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Isolated Ring–Little Finger Metacarpal Synostosis: A New Classification System and Treatment Strategy

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Purpose To devise a comprehensive classification system for isolated ring–little finger metacarpal synostosis that offers a clear guide to specific treatment for each variation of the deformity.

Methods Based on the experience of 13 cases (20 hands) of isolated ring–little finger metacarpal synostosis, we devised a classification system that takes into account 2 key pathological features of this malformation: the fourth-fifth intermetacarpal angle and the severity of hypoplasia of the fifth ray. In our classification, all patients were divided into 3 types, according to the fourth-fifth intermetacarpal angle, and each type was further subdivided into 2 subtypes according to the length of the fifth ray.

Results All 20 hands could be classified according to our classification, including 2 hands of type A (both A1), 10 hands of type B (9 B1; 1 B2), and 8 hands of type C (7 C1; 1 C2). Patients of different classification types received different treatments according to our proposed classification-related guidelines. It was also possible to classify all the cases found in literature according to this scheme.

Conclusions Our classification for ring–little finger metacarpal synostosis is simple and easy to remember. It is applicable to all possible variations of the congenital anomaly and can guide treatment for the whole spectrum of the deformity. *(J Hand Surg Am. 2014;39(1):83–90.*

Type of study/level of evidence Therapeutic V.

Key words Classification, metacarpal synostosis.

METACARPAL SYNOSTOSIS is a rare congenital hand malformation characterized by the partial or complete synostosis of 2 or more adjacent metacarpals. This condition may present as an isolated abnormality or may occur in association with other complex abnormalities, such as central polydactyly, radial and ulnar deficiencies, cleft hand, and Apert syndrome.[1–4] In patients with more complex malformations, the metacarpal synostosis is not the main problem, and it is most often neglected or solved by ray resection.[1] Isolated metacarpal synostosis, on the other side, accounts for a large proportion of the patients that require surgical correction of the fused metacarpals. Isolated metacarpal synostosis most often involves the ring and little fingers.[1,2,5] There are few articles that specifically address this isolated condition, and most reported only a few cases or described a technique used in a single case.[4,6–16]

Two different classification systems for metacarpal synostosis have been proposed. Buck-Gramcko and Wood[2] described a classification based on the extent of the synostosis. In type A, the synostosis occurs

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only at the base of the metacarpal. In type B, the synostosis extends up about half the length of the metacarpal. In type C, the synostosis extends more than half the length and often the entire length of the metacarpal. Foucher et al[1] described an easy-to-remember classification system using letters of the alphabet (I,U,Y,k) to describe different types of the synostosis. The purpose of this article was to devise a practical treatment-oriented classification system, based on a relatively large number of cases that specifically focus on isolated synostosis of the fourth and fifth metacarpals. We based our classification on our observation and treatment of 13 patients (20 hands) with synostosis of the fourth and fifth metacarpals. Although other types of metacarpal synostosis seldom require surgical correction, our classification scheme is applicable to all types of metacarpal synostosis and can guide treatment for the whole spectrum of this malformation.

MATERIALS AND METHODS

After we obtained the approval of our institutional review board, we retrospectively reviewed all patients with metacarpal synostosis of ring and little fingers treated at our department from 1992 to 2012. Patients with associated hand abnormalities, such as central polydactyly, radial and ulnar deficiencies, cleft hand, and Apert syndrome, were excluded. Thirteen patients (20 hands) were included (Table 1). We performed surgical procedures to correct the deformity in 12 patients (16 hands).

Our classification

We devised a classification system for metacarpal synostosis of the ring and little fingers based on 2 key pathological features, the fourth-fifth intermetacarpal angle (IMA) and the presence of severe shortening of the fifth ray. Patients were divided into 3 groups under this classification system (Table 2; Fig. 1).

In type A (narrow IMA type), the IMA is less than normal. The range of IMA is from 0° (parallel growth plate and epiphysis of fourth and fifth metacarpals or complete synostosis of the fourth and fifth metacarpals with only 1 metacarpal head) to normal. In type B (wide IMA type), the degree of IMA is larger than normal. In type C (reverse IMA type, or convergent type), the IMA is a negative value. Each type includes 2 subtypes based on the presence of severe shortening of the fifth ray (Fig. 2).

We measured the IMA on the posteroanterior radiograph. The projected metacarpal growth lines were drawn perpendicularly through the epiphysis of each of the metacarpal heads of the synostosed metacarpals (Fig. 3). The IMA is the angle formed by the intersection of these 2 lines. If the lines intersect proximal to the epiphyses, the IMA is considered divergent and the numerical value is positive. If the lines intersect distal to the epiphyses, the angle is considered convergent and the numerical value is negative. We find the IMA to be a critical clinical indicator of deformity progression and functional limitation.

The IMA of the adjacent metacarpals varies among individuals. Furthermore, this angle shows variability with the abduction and adduction of the fingers.[5] Therefore, it is not appropriate to set a constant normative value of IMA as a reference to direct corrective repair for all patients. We used a practical method to determine normal IMA in each patient. In unilateral cases, we used the ring-little IMA from the contralateral side as a reference. In patients with bilateral involvement, we used the index-middle IMA from the same side as a reference. This was because the normal range of IMA between the index-middle finger metacarpals is very close to that between the fourth and the fifth metacarpals (Fig. 3).

We also developed a method to determine the presence of severe shortening of the fifth ray. We routinely conducted the preoperative planning of an opening wedge osteotomy of the deformed metacarpal (described later) using paper tracings of preoperative plain radiographs. In our experience, if the tip of the little finger could not reach the proximal interphalangeal joint of the ring finger after the virtual opening wedge osteotomy of the fifth metacarpal, the shortening of the little finger would be obvious and unacceptable after the osteotomy. We defined these patients as having severe shortening of the fifth ray, and they were classified as subtype 2.

Treatment strategy

We proposed treatment guidelines based on our classification system (Table 3).

In type A (narrow IMA) (2 hands), the synostosis between the fourth and the fifth metacarpals seldom leads to a substantial cosmetic or functional problem. Thus, treatment is typically not needed for type A metacarpal synostosis. Neither of our 2 cases in this type received surgical treatment.

In type B (wide IMA type) (10 hands), the IMA of the fourth and fifth metacarpals is larger than normal, which leads to 3 typical deformities. The palm is obviously wider due to increased distance between the fourth and the fifth metacarpal heads. There is a bony prominence over the ulnar side of the palm (usually the major concern of the patients and their parents) due to excessive ulnar deviation of the fifth metacarpal head

TABLE 1. Cases of Metacarpal Synostosis of Ring and Little Fingers

Case	Sex	Age at Consultation (y)	Side	Buck-Gramcko Classification	Foucher Classification	Our Classification	Associated Anomalies	Operation Side
1	M	12	Both	II	Ya	B1		Both
2	F	4	Both	IIIa	Left: Ya Right: k	Left: B2 Right: C2		Both
3	M	5	Both	I	Ya	B1		L
4	M	9	Both	Left: II Right: I	Left: Ya Right: Ua	Left: B1 Right: A1		L
5	M	7	Both	Left: IIIa Right: II	k	C1		L
6	M	5	L	IIIa	Ya	B1		L
7	M	13	R	II	Ya	B1		R
8	M	3	R	IIIa	k	C1		R
9	M	6	R	IIIa	k	C1		R
10	M	7	L	II	Ya	B1		L
11	M	4	L	IIIa	Id	A1	Thumb–index metacarpal synostosis	*
12	F	4	Both	Left† Right: I	Left† Right: k	Left: B1 Right: C1		Both
13	M	6	Both	IIIa	k	C1		Both

*Parents of this patient rejected the surgery.
†Could not be classified by this classification scheme.

TABLE 2. Our Classification for Metacarpal Synostosis of Ring and Little Fingers

Type	4-5 IMA	Presence of Severe Shortening of Fifth Ray	Characteristics of the Deformity
Type A	Narrow IMA		No/mild deformity
A1		(−)	
A2		(+)	
Type B	Wide IMA		Wide palm; wide fourth web; bony prominence over ulnar side of palm; poor little finger abduction
B1		(−)	
B2		(+)	
Type C	Reverse IMA		Narrow palm; abduction deformity of little finger
C1		(−)	
C2		(+)	

and excessive radial deviation of the little finger at the metacarpophalangeal joint. The web space between the ring and the little finger is abnormally wide, which is problematic because small objects easily fall out of the hand. We prefer an opening wedge adduction osteotomy of the fifth metacarpal to achieve simultaneous lengthening and correction of the angular deformity. A triangular or trapezoidal bone graft was harvested from the synostosis site (Fig. 4). This technique was described by Yamamoto et al[6] in a case report. We have used this technique for most of our patients with satisfactory results in the last 20 years. In some cases with concomitant severe radial curving of the fourth metacarpal, an opening abduction wedge osteotomy of the fourth metacarpal was performed to decrease the IMA further.

In type C (reverse IMA type) (8 hands), the convergence of the fifth metacarpal head toward the fourth metacarpal usually leads to an abnormally narrow palm. At rest, the little finger is frequently abducted, which can create cosmetic and functional concerns such as getting the little finger caught in

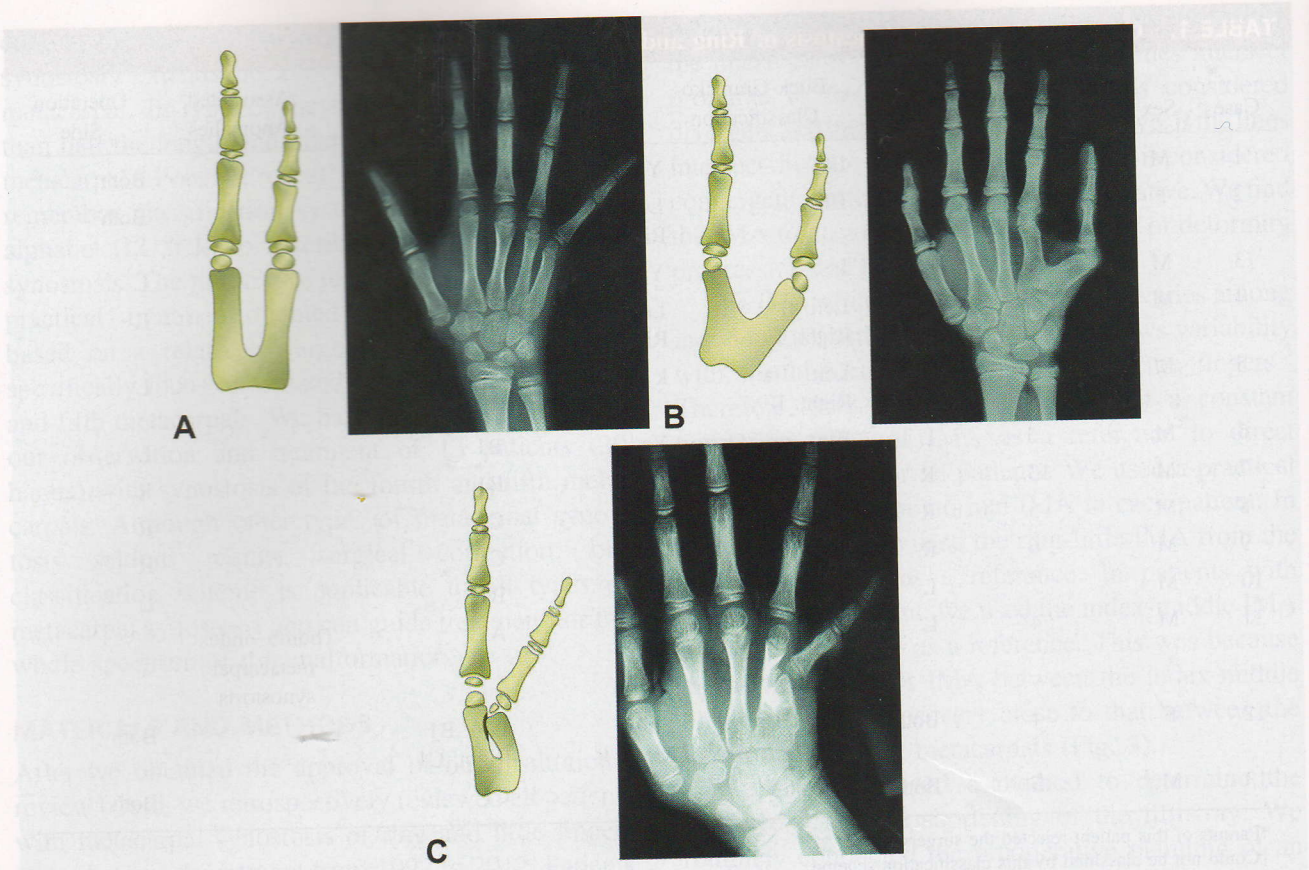

FIGURE 1: Our classification system based on IMA: **A** type A, narrow IMA; **B** type B, wide IMA; **C** type C, reverse IMA.

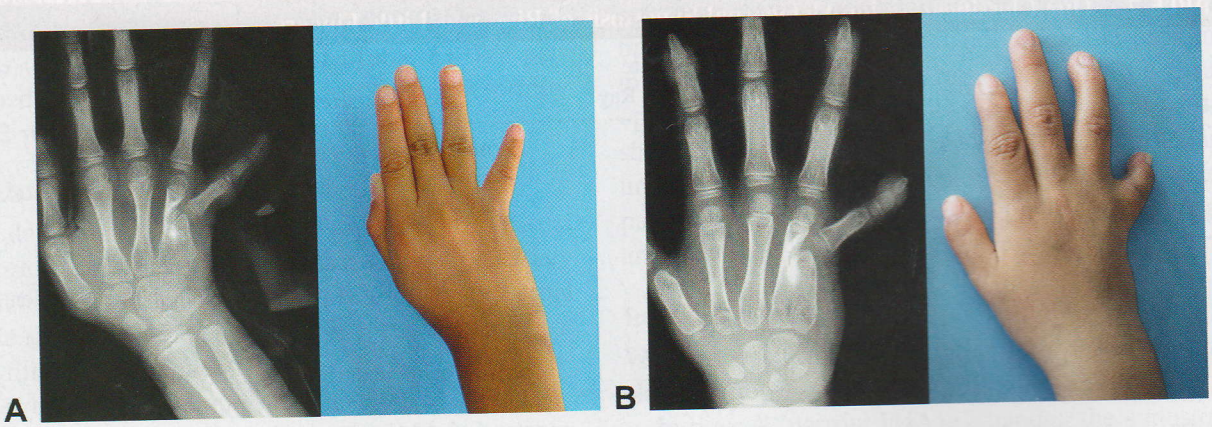

FIGURE 2: Each type was divided into 2 subtypes based on the presence of severe shortening of the fifth ray. **A** Type C1, reverse IMA without severe shortening of the fifth ray. **B** Type C2, reverse IMA with severe shortening of the fifth ray.

pockets or other enclosed spaces. Similar to type B, we prefer an opening wedge osteotomy. The triangular or trapezoidal bone graft is harvested from the synostosis site and inserted into the radial side of the fifth metacarpal. This abduction osteotomy of the fifth metacarpal corrects the negative IMA to normal (Fig. 5).

For subtype 2, the presence of severe shortening deformity of the little finger is a crucial factor that affects both appearance and function of hand, which should not be overlooked. One-stage opening wedge osteotomy alone might not provide satisfactory results. A distraction lengthening should also be considered as a supplemental approach to accomplish full correction.

RESULTS

All 20 hands could be classified according to our classification scheme. Two hands (from 2 patients) were classified as type A (narrow IMA type). Ten hands were classified as type B (wide IMA type),

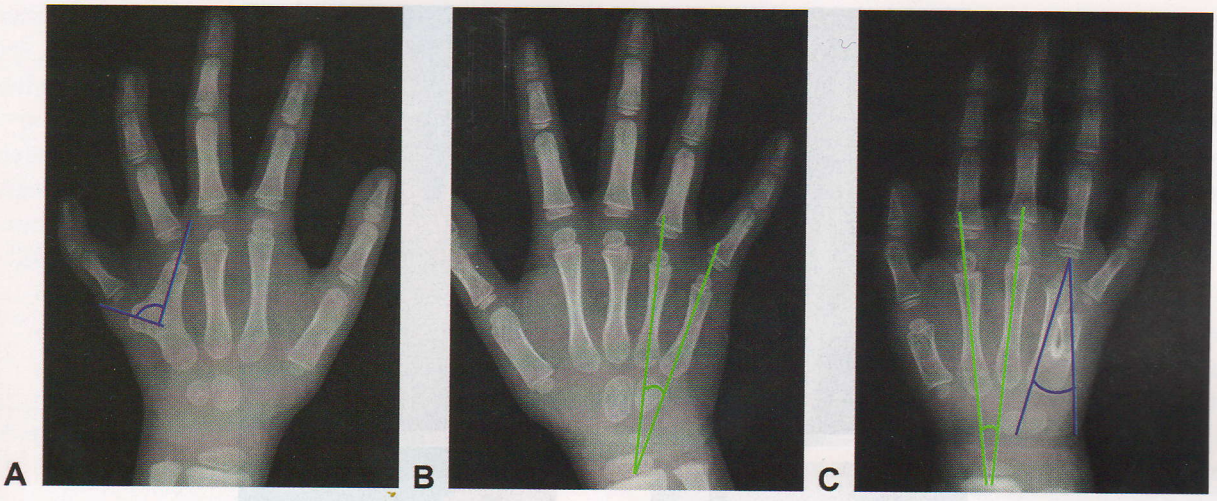

FIGURE 3: Measurements of the IMA on a posteroanterior radiograph. The IMA is formed by the 2 lines that are perpendicular to the epiphyseal line of the fourth and fifth metacarpal heads. **A** Divergent configuration of the adjacent metacarpals forms a wide IMA (blue lines). **B** The normative target angles (green lines) are based on the contralateral normal hand of the same patient. **C** Convergent configuration of the adjacent metacarpals forms a reverse IMA (blue lines), and the IMA between the index and the middle rays (green lines) is used as normative control because the synostosis is bilateral in this patient.

TABLE 3. Treatment Strategy for Metacarpal Synostosis of Ring and Little Fingers

Type	Treatment Strategy
A (narrow IMA)	Conservative treatment
A1	Conservative treatment
A2	Fifth MC lengthening
B (wide IMA)	Decreased IMA
B1	Fifth MC wedge adduction osteotomy*
B2	First + fifth MC lengthening
C (reverse IMA)	Increased IMA
C1	Fifth MC wedge abduction osteotomy*
C2	First + fifth MC Lengthening

MC, metacarpal
*Open wedge osteotomy with bone graft harvesting from the fusion site when necessary.

with 9 hands being B1 and 1 hand B2. Eight hands were type C (reverse IMA type), with 7 C1 and 1 C2 (Table 1).

It was not possible to classify 1 of our cases (left hand of case 12) according to either the Buck-Gramcko/Wood or the Foucher classification (Table 1). This case was classified as type B in our classification system.

The 2 type A hands had minor deformity with relatively normal function. Surgical treatment was unnecessary.

All cases of B1 type (9 hands) were surgically treated by means of adduction wedge osteotomy technique with bone graft being harvested from the synostosis site when necessary. Satisfactory deformity correction was achieved in all but 1 patient (left hand of case 12). In this case, correction of the IMA was technically insufficient owing to the complexity of the deformity, and second-stage osteotomy aiming to achieve normal IMA was planned.

An abduction opening wedge osteotomy was performed for all but 1 hand of C1 type. Correction of the IMA in this type led to a satisfactory cosmetic and functional result. The same operation was proposed for a 7-year-old boy with this deformity, but the family declined it.

Parents of 2 cases of subtype 2 (1 case of B2 and 1 case of C2) declined the suggestion of distraction lengthening of the fifth metacarpal. One-stage opening wedge osteotomy alone was done for these 2 cases. There was substantial improvement of the appearance of the hand; however, the residual shortening of the little finger was still obvious and was not satisfactory in our view.

DISCUSSION

Foucher et al[1] and Buck-Gramcko and Wood[2] have proposed classification systems for metacarpal synostosis. However, Buck-Gramcko and Wood's classification[2] has been criticized because it does not provide enough information on the morphology of the metacarpals and does not guide treatment.

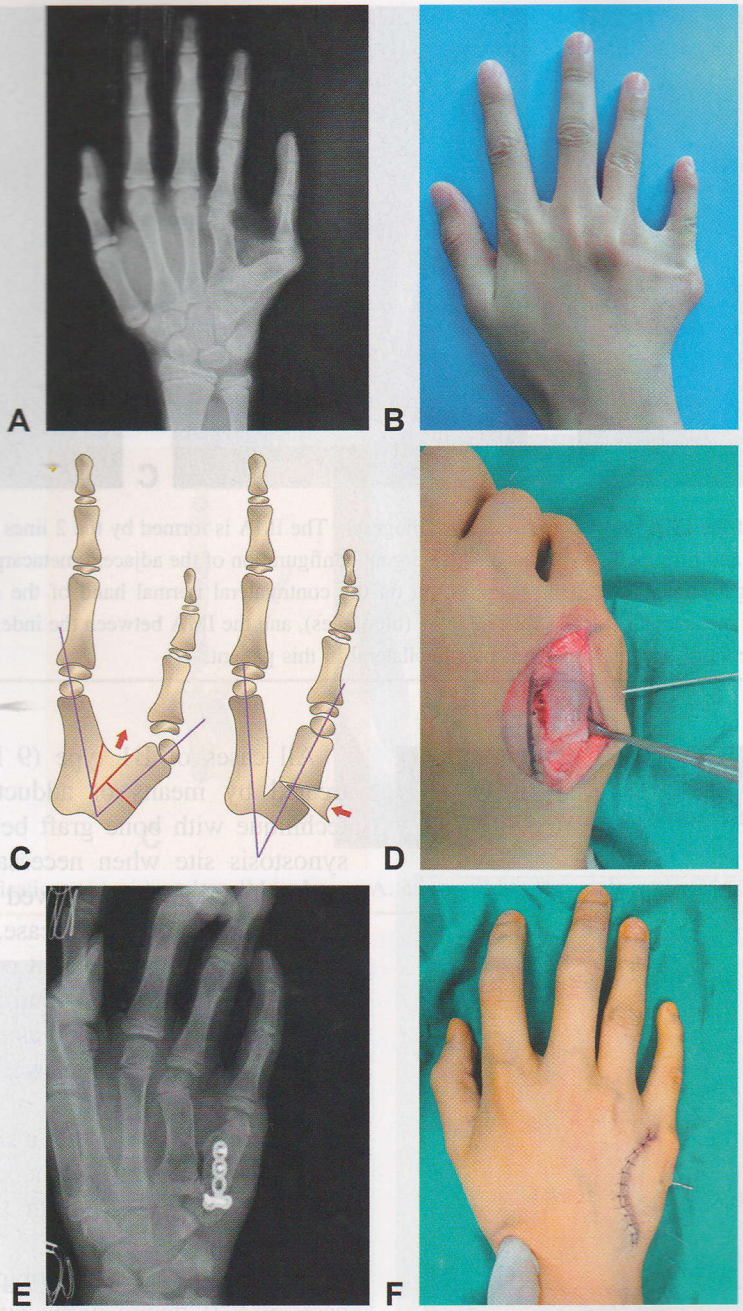

FIGURE 4: Our preferred treatment strategy for type B metacarpal synostosis. **A** Preoperative radiograph of the hand shows increased IMA between the ring and the little fingers. **B** Clinical photograph shows increased web space between the ring and the little fingers and bony prominence over the ulnar side of the palm. **C** The depiction of our preferred opening wedge adduction osteotomy for type B metacarpal synostosis. A triangular or trapezoidal bone graft (red arrows) was harvested from the synostosis site. Note the correction of the IMA depicted by the blue lines. **D** Opening wedge adduction osteotomy was accomplished with bone graft in position. **E** Postoperative radiograph shows the corrected IMA and restoration of normal alignment of the fifth ray. **F** Postoperative appearance with the deformity corrected.

Foucher et al[1] used letters of the alphabet (I,U,Y,k) to describe different types of the synostosis. Although intuitive, not all patients can be classified by this scheme owing to the limitation of this kind of pictographic classification system and the diversity of the deformities. Our classification system covers a full range of fourth-fifth IMAs, which is theoretically an all-inclusive classification system. Moreover, Foucher et al's classification system[1] is relatively complicated, with a total of 8 subtypes. These subtypes were described mainly to mimic the different shapes of the deformity rather than to provide treatment guidelines.

Foucher et al[1] described k-shaped metacarpal synostosis and preferred progressive distraction lengthening

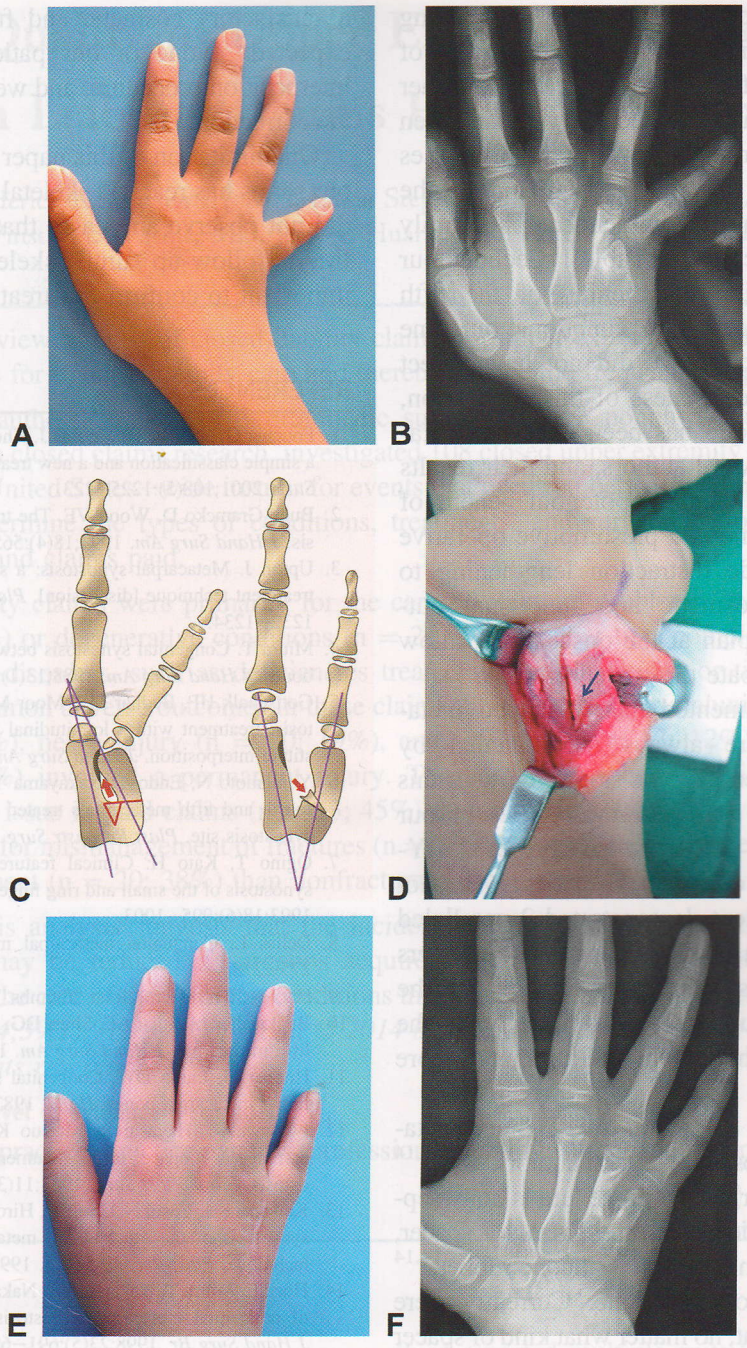

FIGURE 5: The preferred treatment strategy for type C metacarpal synostosis. **A** Clinical photograph shows marked abduction of the little finger. **B** Preoperative radiograph shows reverse IMA between the ring and the little fingers. Note the convergence of the fifth metacarpal head toward the fourth metacarpal with metaphyseal notching and excessive ulnar deviation of the metacarpophalangeal joint of the little finger. **C** The depiction of the preferred opening wedge abduction osteotomy for type C metacarpal synostosis. A triangular or trapezoidal bone graft (red arrows) was harvested from the synostosis site. Note the correction of the IMA depicted by the blue lines. **D** Intraoperative photograph shows the osteotomies around the synostosis site. Note the preparation of the triangular-shaped bone graft (blue arrow). **E, F** Postoperative result at 9 months with corrected deformity and healing of the osteotomy site.

of the fifth metacarpal. However, the k-shaped cases, which we classify as type C (reverse IMA), were not always associated with severe shortening of the fifth metacarpal. Actually, most of our type C patients were subtype C1 (reverse IMA without severe shortening). In these cases, good functional and cosmetic results can be achieved by correcting the reverse IMA alone without progressive distraction lengthening.

The reason why we defined subtype 2 as severe shortening of the fifth ray was that, although many cases were associated with hypoplasia of the fifth ray,

most of them did not require lengthening. An opening wedge osteotomy provided sufficient lengthening of the fifth ray for a satisfactory cosmetic result. Other authors also have found it unnecessary to lengthen the more ulnar metacarpal.[5] However, for the cases with severe shortening, distraction lengthening of the fifth metacarpal is highly recommended. The family of our subtype 2 case (case 2 in Table 1) declined our suggestion of distraction lengthening of the fifth metacarpal, and the cosmetic and functional outcome was substandard. Although we did not have direct data to support the effectiveness of this suggestion, this lengthening technique has been used for metacarpal synostosis by several authors, and their results were convincing.[1,13,14] Thus, a potential benefit of this classification scheme is a presumptive operative plan that might include distraction lengthening to maximally improve cosmetic and functional outcome. A presumptive plan at the onset might allow parents to better anticipate the staged process.

Foucher et al[1] commented that Y-shaped metacarpal synostoses were always accompanied by divergence of the fingers. We do not agree with this observation. The type B (wide IMA type) of our classification system is similar to Foucher et al's Y-type. However, 2 of our type B patients are not typical Y shape; 1 patient demonstrated 2 paralleled fingers, and the other had convergence of the fingers (Fig. 4). These findings support our opinion that the key pathological feature of this deformity is the abnormal IMA rather than the digital alignment more distally.

Different techniques of treating the 2 joined metacarpals have been proposed by several authors.[2,4,6,12,14] The most frequently performed procedure is bony separation with interposition of some form of spacer, including iliac crest bone graft,[2,4,7] silicone rubber,[4,14] costal cartilage,[12] and bone substitute.[5] Currently, there is general agreement that, no matter what kind of spacer is used, recurrence of the coalition of the metacarpals is almost inevitable.[5,7,12,14] However, our experience and that of other authors is that, once the IMA of the 2 adjacent metacarpals is improved and maintained, a satisfactory cosmetic and functional result can be expected.[5] None of our patients received a spacer interposition procedure, and we did not observe loss of the correction.

One limitation of this paper is that only 1 patient in our series has reached skeletal maturity. Although we did not observe any cases that failed to maintain the IMA, follow-up until skeletal maturity will be important to confirm our treatment strategy.

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