartilaginous analge for subsequent enchondral ossification. A circumferential bone collar and periosteum form around each analge. A primary ossification centre is formed across the entire length of the analge which progresses towards each end eventually delimiting an epiphysis and physis at each end. One of the causes for formation of a delta phalanx is the incomplete development of the primary ossification center which leads to incomplete ossification of the bone collar. This has been termed as a failure in sequential differentiation. In a phalanx, sometimes the proximal secondary centre slowly extends to the distal epiphyseal centre and eventually these two coalesce to form the longitudinal epiphyseal bracket. As long as the two centres are separate the bone grows longitudinally.[4]

According to Muller, the pathogenesis of polydactyly can be considered the result of a longitudinal bifurcation of a ray from distal to proximal (Gabelungsprozess). In a sequence of increasing deformities (teratologische Reihe), the delta formation appears as an intermediate stage of the bifurcation.[4,5] [Figure 2] When the duplication originates at a joint level, delta formation can present conjointly in the two adjacent epiphyses.

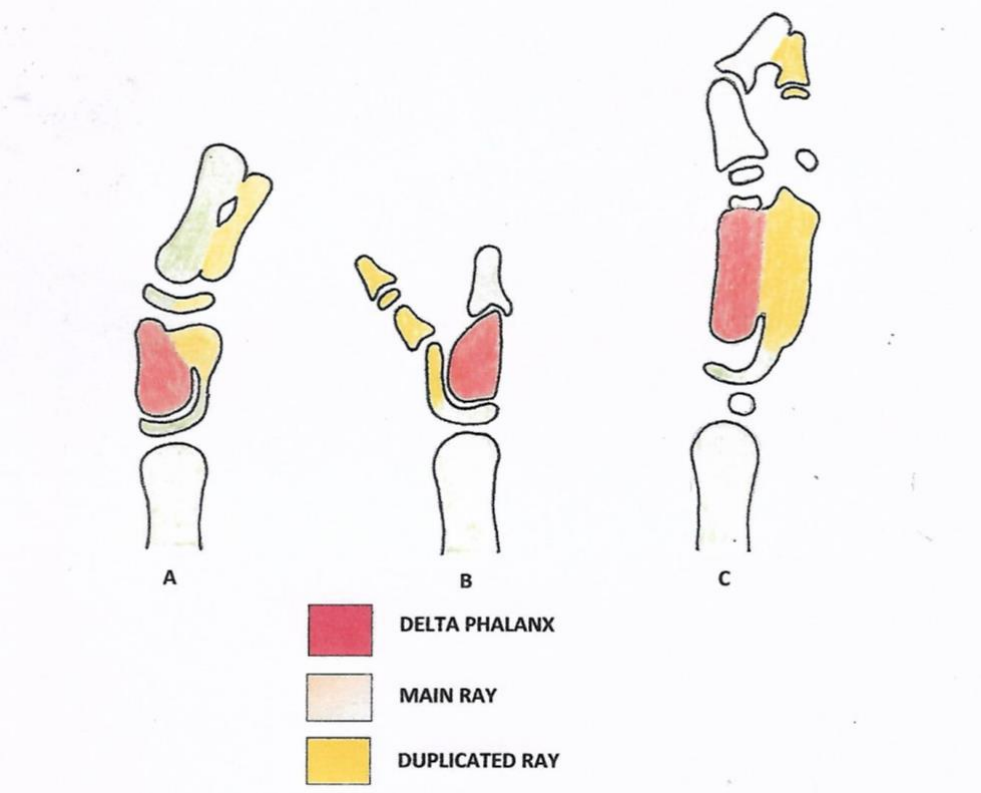

Figure 2: Delta phalanx as a manifestation of polydactylism

A- The proximal phalanx of the thumb shows a delta phalanx. The delta bone (red) has a triangular shape. The epiphysis is seen extending up along one side as if tethered by the duplicated ray (yellow). Two incompletely separated digits are seen beyond this. The angulation is noted towards the side of the tethered epiphysis.

B- The duplicated skeletal ray (yellow) draws the epiphysis up along the left side of the delta bone (red). This tethering effect seems to be the cause for the triangular shape. The main skeletal ray and the extra ray(yellow) are completely separate.

C- The proximal epiphysis is tethered by the supernumerary skeletal ray (yellow). The two rays are attached at their distal ends and the differential growth between the main digit and the extra digit(yellow) is evident. This along with the triangular shape account for the angulation of the digit.

Stages of delta phalanx formation

There are four stages in the ossification process[6].

Stage 1-a radiolucent cartilaginous epiphysis

Stage 2- appearance of secondary ossification centre at the proximal and distal ends

Stage 3 – complete ossification of the bracketed epiphysis

Stage 4- Closure of the physis

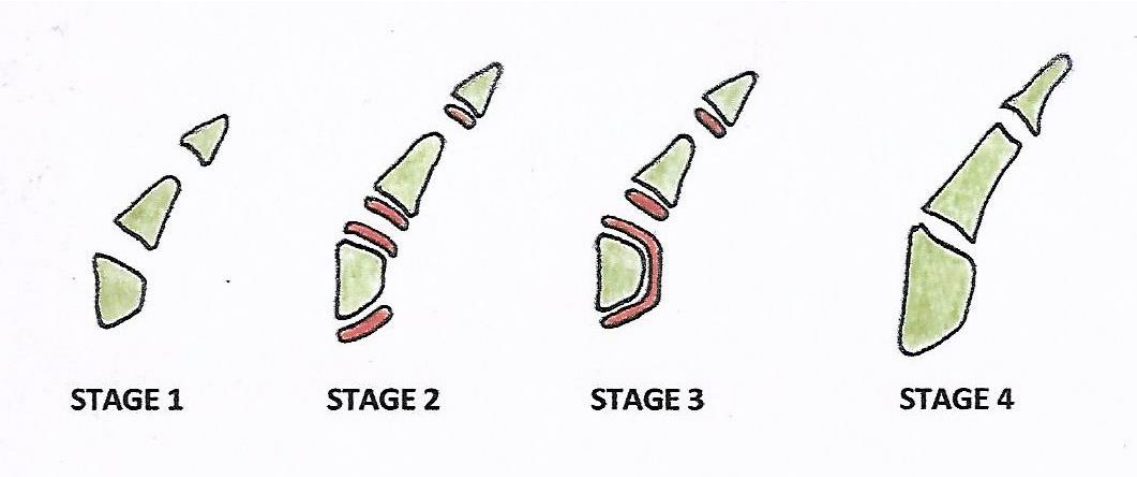

Figure 3: Stages of delta phalanx formation

Inheritance

Though it has been reported to be sporadic, Jager and Refior have described two patients with family history of delta bones.[7] Wood and Flatt have reported that 44% of the patients had strong familial inheritance.[3] As it is associated with polydactyly or syndromes the inheritance pattern will depend upon the original hand anomaly.

Incidence

Wood and Flatt reported an incidence of 3.5% in their study on 84 delta bones in 49 patients.[3] Watson reported 28 delta phalanges in 22 out of the 154 patients with congenital hand anomalies.[8] Jaegar and Refior found 13 out of 485 patients who had one or more delta phalanx in the hand or foot.[7]

Clinical features

The delta phalanx can be triangular, trapezoidal or almost round in shape. Delta formation occurs in tubular bones with a proximal epiphysis like the phalanges, thumb metacarpal and great toe metatarsal. The proximal phalanx is the most commonly affected.[2,8] Literature review by Wood and Flatt revealed the commonest site of delta phalanx as the proximal phalanx of thumb followed by the proximal phalanx of the ring finger.

The 'C' shaped epiphysis because of its peculiar arrangement causes longitudinal growth retardation and progressive angulation deformity. The epiphysis ossifies in a proximal to distal direction. This causes obliquity of the distal articular surface and limitation of growth especially on the involved side. The direction of deviation is to the same side as the epiphysis. The growth in a delta phalanx can occur only outwards and the angulation persists with little gain in length. Some growth is possible in the early stages when the isthmus linking the distal and proximal physes remain cartilaginous. In the presence of supernumerary digits, the abnormal shape of the phalanx and the differential growth of the two distal skeletal rays cause angulation. The epiphysis is seen tethered and appears drawn up by the extra digit.

The border digits deviate towards the rest of the hand. The ulnar deviation of the thumb impairs the hand function as it results in a tip type precision pinch. The index, middle and ring fingers deviate very little, probably due to splinting of the digits to each other particularly in case of synpolydactyly. The little finger tends to deviate in a radial direction and delta phalanx in the middle phalanx of little finger can result in clinodactyly.

Delta phalanx and clinodactyly

It is difficult to separate the two entities. However, delta phalanx does not always produce clinodactyly and clinodactyly is not always due to delta phalanx. Epiphyseal anomalies usually of the proximal phalanges produce a 'leaning finger' rather than a clinodactyly or 'bent finger'.[2] However, it is noteworthy that clinodactyly or 'bent finger' is often a result of delta phalanx at the middle phalanx region whereas the delta phalanx at the proximal phalanx region would often produce a 'leaning' little finger.

Associated anomalies

Watson and Boyes reported that a delta phalanx was always a manifestation of polydactyly.[8] Though delta phalanx is most often associated with polydactyly, it is also seen in Apert's syndrome, hallux varus congenitus, syndactyly, symphalangism, triphalangeal thumb, cleft hand, and hypoplastic hand and Rubenstein-Taybi syndrome.[3]

The "Kissing delta phalanx"

The ''kissing delta'' phalanx consists of two delta bones which are fused together with their convex parts facing each other.

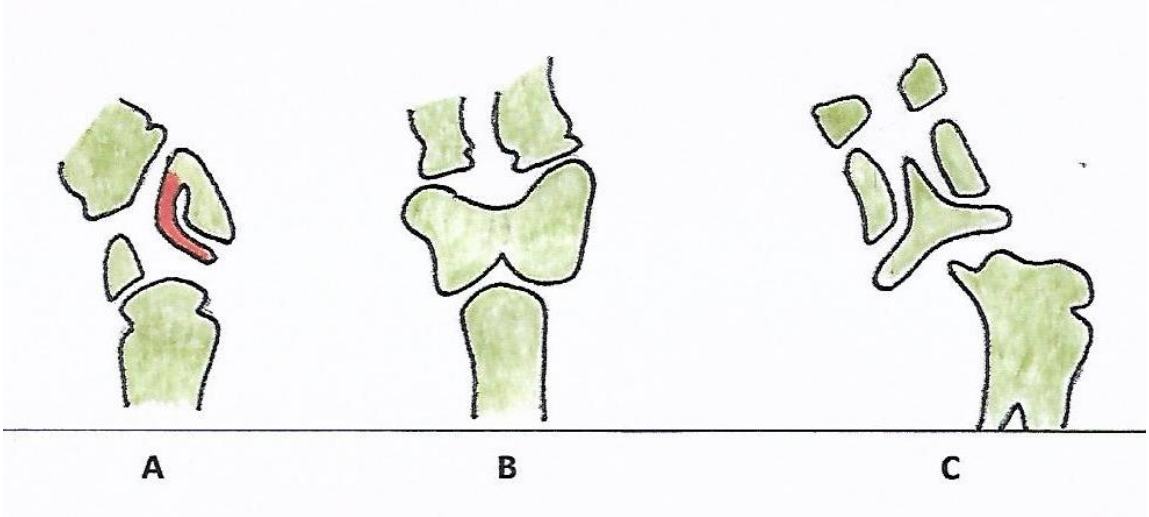

Figure 4: Variations of kissing delta phalanges

A- Unequal, B- Incomplete kissing, C- Double kissing

Wood and Shuren reported that they have seen 13 kissing delta phalanges in their 25 years of experience.[9] They were seen in central polydactyly, Carpenter's syndrome, Cenani Lenz syndrome, symbrachydactyly and cleft hand. The kissing delta bone is an important clue to identifying a syndrome, as every case had a syndrome, or a major congenital anomaly associated with it.

Treatment

Since delta phalanx is a component of some malformation, treatment involves two components: treatment for the associated anomalies and treatment of the delta phalanx itself. The surgical procedure and age at surgery depend on the degree of triangular shape as well as the associated hand anomalies. Early surgery is indicated in cases of severe deformities due to delta phalanx. As described above, delta phalanx in a thumb affecting the precision pinch warrants treatment. Most of the cosmetically unacceptable clinodactyly do not require treatment as they are not functionally disabling. Rectangular shaped delta phalanx shows slight angulation and surgical treatment may not be needed. Similarly, in the case of delta phalanx associated with a supernumerary digit, if the extra digit and main skeletal rays are well united along their course they may be functionally and cosmetically an adequate digit. If they are widely separated, the least functional of the two may be removed.

Splinting for the angular deformities is often ineffective in infancy. Surgical treatment options for the delta phalanx includes growth plate restoration surgery (physiolysis or resection of the bracket physis), resection of a part of the physis with fat grafting, opening wedge osteotomy with or without bone grafting, reverse wedge osteotomy or wedge osteotomy with arthrodesis. Jones stated that the correction obtained at the first operation is often disappointing after reviewing the results of division of epiphysis, osteotomy with bone grafting in 6 fingers. The limiting factor according to him was the skin tightness for which Z plasty was of little use.[1] In such cases, the primary surgery may be repeated after a few years.

Wedge osteotomy

This surgery is indicated in severe angulation deformities and is the only option after maturity. A closing wedge osteotomy though simple will lead to loss of length. An opening wedge osteotomy with bone grafting or reverse wedge osteotomy are superior to closing wedge osteotomy.

(Figure 5)

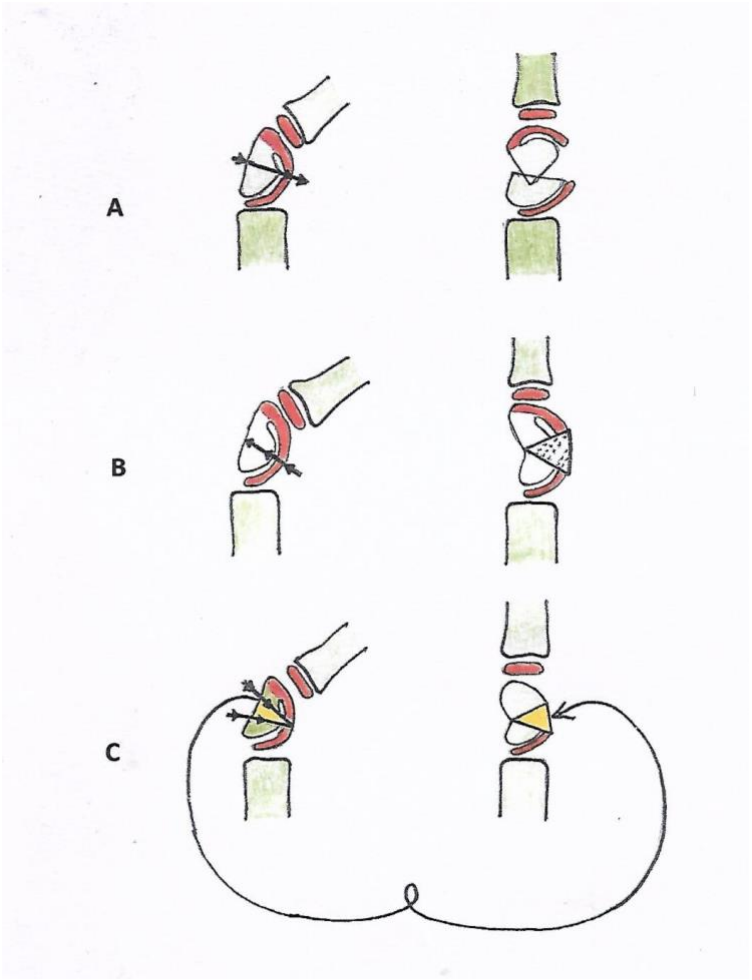

Figure 5: Different procedures for surgical treatment of delta phalanx

A- opening wedge osteotomy without bone graft, B- opening wedge osteotomy with a bone graft and C- reverse wedge osteotomy.

Osteotomy with fat grafting

Through a midlateral incision, osteotomy is done at the midportion of the delta phalanx with preservation of a part of the cortex of the opposite side to act as a hinge. Free fat graft is inserted in the osteotomized bone and is stabilized by K wires. A second surgery in the form of open wedge osteotomy may be needed later if the amount of correction obtained is unsatisfactory.[2,10]

Physiolysis:

If osteotomy is performed in an immature bone, a premature physeal fusion may occur and it will lead to recurrence of the deformity. Also, it is believed that osteotomy without physiolysis does not address the underlying issue. Physiolysis which involves resection of a part of the bracket physis is a simple procedure in children who have not attained bone maturity as it enables progressive growth in length and alignment. Langenskiold described a procedure for management of partial physeal arrest wherein the bony bar is resected and an interposition material is placed.[11] Vickers modified this procedure in 1987 and the technique has been quoted and practiced by many.[12] After removal of the tether on the short side of the phalanx, he used an interposition material like fat graft to obliterate the void. Through a midlateral incision or Z plasty incision, the mid portion of the physis was excised by scalloping using a scalpel blade. The resection should involve full thickness of the physis to interrupt its continuity. The fat graft can be harvested from the ulnar border of the forearm, hypothenar eminence or abdomen.[13] The fat lobules are placed in the surgical void and the skin is sutured to keep the fat in contact with the physis. This technique addressed the pathological tissue while sparing the proximal and distal physis. The fat restores growth and prevents premature fusion of epiphysis. Since there is no instability of the phalanx after physiolysis, immobilisation or pin fixation is not required and hence there is little risk of joint ankylosis.[6,13]

Caouette-Laberge et al. reviewed 35 fingers that had a physiolysis procedure.[13] At a mean follow-up of 3.2 years, the mean degree of correction obtained was 11.1 degrees. The mean degree of correction was better in children who had surgery before 6 years of age (17.9°) compared with older children (6.5°). Ten digits had a second physiolysis surgery and it was not beneficial in 8/10 digits. Premature physeal fusion was reported as a complication by Vickers (1/12) as well as Laberge (2 among the 10 who had physiolysis twice).

Ogino reported the results after surgery for delta phalanges in 14 bones- 9 underwent open wedge osteotomy with free fat grafting and 5 had physiolysis with free fat grafting.[10] Improvement and the percentage of improvement of the lateral deviation angle after surgery seemed better in the physiolysis group than in in the osteotomy group.

Conclusion:

Delta phalanx or longitudinal epiphyseal bracket has a defective epiphysis which is longitudinal instead of its normal transverse course. This peculiar pattern causes angular deformity of the distal skeletal ray as well as growth retardation. Though it is now known to be associated with several anomalies it is commonly seen in polydactyly of the hand or foot. Though several techniques have been described in literature, physiolysis with free fat grafting is the ideal procedure to permit bone growth and improve the deviation angle. A secondary osteotomy can be done once the bone matures if further correction is necessary. Delta phalanges are not rare as was thought earlier and gaining knowledge about the treatment options is inevitable.

References

1. Blundell Jones G. Delta phalanx. J Bone Joint Surg. 1964; 46B:226 –228.

2. Ogino T. Bone and joint deformities. In Buck-Gramcko D Congenital malformations of the hand and forearm. London: Churchill Livingstone; 1998:334

3. Wood VE, Flatt AE. Congenital triangular bones in the hand. J Hand Surg Am. 1977;2:179-193

4. Light TR, Ogden JA. The longitudinal epiphyseal bracket: implications for surgical correction. J Pediatr Orthop. 1981; 1:299 –305.

5. Olason AT, Döhler JR. Delta formation in foot polydactyly. Arch Orthop Trauma Surg. 1988;107:348-353

6. Choo AD, Mubarak SJ. Longitudinal epiphyseal bracket. J Child Orthop. 2013;7(6):449-454.

7. Jaeger M, Refior HJ. The congenital triangular deformity of the tubular bones of hand and foot. Clin Orthop Relat Res. 1971;81:139-50.

8. Watson HK, Boyes JH (1967) Congenital angular deformity of the digits. Delta phalanx. J Bone Joint Surg Am. 1967; 49:333–338

9. Wood VE, Shuren N. Duplicated longitudinal bracketed epiphysis 'kissing delta phalanx' in the hand. J Hand Surg Br.2002;27:249-252.

10. Ogino T, Ishigaki D, Satake H, Iba K. Free fat graft for congenital hand differences. Clin Orthop Surg. 2012;4:45-57.

11. Langenskiöld A. Surgical treatment of partial closure of the growth plate. J Pediatr Orthop. 1981;1:3-11.

12. Vickers D. Clinodactyly of the little finger: a simple operative technique for reversal of the growth abnormality. J Hand Surg. 1987;12B:335–342.

13. Caouette-Laberge L, Laberge C, Egerszegi EP, Stanciu C. Physiolysis for correction of clinodactyly in children. J Hand Surg 2002;27A:659 – 665.