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Case Report

# The flap-bag technique: A new closure technique for treatment of cleft foot deformities with two central ray deficiencies☆

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A R T I C L E I N F O

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A B S T R A C T

*Background:* The use of conventional techniques in treating cleft foot deformities with two central ray deficiencies often yields unsatisfactory outcomes. This study describes the flap-bag technique, a novel technique using both a dorsal rectangular flap and a plantar triangular flap that was designed to yield more favorable outcomes in the treatment of this condition, and the outcomes obtained for three patients surgically treated with this technique.

*Methods:* After the proper width of the forefoot was measured by manually holding the toes to maintain a transverse arch around the metatarsophalangeal (MTP) joint, a plantar triangular flap was designed. A dorsally based rectangular flap was subsequently designed on the dorsal side of the interdigital portion, including the deepest side of the cleft, to create a natural dorsal slope.

*Results:* Application of this technique yielded favorable outcomes by maintaining the width and transverse arch of the forefoot, preventing dorsal scarring, and creating a natural interdigital space and dorsal slope.

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*Conclusion:* Compared to the use of conventional techniques, use of the flap-bag technique achieves correction of a cleft foot with a more cosmetically desirable outcome.



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Cleft foot is a relatively rare congenital anomaly inherited as an autosomal dominant trait[1] that is characterized by the absence of one or more of the central rays of the forefoot. In a severe type of cleft foot, the second through the fourth rays are absent. Other anomalies that often occur in association with cleft foot include cleft lip and palate, syndactyly, triphalangeal thumb, and deafness.[2] Almost all previous reports of this condition described cases of cleft foot in combination with cleft hand, with few reporting on a case of cleft foot alone,[3–5] and none clearly described the design used for treatment.

We describe the development of a new closure technique for cleft foot deformities with 2 central ray deficiencies using a plantar triangular flap and a dorsally based rectangular flap. Because our method for closing the interdigital space by the flap is similar to that for closing the flap bag, we refer to this method as the flap-bag technique. In this report, we describe the design of and procedures used in our novel method and report the outcomes for 3 patients who we treated using this method.

## Patients and methods

Between April 2008 and August 2010, we treated the 4 affected feet of 2 male patients and 1 female patient using our recently developed method. Case 1 had been diagnosed with unilateral cleft foot and Cases 2 and 3 with bilateral cleft foot. In accordance with Blauth and Borisch classification (Figure 1.),[6] 2 feet was classified as Type II and 2 feet as Type III. All cases were associated with ectrodactyly-ectodermal dysplasia-cleft (EEC) syndrome. The mean age of the patients was 8.6 years (range 5–15 years) and the mean of duration of surgical follow-up was 17 months (range 15 to 18 months). For Case 2, division and full-thickness skin grafting was performed for both syndactyly feet as an additional form of correction. For Case 3, a secondary operation was performed on only the left foot to correct slight webbing and deepen a shallow interdigital space in addition to metatarsal osteotomy, which performed to alleviate dorsal pain due to metatarsal bone prominences.

One month before undergoing surgery, all patients participated in therapy consisting of walking with an attached orthosis with holding toes to become familiar with their postoperative condition.

## Surgical procedure

The first step in using the flap-bag technique is the drawing of 2 lines: (1) a horizontal line at the midpoint of the proximal phalanx of the great toe perpendicular to the longitudinal axis toward the plantar and (2) an equidistant parallel line between the lateral midline of the cleft side and the plantar midline. After the lines have been drawn, Point A is marked as the intersection of the 2 lines and Point B is drawn at the fourth toe. Points A and B serve as the border of the plane of the load bearing and zero load sides (Figure 2a).

The proper width of the forefoot is determined from unaffected side or width of the shoe, and measured as the distance between Points A and B by grasping the foot manually to maintain a transverse arch around the metatarsophalangeal (MTP) joint. After determining the distance from Points A to B, referred to as the interdigital distance, a plantar triangular flap is subsequently designed. Point C, which serves as the vertex of the triangular flap, is plotted on the dorsal side by considering the proximal or the relative distal position between Points A and B. The distance from Points A to B must be equal to that from Points B to C. Therefore, if Point A moves to the proximal side, Point C also moves

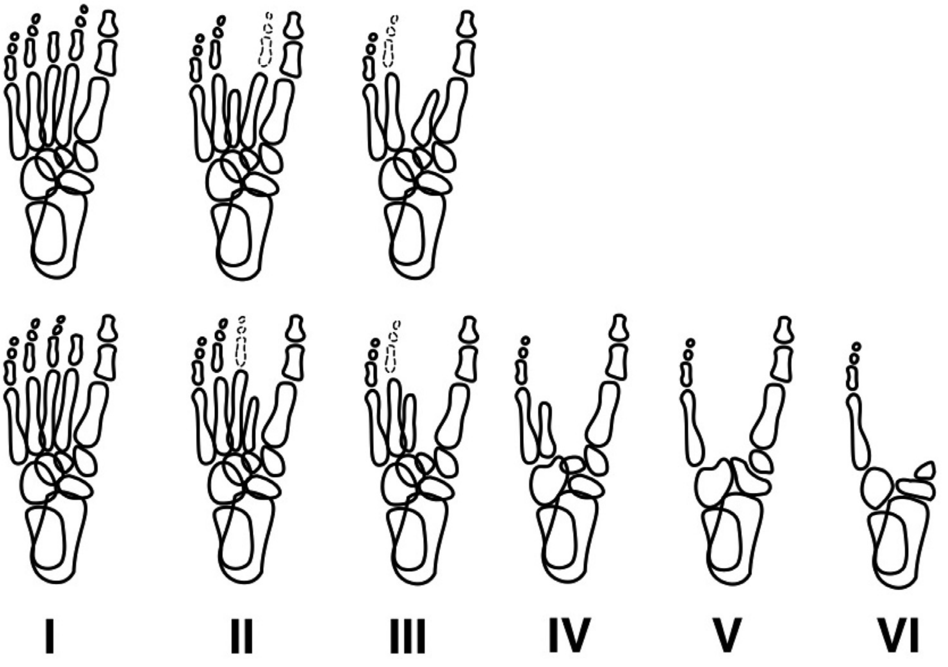


**Figure 1.** Blauth and Borisch classification of cleft foot.

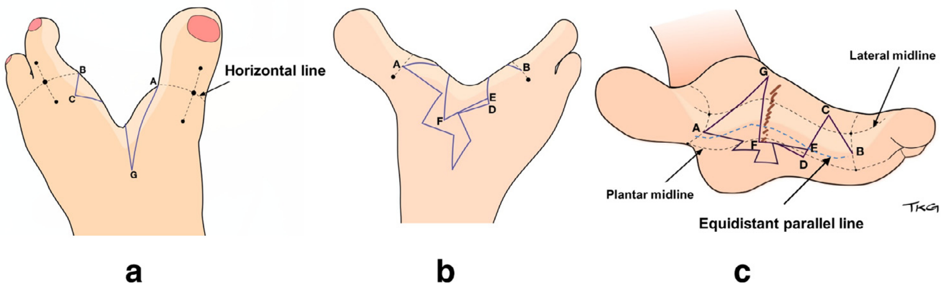


**Figure 2.** Preoperative schematic illustration.
(a) The flap design of the dorsal side.
(b) The flap design of the plantar side.
(c) The flap design of the interdigital space.

to the proximal side, leading the angle of DBC to decrease. A zigzag incision measuring 2–2.5 cm is typically created on 1 side of the flaps (Figures 2b and 3b). Point D, which serves as the proximal base of the triangular flap, is plotted by considering the design of the zigzag incision on the plantar side.

Finally, a dorsally based rectangular flap (the flap bag) is designed on the dorsal side of the interdigital portion by determination of the lengths that Line A–B and Line B–C must be to cover the entire region of the interdigital space. Point E is positioned on Line C–D such that the length of Line C–E is equal to that of Line B–C. Point G, whose position should be determined prior to that of Point F, is plotted in the deepest side of the interdigital space, where it should run approximately 1–1.5 cm dorsally from the lateral midline. In cases of metatarsal deficiency, whether to a partial or greater

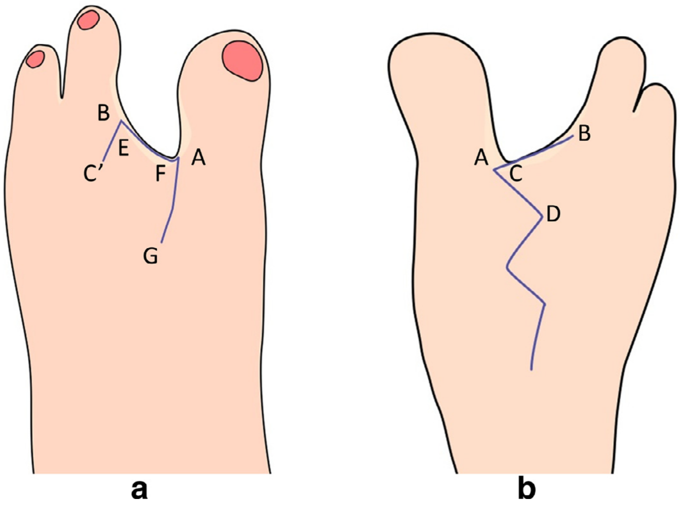


**Figure 3.** Postoperative schematic illustration.
(a) The flap design of the dorsal side and the interdigital space.
(b) The flap design of the plantar side.

extent, Line A-G may be linearly shaped or slightly curved. In the remaining metatarsals, Line A-G may assume a boomerang shape.

While conducting these procedures and measurements, it is important to consider the natural interdigital space and dorsal slope. Point F is determined such that the length of Line C–E is equal to that of Line E–F, which itself is equal to that of Line A-B, and such that the length of Line F–G is equal to that of A–G (Figure 2c).

The rectangular flap should be raised, including that part on the deepest side of the cleft, to create a natural interdigital portion and dorsal slope (Figure 3a). However, if the interdigital portion is overly deep, the deepest side may not be able to serve as the rectangular flap.

## Results

After surgery, none of the patients experienced pain when putting on shoes or developed slight webbing, a shallow interdigital space, or painful plantar scars. However, 2 patients developed painful scars due to splitting of the toes and 1 patient experienced slight instability of the MTP joint.

## Case reports

### *Case 1*

A 5-year-old boy was admitted for treatment of left cleft foot associated with EEC syndrome. As the second and third metatarsals were partially absent, the case was classified as Type III in accordance with Blauth and Borisch classification and the flap-bag technique subsequently performed. Despite a short first metatarsal and wide interdigital space, metatarsal osteotomy and intermetatarsal suture were not performed, as the first consideration in primary surgery should be correction of the width (Figure 4). Observation 18 months after surgery indicated that the surgery had led to creation of a natural dorsal slope that allowed for maintenance of the transverse arch of the forefoot and had resulted in inconspicuous dorsal scarring (Figure 5).

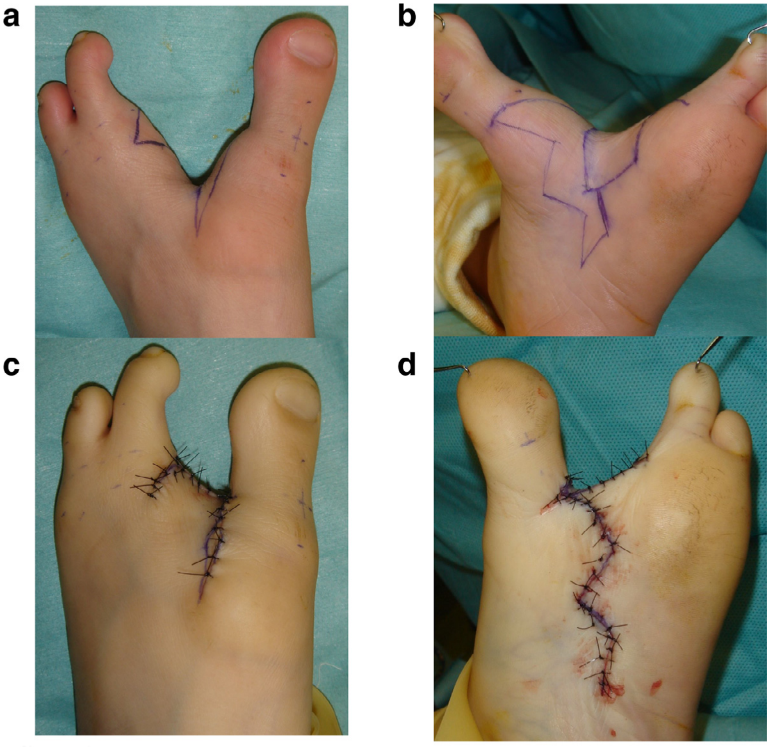


**Figure 4.** Case 1 flap design.
(a) Preoperative flap design of the dorsal side and the interdigital space.
(b) Preoperative flap design of the plantar side.
(c) Postoperative view of the dorsal side and the interdigital space.
(d) Postoperative view of the plantar side.

### *Case 2*

A 5-year-old boy was admitted for treatment of bilateral cleft foot associated with EEC syndrome. The right foot was classified as Type III due to the absence of a second metatarsal and partial absence of a proximal metatarsal while the left foot was classified as Type II due the partial absence of a second metatarsal. Surgery was performed on both sides. Because the interdigital space of the right side was narrow and the first metatarsal was short, intermetatarsal suturing was not performed and the angle of DBC decreased. Because part of the second metatarsal remained on the left side, Line A-G was designed in a boomerang shape (Figure 6). Observation 18 months after surgery indicated that the surgery for both sides had led to creation of a natural dorsal slope that allowed for maintenance of the transverse arch of the forefoot and had resulted in inconspicuous dorsal scarring. As the right side had been almost absent of second and third metatarsals, the volume of soft tissue in the interdigital space was low (Figure 7).

## Discussion

Previous authors have described the use of several methods for the treatment of cleft foot. Among them, Onizuka[7] attempted to create 5 toes from a cleft foot by raising a double-pedicled flap from the cleft area to form new toes, Tani et al.[8] to eliminate splaying metatarsals by making multiple-z plasty incisions along the cleft and intermetatarsal suture, and Wood et al.[9] to close the cleft using

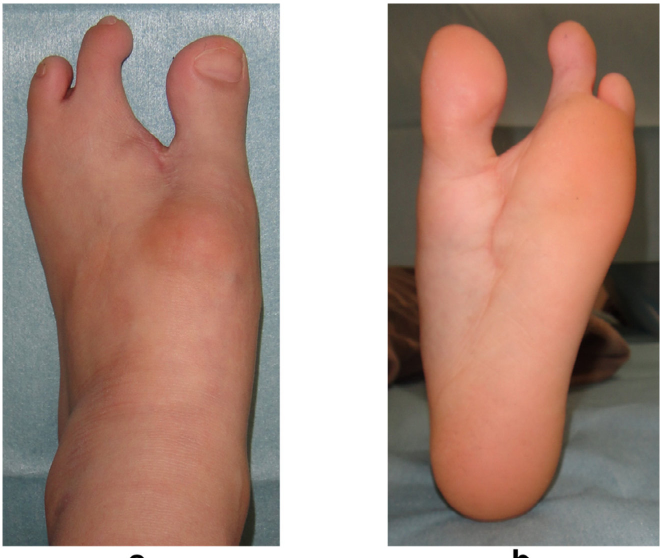

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**Figure 5.** Case 1 postoperative appearance after 18 months.
(a) Appearance of the dorsal side. Scarring is inconspicuous and the width of the forefoot is preserved.
(b) Appearance of the plantar side. Neither slight webbing nor a shallow interdigital space is observed.

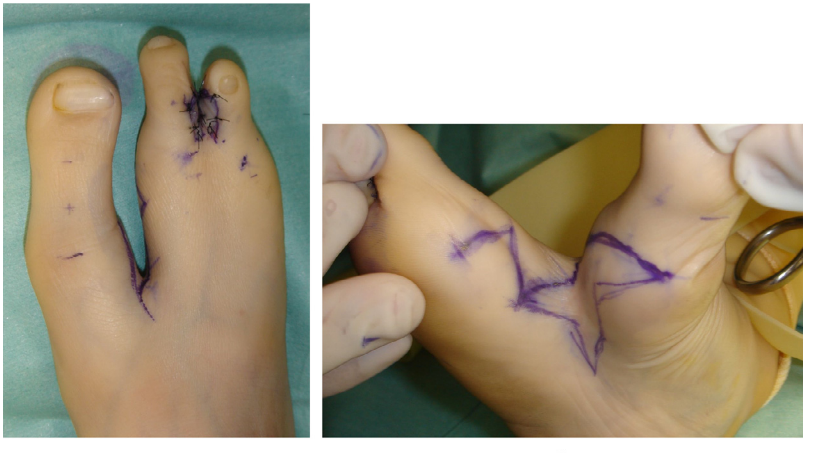

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**Figure 6.** Case 2 flap design on right side.
(a) Preoperative flap design of the dorsal side.
(b) Preoperative flap design of the plantar side.

rectangular flaps. In a review of the outcomes of surgical treatment for 32 feet of 21 patients, Kovalsky and Guttmann[10] found that satisfactory cosmetic results could be obtained for patients with no or one central ray deficiency by primary closure of the cleft using a triangular flap or a double-pedicled flap, but not for patients with 2 or 3 central ray deficiencies. Therefore, they recommended insertion of a silicone block to maintain the defect for this latter group of patients. We developed the method described here after obtaining unsatisfactory correction using only a rectangular flap.

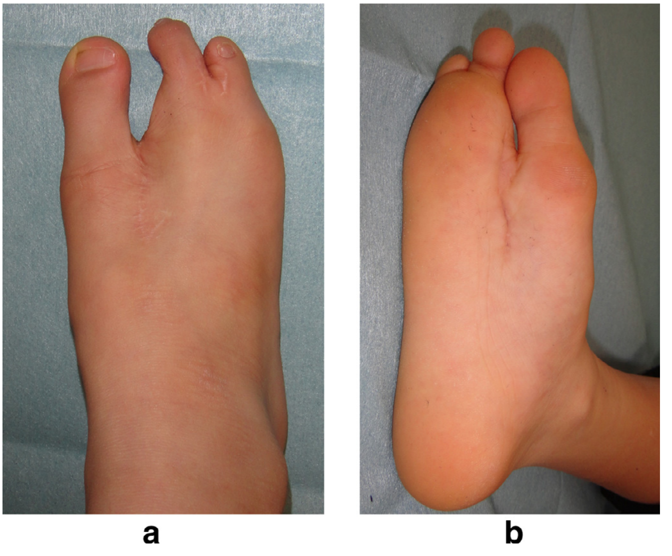


**Figure 7.** Case 2 postoperative appearance after 18 months.
(a) Appearance of the dorsal on right side.
(b) Appearance of the plantar on right side.

Digital anomalies and syndactylies should be corrected by closure of the cleft, while metatarsal osteotomy, removal of useless metatarsals, and the holding of the remaining metatarsal with a ligament should be performed as helpful additional techniques. Giorgini et al.[1] and Colman and Aronobitz[11] recommended the use of a 2-stage approach, with the first stage aimed at reduction of the width of the foot and the second stage at correction of digital abnormalities and syndactylies. After reviewing the radiographic findings of a series of studies, Blauth and Borisch[7] classified digital anomalies and syndactylies into 6 major types based on the number of metatarsal bones and the extent of malformation. Type I, the mildest form of malformation, is characterized by 5 normal metatarsals; Type II by 5 partially hypoplastic matatarsals; Type III by 4 matatarsals; Type IV by 3 metatarsals; Type V by 2 metatarsals; and Type VI, the most serious form of malformation, by monodactylous cleft foot. After reviewing the findings for 32 feet of 16 patients, Choudry et al.[13] developed an alternate means of clinical classification of 3 major types based on the extent of malformation.

A major deficiency of previous reports of surgical treatment of cleft foot is their lack of a clear description of the design and method used. As determining the best design is often difficult in actual practice, the surgical procedure for each patient varies slightly, depending on the judgment of the surgeon. The major disadvantage of current surgical methods is that they result in the formation of (1) a conspicuous dorsal zigzag or straight scar and (2) 2 linear scars of the flap across the interdigital space, which prevents formation of a natural interdigital space. To avoid such scarring, we clarified the design method and devised a surgical procedure that addressed the drawbacks associated with conventional methods.

The major objectives of surgery for cleft hand are preservation of the precise functioning of the hand and a cosmetically pleasing appearance. The major objectives of surgery for cleft foot are development of the ability to wear normal shoes; maintenance of the capability of the foot, including when the transverse arch and longitudinal arch are subjected to a load; and a cosmetically pleasing appearance.[11–14] Based on consideration of these objectives, we developed a method that aims to (1) prevent dorsal scarring, (2) reduce scarring of the interdigital space, (3) create a natural interdigital space, and (4) maintain the arch of the foot and the width of the forefoot. To prevent dorsal scarring and reduce scarring of the interdigital space, we chose to make the rectangular flap on the dorsal side. When making the boundary of the toes and interdigital suture line, we aimed at inconspicuous scarring of the rectangular flap. We found that using the deepest side of the cleft helped us create a natural interdigital space and that adjusting the size and shape of the plantar triangular flap helped us maintain the width and transverse arch of the forefoot.

The shape of the plantar triangular flap varies according to the location of Points A and B and the distance between them. Therefore, in a case of the brachymetapody, the tip of the triangular flap moves to the proximal side, but moves to the distal side in a case of the normal metatarsal. Because a zigzag scar allows for better dispersion compared to a linear scar, formation of a zigzag scar allows for better maintenance of the longitudinal arch of the foot.

In Type II and III, we believe that reconstruction of deeper retaining structures is not always necessary. In untreated case of epiphyseal closing, the forefoot cannot be reduced manually. It is considered that if cleft closure is performed before the epiphyseal closing, the metatarsal axis will be corrected when the epiphyseal line is closed by wearing braces or shoes. Of course, if inter-metatarsal suture is performed if necessary.

Postoperatively, none of our patients experienced pain when putting on shoes or developed slight webbing, a shallow interdigital space, or painful plantar scars, but 2 (50%) experienced pain from scarring due to splitting of the toes. One year after surgery, this pain disappeared for 1 patient and gradually decreased for the other patient. The interdigital pain often experienced by patients who have undergone other surgical methods was not experienced by our patients. As scarring across the interdigital space can affect morphology and symptomology, avoiding scarring to the greatest extent possible is desirable.

## Conclusion

Use of the flap-bag technique to treat cleft foot deformity was found to improve the ability to wear normal shoes without pain and the cosmetic appearance of the foot, the 2 major objectives of surgery for this condition. Application of this method yields these favorable outcomes by allowing for maintenance of the width and transverse arch of the forefoot, preventing dorsal scarring, and creating a natural interdigital space and dorsal slope.

## Funding

None.

## Conflicts of interest

None declared.

## Ethical approval

Not required.

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