Dressing Techniques in Percutaneous Toe Surgery

Frederick Michels, MD† and Francesc Malagelada, MD, PhD†‡*

Abstract: Percutaneous techniques are becoming increasingly popular in forefoot surgery. In percutaneous toe corrections, usually, no hardware is used. The hardware-free technique avoids any hardware-related complications, but relies highly on the effect of the dressing to keep the foot in the desirable corrected position while healing occurs. The first postoperative dressing is applied by the surgeon. A combination of adhesive taping, sterile gauzes, and an elastic cohesive bandage is used for the first 10 to 14 days. The technique is tailored to the surgical procedure performed and aimed at correcting the preoperative deformity. For the next phase of healing, different bandage techniques can be used. Customized elastic taping is helpful to guide toe position. Alternatively, orthodigital splints can be used. Surgeons should master several bandage techniques. This allows them to choose the best technique depending on the situation. Often, the bandage techniques should be modified to the preoperative situation, the surgical technique, the deformity, and the correction achieved.

Level of Evidence: Diagnostic Level V. See Instructions for Authors for a complete description of levels of evidence.

Key Words: percutaneous, minimally invasive surgery, forefoot, dressing, taping

(*Tech Foot & Ankle* 2021;00: 000–000)

HISTORICAL PERSPECTIVE

Dressings are part of the routine postoperative care in forefoot surgery, becoming essential in the percutaneous techniques. Especially in percutaneous toe corrections, the dressing is even more important as no hardware is used. A hardware-free technique avoids hardware-related complications, but relies heavily on the postoperative dressings and bandages to maintain the correction achieved intraoperatively.

Most complications in toe surgery are preventable by adhering to the correct surgical technique and an adequate postoperative care. The dressing techniques play a significant role in this. Despite the increasing number of publications in percutaneous surgery, the literature on dressing techniques is still lacking, often limited to a short paragraph without the level of detail that is required.

In recent years, percutaneous techniques have become increasingly popular. At the end of the 1980s, and throughout the 1990s, Isham[1] set the foundation for the current percutaneous techniques. He pioneered different techniques and published the percutaneous hallux valgus correction in 1991. Mariano De Prado, following Isham's guidance, introduced these techniques in Europe. De Prado and anatomist Pau Golano expanded and refined the techniques, which they published in the book "Cirugia percutanea del pie" in 2003, with an English version in 2009 "Minimally Invasive Foot Surgery."[2,3] The newly created techniques and increased popularity led to the formation of the Grecmip (Group of Research and Study in Minimally Invasive Surgery of the Foot) in 2002, a scientific society focusing on research and education in the field of minimally invasive foot and ankle surgery. In the following years, a growing number of foot surgeons undertook specific training in this field and implemented these new techniques. New instruments were developed for specific percutaneous use, which helped to increase the reliability and reproducibility of the techniques. Consequently, these efforts resulted in a surge in publications describing the anatomical basis[4–6] and reporting the clinical benefits and outcomes.[7–11]

The aforementioned factors set the ideal scenario for percutaneous foot surgery to flourish. Today, percutaneous techniques in forefoot surgery are used all over the world. Similar to endoscopic techniques, the percutaneous techniques have become an additional tool in the toolbox of the foot and ankle surgeon. The dressing techniques should be a part of this toolbox.

INDICATIONS AND CONTRAINDICATIONS

Percutaneous techniques can address multiple forefoot pathologies. The most common are hallux valgus, bunionette, metatarsalgia, and toe deformities. Percutaneous toe corrections are a combination of small gestures including soft tissue procedures and osteotomies.[3,12–15] The soft tissue procedures consist of detachments of tendons from the bone, tenotomies, and capsulotomies. Osteotomies can be performed in different directions. They are partial or complete. A shortening of the bone can be achieved if needed. The entire procedure is adapted to the preoperative deformity and adopts a step-wise approach until full correction is achieved. Often, the toe corrections are performed in combination with other forefoot procedures. A commonly used toe correction in the first ray is a percutaneous akin procedure in hallux valgus surgery. The described bandage techniques can be used to maintain the correct position of the hallux.

An important characteristic of percutaneous techniques is the limited use of hardware. This obviates any hardware-related complications such as soft tissue irritation, wound problems, pin-tract infection, hardware failure, etc. Because the fixation effect is not maintained by hardware in percutaneous techniques, the importance of postoperative dressings is amplified. The described dressing techniques were developed to provide stability in the hardware-free minimally invasive techniques. Of course, their use can be considered in more open procedures. An important condition to use these techniques is good wound healing.

PREOPERATIVE PLANNING

The surgeon who performs percutaneous techniques must have the necessary skills to correctly apply the dressings to control the toe position in the immediate postoperative period and the 6 weeks after surgery. Similar to any surgical procedure, the learning process of dressing techniques involves a mix of theoretical and practical knowledge. The surgeon should be

From the *Orthopaedic Department, AZ Groeninge, Kortrijk, Belgium; †MIFAS by GRECMIP (Minimally Invasive Foot and Ankle Society), Merignac, France; and ‡The Foot and Ankle Unit, Department of Trauma and Orthopaedics, Barts Health NHS Trust, The Royal London Hospital, London, UK.

The authors declare no conflict of interest.

Address correspondence and reprint requests to Frederick Michels, MD, Orthopaedic Department, AZ Groeninge, President Kennedylaan 4, 8500 Kortrijk, Belgium. E-mail: frederick_michels@hotmail.com.

FIGURE 1. First postoperative dressing in different layers. A, A first layer with adhesive tapings is used to maintain the toes in a corrected position. B, Next layer with sterile gauzes to protect against contamination, to separate the toes, and to absorb some wound fluid or blood. C, An elastic cohesive bandage is used to keep the bandage in the corrected position.

able to use different dressing techniques and to adapt them to each specific situation.

All the necessary equipment should be available to perform the dressings. Commonly used materials include sterile woven gauzes, elastic cohesive bandages, and adhesive wound closure strips (steristrips). If steristrips are used, it is important that they are resistant to humidity and retain their adhesive properties for several weeks. An elastic cohesive dressing is often used to provide mild compression to the osteotomy site, for example, Coban (3M), Peha-haft (Hartman).

TECHNIQUE

General Principles

(1) The postoperative dressing should be seen as an intrinsic part of the surgical technique and should be applied by the surgeon.
(2) The dressing technique is adapted to the needs of the surgical technique, the preoperative deformity, and the postoperative result. There is no one bandage that fits all.
(3) The toes are separated with in between gauzes to avoid skin maceration. Circular bandages should be avoided.
(4) The first postoperative bandage is kept in place for 10 to 14 days.
(5) In general, the metatarsophalangeal (MTP) joints are pushed into plantarflexion and the interphalangeal (IP) joints into extension. The toes are usually pushed medially. This is to counteract the main forces going through each joint.

Immediate Postoperative Bandage and Postoperative Care

The first bandage is applied in the operating theater and is of utmost importance in maintaining acceptable correction of the toes until there is sufficient soft tissue healing. Usually, no stitches are used. The foot is cleaned with sterile gauzes. The bandage consists of different layers (Fig. 1). In a first layer, adhesive strips allow for a powerful and precise positioning of the toes. They are especially useful to hold the toes in a corrected position. The application is adapted to the preoperative deformity and the performed surgical technique. The skin has to be as dry as possible. In a next layer, sterile gauzes are applied to protect against contamination, to separate the toes, and to absorb some wound fluid or blood. The addition of gauzes in between toes supplements the adhesive properties of the strips in the later postoperative situation. The stabilizing effect reduces inflammation and stimulates wound healing. A first dressing sling is applied at the greater toe. This is followed by another sling around the next toe until all toes are covered. An elastic cohesive bandage is used to keep the bandage in the corrected position.

While in the recovery room, the foot must be elevated and the perfusion to all toes must be checked. The dressing should be adapted as and when required. Of particular importance in extensive forefoot corrections, elevation should continue for as much as possible in the first 7 to 10 days postsurgery. By elevating the foot regularly, an impact can be made to reduce swelling and pain, and contribute to wound healing. Elevation of the foot in the early postoperative period is beneficial for the first phase of wound healing. Consequently, it is helpful to avoid a prolonged or

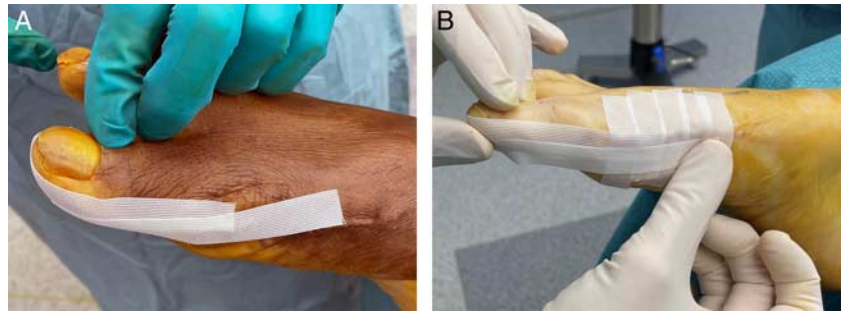

FIGURE 2. Maintaining the hallux in a corrected position after an akin osteotomy. A, The hallux is hold in a valgus deviation while applying the adhesive tapings. B, This taping technique can be used in combination with an open technique as demonstrated in this example.

FIGURE 3. An elastic taping can be used to maintain or adjust any medial deviation of the hallux after a percutaneous phalangeal osteotomy or a lateral capsular release. The elastic properties of the kinesiotape are used to maintain the adjusting force. Addition of more strips is often not necessary but provides a more powerful correction. The location of the strip on the skin will also add rotational traction if desired. A, No strips. B, One strip. C, Two strips. D, Three strips. E, Lateral view with 3 strips.

increased inflammation phase. The patient is instructed to perform calf exercises for venous thromboembolism (VTE) prophylaxis. Early mobilization exercises of the toes are recommended during these initial weeks. A stiff-soled postoperative shoe is commonly used for 4 to 6 weeks. Weight-bearing status will depend on the procedure. Early weight-bearing is recommended after a distal metatarsal osteotomy to stimulate the "self-adjustment" effect of the metatarsal heads according to the distribution of ground reaction forces.

Postoperative Bandage Changes

The first postoperative review (wound review) takes place at 10 to 14 days after surgery. The elastic bandage and gauzes are removed to inspect the wounds. Very often, the adhesive strips are still strongly adhered and can be covered by a new elastic cohesive bandage. This second bandage should be less bulky than the first one.

There are various techniques of maintaining the toes once the dressings are removed at the first postoperative review, but essentially, the toes must be controlled in the desired position until union has occurred (if osteotomies were part of the surgical correction). The subsequent reviews can be performed with varying frequencies depending on the type of procedure performed and the ability of the patient to self-care for his or her strapping/taping successfully.

Elastic tapings such as kinesiotape can be very helpful to maintain the toes in a corrected position as a second-stage bandage. Because of their elastic feature, these tapings will impart a continuous stretch toward the desired correction. As discussed previously, the toes generally benefit from a plantarflexed position. A tape can be applied dorsally around the most proximal part of the toe to maintain the toe in plantarflexion. If needed, additional tapes can be used to correct further deviations or rotations. A larger strip of tape can be used to

FIGURE 4. Taping used after a percutaneous hallux interphalangeus correction.

maintain the position of the hallux. There are ready-made strips of kinesiotape available. However, it is easier to cut strips to size according to each patient's needs. Patients can be taught how to cut and apply the tapes themselves. There are different colors and fashionable prints available.

A good alternative to adhesive taping is silicon digital splints. The splints are custom made and commonly used by podiatrists to accommodate multiple deformities. In a postoperative setting, they can be used to protect and separate the toes. It is a soft and easily kneadable material, which, when used with a "catalyst hardening paste," adopts a putty-like consistency. Hardening takes 1 to 5 minutes, in which the practitioner can adapt its shape to the needs of the patient. As the material does not absorb fluid, silicon splints should not be used when in contact with open wounds. For the same reason, it is recommended that talcum powder is added to avoid maceration of the skin.

FIGURE 5. Maintaining the hallux in a corrected position using a custom-made silicon splint. This splint can also be used after combined hammertoe surgery.

In the first few weeks, patients are advised to begin with range-of-motion exercises. These exercises should focus on plantarflexion of the toes. Both passive and active flexion exercises are recommended to avoid contractures. It is mandatory that the dressings allow these exercises to be started. Some surgeons mark the proximal part of the toe with a dot and instruct the patients to push the dot several times a day. After 6 weeks, physiotherapy can be considered. Again, the focus should be on passive and active flexion exercises of the MTP joints and extension of the IP joints. Any given exercise should avoid excessive strain on osteotomy sites, or else prolonged inflammation and delayed bone healing will occur.

SPECIFIC TECHNIQUES

Maintaining the Akin Osteotomy in Hallux Valgus Surgery

A correction of the hallux is often needed to create some space for the lesser toes. When performing a percutaneous akin osteotomy, it is the surgeon's choice to either fix the osteotomy with a screw or to use no internal fixation. In the latter situation, it is important that the hallux is maintained in an overcorrected position. This can be done by applying 1 or 2 adhesive strips on the medial side of the hallux and first metatarsal (Fig. 2). This bandage technique can also be used in open hallux valgus surgery. During a first or second postoperative review, this bandage can be replaced by a kinesiotape (Fig. 3). The kinesiotape is attached to the tip of the hallux. The tape is tensioned on the corresponding location of the osteotomy. By applying it in a spiral manner, a rotational deviation can be corrected or adjusted. Therefore, the elastic properties of the kinesiotape can be used. A similar taping can be used after a hallux interphalangeus correction (Fig. 4) An alternative is the use of a custom-made silicon digital splint (Fig. 5). It maintains the hallux in an overcorrected position, which is needed to keep the osteotomy area closed. This splint can also be used after a combined hammertoe surgery.

Clawtoe/Hammertoe Correction

A clawtoe or hammertoe is a deformity in the sagittal plane. The percutaneous surgical technique is adapted to the specific deformity.[12] Most commonly, a dorsiflexed MTP joint and plantarflexed IP joints need to be corrected. To correct increased dorsiflexion, a tenotomy of the extensor tendons and a release of the dorsal joint capsule are commonly used. This can be associated with a percutaneous osteotomy of the base of P1. Despite these corrections, the MTP joint often tends to remain in dorsiflexion. To ensure that a good correction is achieved, the MTP joint should be pushed plantarly. This can be done by applying adhesive strips starting on the dorsal aspect of P1, running between the toes, and attached plantarly on the forefoot (Fig. 6). These strips can also be used to maintain the position after correcting a medial or lateral deviation of the MTP joint. The toe must be held in the desired position when applying the strips (Fig. 7). A circular application should be avoided as it may compromise blood flow to the

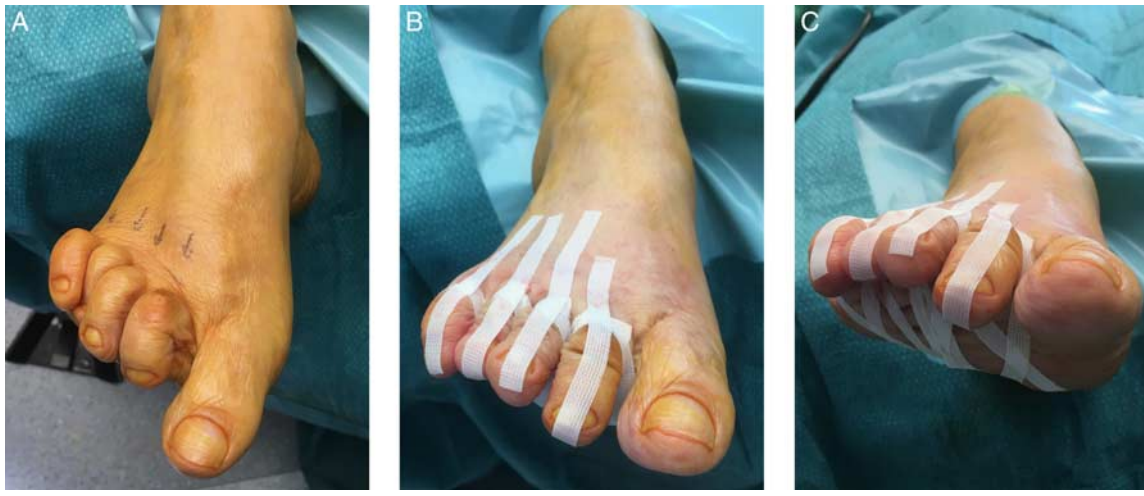

FIGURE 6. Percutaneous treatment of clawtoe deformity. A, Preoperative image. B, Postoperative image with application of adhesive strips, superior view. C, Postoperative image, inferior view.

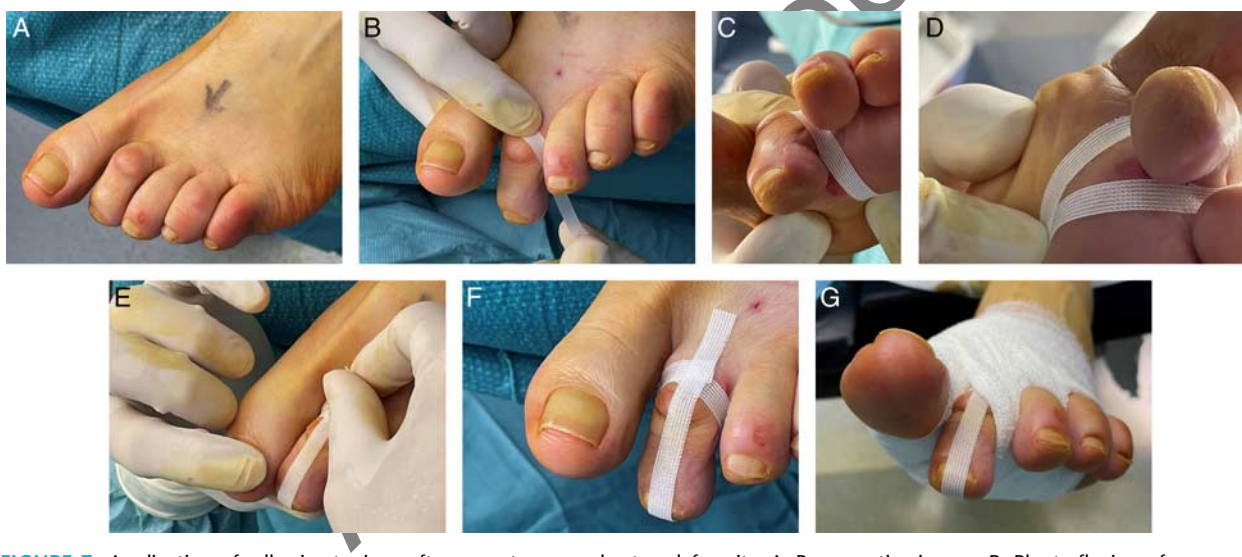

FIGURE 7. Application of adhesive tapings after percutaneous clawtoe deformity. A, Preoperative image. B, Plantarflexion of metatarsophalangeal joint. C, Application of the tape with the metatarsophalangeal joint in plantarflexion. D, Two tapings maintaining the metatarsophalangeal joint in plantarflexion. E, Extension of the interphalangeal joints. F, Application of dorsal tape with interphalangeal joints in extension. G, Final bandage with gauzes and elastic taping.

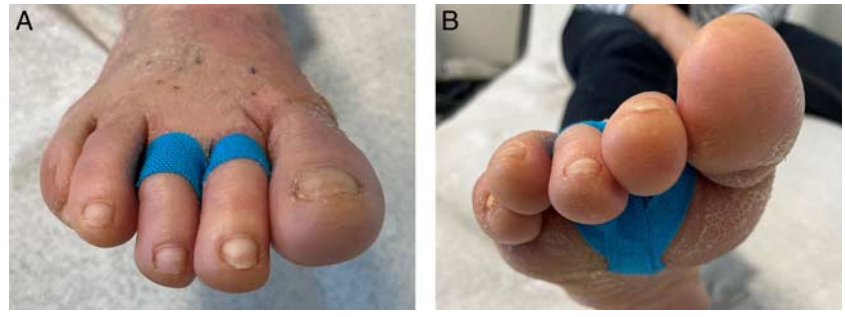

FIGURE 8. An elastic taping is commonly used to maintain the metatarsophalangeal joint in a plantarflexed position during healing after hammertoe correction combined with metatarsal osteotomy. A, Superior view. B, Inferior view.

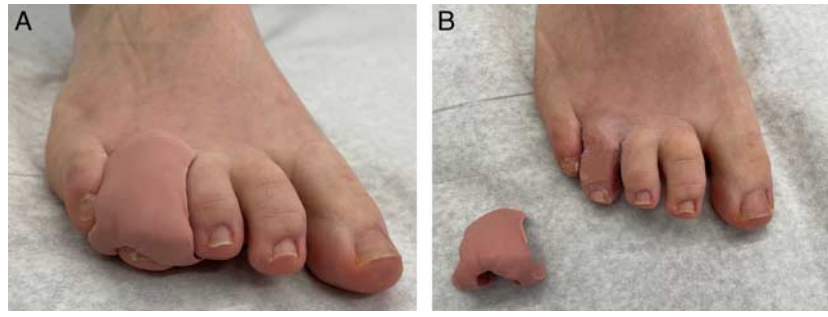

FIGURE 9. A, Foot with silicon splint in applied position. B, Foot with silicon splint next to the foot.

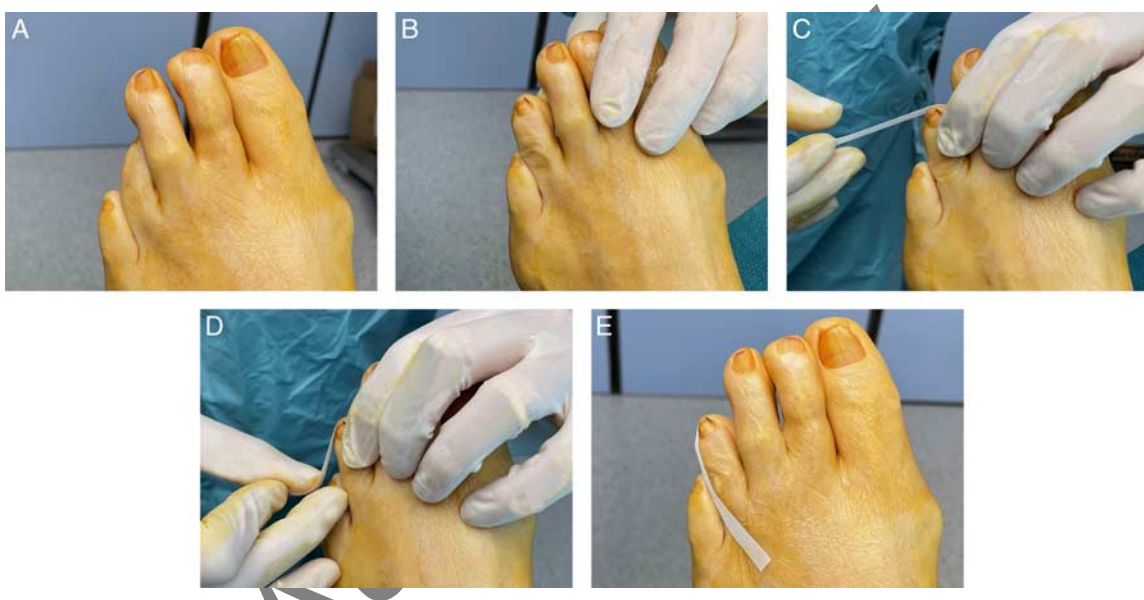

FIGURE 10. Percutaneous treatment of medial deviation. A, Preoperative image. B, Postoperative image. C–E, Application of adhesive strips with the toe maintained in the corrected position.

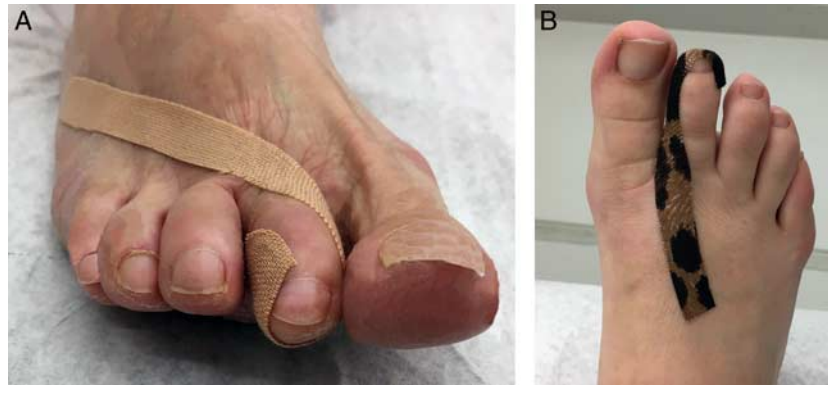

FIGURE 11. An elastic taping can be used to maintain or adjust the toe position. A, Rotational deformity. B, Lateral deviation.

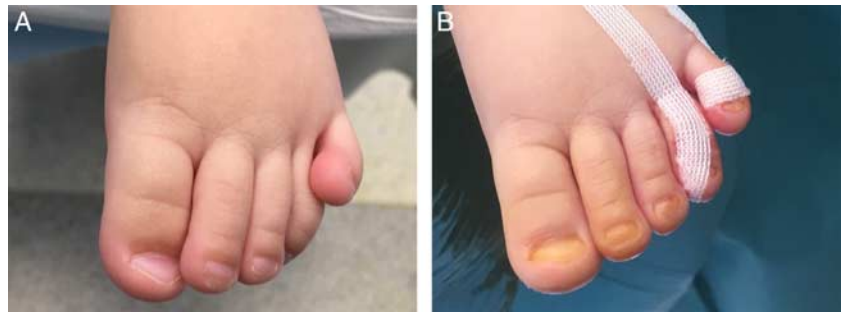

FIGURE 12. Adhesive taping in a 1-year-old child after a percutaneous soft tissue procedure for an overlapping toe. A, Preoperative situation. B, Postoperative view with taping maintaining the fourth second toe in extension and correcting the rotational deformity of the fifth toe.

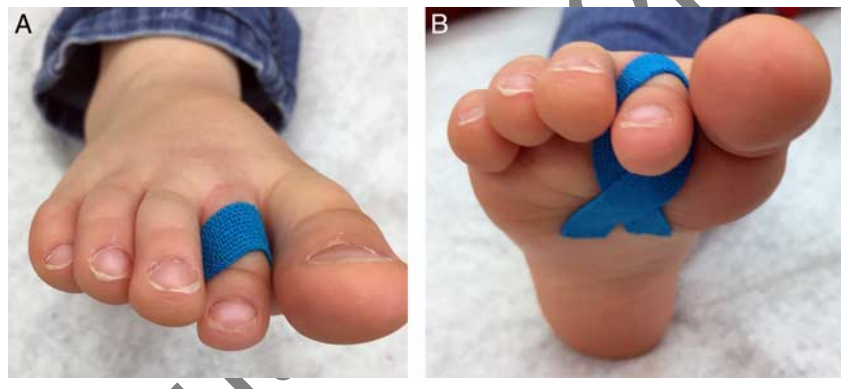

FIGURE 13. Elastic taping applied in a child after a tenotomy of the extensor tendons. A, Superior view. B, Inferior view.

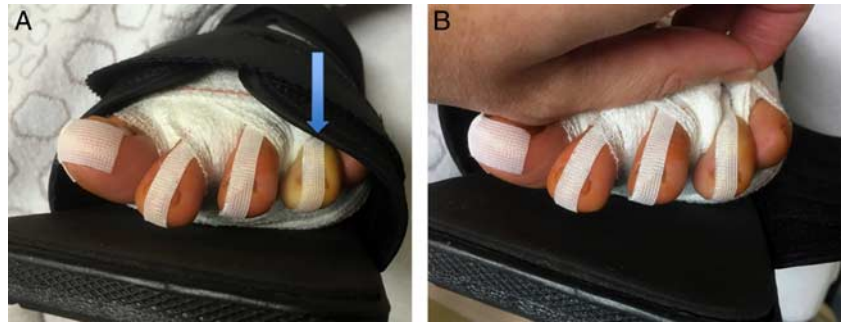

FIGURE 14. Toe perfusion should be checked postoperatively. A, Impaired fourth toe indicated with blue arrow. B, Tight dressing should be loosened or taken down.

FIGURE 15. Forefoot dressing. The dashed line indicates the place to cut the dressing in case of a tight bandage. The dot indicates the proximal phalanx. The patient is asked to push the dot regularly to start plantarflexion exercises.

toe. Frequently, percutaneous techniques are used to correct hyperflexion deformity of the proximal interphalangeal and distal interphalangeal joints. A dorsally applied strip will keep the toes in a corrected position. Finally, the dressing is finished with gauzes and an elastic cohesive bandage. It is mandatory to leave the tip of the toes visible outside the dressing to check for circulation issues and perfusion.

In a second dressing, kinesiotape is often used to maintain the MTP joint in a plantarflexed position (Fig. 8). It is used until 6 weeks postoperatively but this can be prolonged if needed. Usually, the patients can change the tapes themselves, which allows them to wash their feet. An elegant but less powerful technique is a custom-made silicon digital splint (Fig. 9). This allows to maintain the correction, while adjustment of the toe position is very limited.

Lateral and Medial Deviation

Toe deformities can be seen in all different directions. The different steps in the percutaneous technique are used to perform the correction. The postoperative bandage is used to maintain the correction. In an early stage, the adhesive taping is used to maintain the correction (Fig. 10). In a later stage, a kinesiotape avoids the return of a deviation or a rotational deformity (Fig. 11).

Curly Toe Correction

In children, curly toes are often seen associated with an overtight tendon. After a percutaneous soft tissue release, the toe is pulled in the reverse position, which corrects the deformity. As the skin position will adapt to the new situation, an extended skin incision like that used in a Butler technique is not needed. A first adhesive strip is kept for the first 2 weeks (Fig. 12). Parents can be instructed to apply a kinesiotape for the next 4 to 6 weeks (Fig. 13).

COMPLICATIONS

Complications are uncommon after a percutaneous toe correction. Most complications can be avoided by a correct surgical technique, an adapted dressing technique, and a dedicated follow-up. The patient must be instructed as thoroughly as possible about the correct postoperative care.

Tight Dressing

With elastic bandages, the risk of overtightening the dressing exists. Toe discoloration and perfusion should be checked regularly. In the event of reduced perfusion, the dressing should be loosened or taken down if needed (Fig. 14). Excessive pain can also be a sign of an overtightened dressing. Generally, this can be addressed by cutting the bandage in an area away from the operated toes without having to remove the entire bandage. The use of long-lasting locoregional nerve blocks can mask or delay the appearance of pain. The patient should be informed about this risk and special attention should be paid to other signs. Some surgeons prefer to cut the circular cohesive bandage at the end of the procedure; others indicate where to cut it and instruct the patients to do it as needed (Fig. 15).

Infection/Burn

Superficial wound infections are very rare, but still possible in percutaneous techniques. Infections can be induced by burns caused by the burr. The risk of burns can be significantly reduced if the adequate preventive measures are considered: correct portal placement, continuous cooling of the burrs, and an accurate technique. An area of burnt skin can be excised if

FIGURE 16. Secondary displacement of a too-distal percutaneous Akin-osteotomy. A, X-ray at 3 weeks. B, X-ray at 6 weeks after corrective kinesiotape.

noticed during surgery. A superficial infection can usually be treated with oral antibiotics and daily wound care.

Loss of Correction

An early loss of correction is a possible complication in percutaneous techniques. If this secondary displacement occurs in the toes, an early corrective taping may be very helpful (Fig. 16). A dedicated follow-up decreases the risk of this complication.

Swelling

Limited swelling is normal and can last 3 to 4 months. The patients should be informed about the long duration of swelling. Severe swelling can be caused by a lack of elevation in the immediate postoperative period. This is often associated with overuse or noncompliance. The patient should be instructed to keep the foot elevated and to refrain from any standing or walking activities for the first 3 to 4 days. After this initial period of time, activities can be resumed progressively. Patients with venous insufficiency are more at risk of longstanding and/or severe swelling.

Stiffness

Excessive postoperative stiffness is related to inflammation. Patients with postoperative infections, severe swelling, or early overuse are at risk. Limiting inflammation is important during the early postoperative period. If inflammation is controlled, early mobilization can be recommended safely. At 6 weeks postoperatively, physiotherapy is often considered. In the case of persistent stiffness after the bone is healed, an injection with corticosteroids and manipulation can be considered.

CONCLUSIONS

Due to the limited use of hardware in percutaneous forefoot techniques, the dressing becomes instrumental as a way to provide primary stability. The first postoperative dressing should be seen as part of the surgery and should be applied by the surgeon. Following some general principles, the specific technique is adapted to the preoperative deformity and the surgical goals. During the entire surgical aftercare period, bandage techniques will be paramount to keep the foot in a corrected position while healing occurs.

POSSIBLE CONCERNS, FUTURE OF THE TECHNIQUE

A major concern is the tendency of limiting the training to purely surgical technical aspects. Training should not only be limited to performing the percutaneous techniques but also include different other aspects of patient care. First, dressing techniques are extremely important as mentioned above. The surgeon should master different bandage techniques and apply them according to the specific needs. Second, knowledge about how to avoid and how to handle complications is also very important, and this includes those complications that arise from inappropriate dressing application. Third, as surgery is performed within a team, the surgeon introducing new techniques should also train and inform other team members. Colleagues, physiotherapists, and radiologists should be made aware of key characteristics of the newly introduced surgery and the impact on the aftercare. Finally, the surgeon should have sound insight into the limitations and possibilities of the percutaneous techniques. They are nothing more than an extra tool in the toolbox of the foot and ankle surgeon and must be indicated sensibly. Only those surgeons mastering both open and Minimally Invasive Surgery procedures will be able to decide which one to use for the benefit of their patients.

REFERENCES

1. Isham S. The Reverdin-Isham procedure for the correction of hallux abductovalgus. A distal metatarsal osteotomy procedure. *Clin Podiatr Med Surg*. 1991;8:81–94.
2. De Prado M, Ripoll PL, Golano P. *Cirugia Percutanea Del Pie*. Barcelona: Masson Elsevier; 2003.
3. De Prado M, Ripoll PL, Golano P. In: Golano P, eds. *Minimally Invasive Foot Surgery*, 1st. Barcelona: About Your Health Publishers; 2009.
4. Malagelada F, Dalmau-Pastor M, Sahirad C. The Foot Anatomical considerations for minimally invasive osteotomy of the fi fth metatarsal for bunionette correction—A pilot study. *Foot*. 2018;36:39–42.
5. Dalmau-Pastor M, Vega J, Malagelada F, et al. An anatomical study of nerves at risk during minimally invasive hallux valgus surgery. *J Vis Exp*. 2018;17:56232.
6. Malagelada F, Dalmau-Pastor M, Fargues B, et al. Foot and ankle surgery increasing the safety of minimally invasive hallux surgery—an anatomical study introducing the clock method. *Foot Ankle Surg*. 2018;24:40–44.
7. Hernandez JL, Chauveaux D, Laffenêtre O. Treatment of moderate hallux valgus by Chevron (PERC) osteotomy. *Bone Joint J*. 2016;98-B:365–373.
8. Johansen JK, Jordan M, Thomas M. Foot and ankle surgery clinical and radiological outcomes after Weil osteotomy compared to distal metatarsal metaphyseal osteotomy in the treatment of metatarsalgia—a prospective study. *Foot Ankle Surg*. 2019;25:488–494.
9. Kaufmann G, Dammerer D, Liebensteiner M, et al. Minimally invasive versus open Chevron osteotomy for hallux valgus correction: a randomized controlled trial. *Int Orthop*. 2019;43:343–350.
10. Michels F, Van Der Bauwhede J, Guillo S, et al. Percutaneous bunionette correction. *Foot Ankle Surg*. 2013;19:9–14.
11. Laffenêtre O, Millet-barbé B, Darcel V, et al. Percutaneous bunionette correction: results of a 49-case retrospective study at a mean 34 months' follow-up. *Orthop Traumatol Surg Res*. 2015;101:179–184.
12. Cordier G, Nunes GA. Minimally invasive advances: lesser toes deformities. *Foot Ankle Clin*. 2020;25:461–478.
13. Redfern DJ, Vernois J. Percutaneous surgery for metatarsalgia and the lesser toes. *Foot Ankle Clin*. 2016;21:527–550.
14. Frey-ollivier S, Catena F, Hélix-giordanino M, et al. Treatment of flexible lesser toe deformities. *Foot Ankle Clin*. 2018;23:69–90.
15. Frey S, Hélix-Giordanino M, Piclet-Legré B. Percutaneous correction of second toe proximal deformity: proximal interphalangeal release, flexor digitorum brevis tenotomy and proximal phalanx osteotomy. *Orthop Traumatol Surg Res*. 2015;101:753–758.