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Minimally Invasive Corrective Osteotomy (MICO) of the Hand a Novel Technique

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Learning Point of the Article:

Minimally invasive approach for corrective osteotomy of the phalanx.

Abstract

Introduction: Patients facing post-traumatic malunion or congenital hand differences often contend with functional and cosmetic issues. Traditional correction methods involve open osteotomy, marked by drawbacks like scarring, non-union risks, prolonged rehabilitation, and adhesions. We therefore introduce a novel minimally invasive technique called Minimally Invasive Corrective Osteotomy of the Hand (MICO), which can be performed under local anesthesia. MICO employs a low-speed, high-torque burr to address finger malunions and congenital anomalies.

Case Report: A 49-year-old male patient, generally healthy and right hand dominant, presented with a post-traumatic left middle finger, middle phalanx malunion who underwent the MICO procedure, with a 1-year post-operative follow-up.

Conclusion: Our findings suggest that MICO offers a straightforward, reproducible, and delicate solution for correcting hand malunions and congenital finger deformities, potentially mitigating the well-established disadvantages and complications associated with the traditional open approach. Although early results of MICO are promising, a larger case series is needed to evaluate the superiority of this technique compared with current open corrective osteotomy methods.

Level of Evidence: IV

Keywords: Osteotomy, minimal invasive surgery, finger deformity.

Introduction

Congenital hand deformities and post-traumatic malunions of the hand can result in significant functional limitations and esthetic concerns. These deformities encompass conditions such as finger scissoring, tendon imbalance, and reduced grip strength [1]. Corrective osteotomy is a commonly employed procedure to restore proper anatomical alignment, thereby enhancing functional outcomes. This surgical intervention entails the precise incision and realignment of the deformed bone through the utilization of handheld osteotomes or saws, followed by the subsequent stabilization of the osteotomy site using pins or plates [2].

While an open surgical approach is frequently required to address these deformities, the available data regarding open corrective osteotomy procedures is limited. The existing literature primarily comprises outdated descriptions,

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Figure 1: A pre-operative photograph of the patient's hand, revealing a left middle finger that is radially deviated at the middle phalanx level.

Figure 2: The osteotomy process using a fine 12 × 2 mm Shannon burr, attached to an electric motor-driven machine with variable speed (NSK Surgic Pro, NSK, IL, USA).

predominantly composed of case series and case reports, which often feature limited follow-up data [3-5].

The drawbacks of an open approach are well described and include inevitable surgical incision scarring, non-unions due to abrupt soft-tissue dissection, long rehabilitation time, and up to 50% chance of adhesions in some of the studies [5-8]. The conventional osteotomy instruments, including oscillating saws and osteotomes, carry the inherent risk of causing nerve and soft-tissue damage, present limitations in terms of precise control during the procedure, and may result in substantial heat generation at the fracture site, with these issues being further compounded by the proximity of crucial anatomical structures surrounding the bones [6,9].

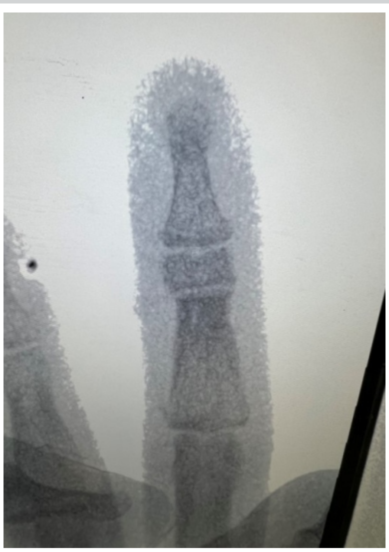

Figure 3: Intraoperative fluoroscopy image after the osteotomy.

The utilization of low-speed burrs in minimally invasive surgery for correcting hallux valgus is an increasingly expanding approach, offering potential advantages such as smaller incisions, reduced pain and recovery duration, decreased likelihood of neurovascular complications, and enhanced range of motion (ROM) [10].

The objective of this study was to document the technical aspects and outcomes in a group of patients experiencing phalangeal deformities that were affecting both their appearance and functionality. In this context, we introduce a novel technique known as percutaneous Minimally Invasive Corrective Osteotomy of the Hand (MICO), which can be carried out using local anesthesia.

Cases Report

A 49-year-old male patient, in overall good health and right-hand dominant, sought medical attention due to an untreated malunion of the middle phalanges of his middle and ring fingers. He had not previously consulted with a hand specialist.

On conducting a physical examination, it was apparent that the middle finger exhibited radial deviation, while the ring finger displayed ulnar deviation (Fig. 1). His primary concern was the radial deviation of his middle finger, which was significantly affecting his daily activities.

Radiographic images confirmed the radial deviation of the third finger and the ulnar deviation of the fourth finger, particularly around the middle phalanges.

Technique

The affected extremity was prepared and draped. We administered an 8 cc injection of 1% Lidocaine solution for digital nerve block. The precise correction site was identified as the point nearest to the center of correction and angulation (CORA). This had been determined preoperatively and confirmed using fluoroscopy before the osteotomy. The CORA location, situated around the neck of the middle phalanx, was marked on the ulnar side of the skin.

A 2-mm mid-lateral incision was made at the marked location using a 367-beaver blade. We employed an electric motor-driven machine with adjustable speed (NSK Surgic Pro, NSK, IL, USA) for the osteotomy. A 12*2 mm Shannon burr was

Figure 4: Anterior-posterior radiograph displays fixation at the osteotomy site and temporary pinning of the distal interphalangeal joint using retrograde Kirshner wires.

Figure 5: Clinical photographs reveal well-aligned finger positioning, nearly imperceptible scars from the stab incisions and full tip-to-palm flexion of the operated middle finger.

introduced beyond the skin to precisely determine the osteotomy site on the ulnar aspect of the middle phalanx's neck, and this was confirmed with fluoroscopy.

The ulnar dorsal and palmar cortex were then unilaterally cut using the burr, operating at a speed of 2500 RPM and a torque of 80 Nm (low speed, high torque) (Fig. 2).

After completing the close-wedge osteotomy (Fig. 3), a retrograde 1.2 Kirschner wire was guided through the distal interphalangeal (DIP) joint and the osteotomy site under fluoroscopic guidance, while concurrently compressing the osteotomy line. A second retrograde oblique Kirschner wire was inserted through the fracture site for rotational stability.

We confirmed the intact rotational alignment of the finger through active finger flexion and extension.

A volar aluminum splint was used to immobilize the DIP joints. After 4 weeks, when radiographs indicated union, the Kirschner wires were removed. Following this, patients commenced hand therapy exercises aimed at improving the ROM in all their finger joints to achieve full grip and extension.

The initial follow-up radiographs after the correction revealed successful deformity correction and proper positioning of the Kirschner wires (Fig. 4).

At the 1-year follow-up, subsequent radiographs indicated complete union at the osteotomy site, while physical examination demonstrated a well-aligned finger arrangement, full range of fingers motion, and barely noticeable incision scars (Fig. 5).

Discussion

Posttraumatic malunion and congenital finger deformities may cause cosmetic and functional deficits including scissoring or finger deviation that can cause tendon imbalance and decreased grip strength [11].

In cases of impaired hand function, corrective osteotomy is recommended to restore anatomical alignment, with open approach being the predominant method currently employed.

The complications of open osteotomy are well described. Common complications include post-operative scars, joint and tendon adhesions, damage to proximity structures such as nerves and blood vessels, delayed union due to periosteal dissection and infection [5-8].

The traditionally used osteotomes have numerous disadvantages including damage to the periosteal layer, significant heat generation that can lead to bone necrosis and can potentially damage adjacent neurovascular structures. Chisel's disadvantages include the inability to control the extent of osteotomy, high risk of incurring adjacent fractures, possibility of tendon/ligament and neurovascular mechanical damage, and its impracticability for performing intra-articular osteotomies [12].

Minimal invasive chevron and akin osteotomy for hallux valgus correction have been developed by Walker and Redfern who described a high torque, low-speed modification of the Shannon burr to avoid the risk of skin or soft-tissue thermal damage [13]. While the benefits of this technique have already been recognized and widely used in foot reconstruction, MICO is the first surgical technique using this system in hand surgery.

The authors concur that corrective osteotomy should be conducted at the fracture site in order to minimize the translation and/or angulation of the correction. Nevertheless, it is important to note that the original fracture site carries the highest risk for generating additional adhesions and potential damage to nearby structures during the dissection process. The utilization of MICO in hand surgery offers a distinct advantage. With MICO, surgeons can make minimal incisions, often as small as 2 mm. This obviates the need for extensive dissection of the surrounding tissues, thereby reducing the likelihood of additional adhesions and the potential for adjacent neurovascular injury.

The selection of fixation modality remains a topic of active discussion. While certain rigid fixation methods, such as the use of plates, may enable early ROM, this approach demands a high level of technical expertise and entails soft tissue dissection. In addition, hardware removal and tenolysis are frequently required through a subsequent surgical procedure [14, 15].

There is ongoing interest in the utilization of intramedullary headless compression screws for the management of phalangeal and metacarpal fractures [16]. A recent retrospective analysis, involving 20 patients who underwent corrective osteotomy using an oscillating saw alongside intramedullary headless compression screws, has demonstrated encouraging outcomes [17]. Using an intramedullary headless compression screw as fixation device offers several advantages, including the achievement of a sufficiently rigid fixation that facilitates early ROM, as well as the requirement for only a minimal incision. However, it is imperative to note potential limitations, such as the risk of articular surface damage at the insertion site and the technical complexities associated with screw removal. The consideration of headless compression screws used in MICO future cases should be judiciously made in select cases.

Surgical scars have been identified as conspicuous indicators of psychological distress in patients experiencing symptoms of depression, anger, anxiety, and post-traumatic stress [18]. Therefore, the MICO surgical technique, with its scarless approach, is especially pertinent, making this procedure elegant, delicate, and well-suited for the hand's gentle anatomy.

The MICO technique offers several advantages over standard osteotomies conducted using an oscillating saw or osteotome. These advantages encompass the ability to perform a percutaneous osteotomy, minimizing harm to the periosteal layer, enhancing precision for improved osteotomy and bone alignment control, reducing stiffness and pain through a smaller surgical incision, minimizing the risk of collateral damage to nearby neurovascular structures, and lowering heat generation.

We also recommend preforming this procedure under local anesthesia with the patient wide awake whenever possible to appreciate accurate rotational alignment of the operated finger throughout ROM.

Conclusion

MICO for hand procedures represents a straightforward, delicate, reproducible, and accessible solution for addressing malunions and congenital anomalies of the fingers. It may offer advantages by circumventing the recognized drawbacks and complications associated with an open corrective osteotomy approach.

While initial outcomes of MICO show promise, a more extensive case series is required to assess the potential superiority of this technique in comparison to existing open corrective osteotomy methods.

Clinical Message

MICO is a reproducible and accessible solution for malunions and congenital anomalies of the fingers and may avoid the known disadvantages and complications of an open approach.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Conflict of interest: Nil **Source of support:** None

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