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CORRECTIVE DEROTATING OSTEOTOMY WITH THREE-DIMENSIONAL IMPRESSION MODEL: REVIEW OF THE TOPIC BASED ON A CLINICAL CASE

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Abstract: Corrective derotating osteotomies may be indicated for the correction of congenital pathologies at the level of the phalanges, or acquired due to trauma. In this article we will focus on traumatic deformities. Fractures of the fingers are the most common fractures. In most cases they are treated with conservative treatment, achieving good results, although in some cases surgical treatment using percutaneous or open osteosynthesis may be necessary. Despite strict controls, displacement of the fracture can occur with consequent poor union of the fracture focus, resulting in functional limitations of the hand. In these cases, treatment through corrective osteotomies may be feasible. In the case of rotational displacements at the level of proximal phalanx fractures (F1), on which we will focus, a digital crossing will occur. To correct this deformity, derotating osteotomies can be chosen at the F1 level or in the metacarpal (MTC). We will evaluate the use of computed tomography with three-dimensional printing for decision making and treatment planning. The objective of the present study is to update the topic through a review of different publications on corrective derotating osteotomies and also the use of 3D reconstruction for their treatment, based on a clinical case operated by the author. We carried out a bibliographic review on derotating osteotomies including the Medline databases (Pubmed interface), Scielo and Google Scholar. Material and methods: A narrative bibliographic review was carried out on derotating osteotomy at the phalanx and metacarpal level in traumatic malunions. The search was carried out including the Medline (Pubmed interface), Scielo and Google Scholar databases. Discussion: Based on a clinical case, different possibilities regarding the topography of the osteotomy are evaluated; at the level of the original fracture, in the proximal phalanx or at the level of the corresponding MTC, the type of osteotomy; transverse or stepped, the type of fixation used, and the use of three-dimensional reconstruction. Results: a preference was seen for MTC osteotomy compared to phalanx osteotomy. Although for complex cases with a greater need for rotation, it is preferable to opt for an osteotomy in the proximal phalanx. No published articles were found that compare transverse derotating osteotomies with step osteotomies, although it has been proven that step osteotomies have a lower correction capacity. Stable osteosynthesis methods are preferred to achieve early rehabilitation and mobilization. There is only one article that uses three-dimensional reconstruction with excellent results. Conclusion: Derotating osteotomy is a simple technique used in cases of poor union of the proximal phalanx, with evident functional and aesthetic alteration with good results. In all cases, treatment must be individualized. The evaluation with computed tomography and previous 3D reconstruction allows a specific evaluation for each patient. It allows the surgery to be previously planned by evaluating the osteotomy site, the degrees of rotation necessary for adequate correction and the premolding of the plate, thus facilitating and shortening surgical time.

Keywords: "corrective osteotomy", "derotational", "mal union", "3D reconstruction".

INTRODUCTION

Corrective derotating osteotomies may be indicated for the correction of congenital pathologies at the level of the phalanges or acquired due to trauma. In this article we will focus on traumatic deformities.

Finger fractures are the most common fractures.[1] Phalanx or metacarpal fractures can be treated conservatively by immobilization with small degrees of angulation or rotation without obvious clinical consequences, this being the most common treatment. However, when the rotational deformity is substantial, considered a rotation greater than 10 degrees in F1, it results in digital interlocking, being maximum in flexion. [2]

Overlapping a toe can cause significant functional and aesthetic impairment. Once the fracture has consolidated in this unfavorable position, surgical correction through a derotating osteotomy will be necessary.

Malunion is defined as fractures that heal with some degree of displacement.

In addition to causing digital crossing, it can cause pain due to distortion at the joint level, tendon imbalance and reduction in the overall grip strength of the hand.

Malunion in the phalanges of the first finger or in the middle or distal phalanx of the long fingers present fewer functional alterations than in the proximal phalanx, which is why we will focus on the latter where corrective osteotomies are normally indicated.

The functional impact of a malunion at the level of the proximal phalanx can vary depending on the location, the type of stroke, the severity of the displacement, whether or not it includes articulation, and the presence or absence of tendon involvement.

The corrective derotating osteotomy can be performed in these cases at the level of the original fracture, the proximal phalanx or at the level of the corresponding MTC.

Satisfactory results in terms of functional improvement of the hand with osteotomies have been described based solely on clinical and radiological studies.

Plain radiography is the standard for evaluating bone deformities. Computed tomography allows a more complete evaluation of the deformity that can not be obtained with conventional x-ray. Recent advances in 3D printing technology have made it easier to produce patient-specific guides, allowing for better preoperative planning tailored to each patient. This approach has presented excellent results particularly in corrective osteotomies of forearm bones.

The objective of the study is to update the topic through a review of different publications on corrective derotating osteotomies and also the use of 3D printing for their treatment, based on a clinical case.

MATERIALS AND METHODS

A narrative literature review was carried out on derotating osteotomy at the phalanx and metacarpal level in traumatic malunions. The search was carried out including the Medline (Pubmed interface), Scielo and Google Scholar databases.

The key words were used: “corrective osteotomy”, “derotational”, “mal union”, “3D reconstruction”.

From the initial search, 17 articles emerged, which were analyzed by the authors, selecting publications that met the following inclusion criteria: clinical trials, case series, case reports and bibliographic reviews that include patients in whom osteotomy was performed. The articles published in English, Spanish, Portuguese, French and German. No restriction was established regarding the publication time period.

The exclusion criteria were: publications without an identifiable scientific article format, works in the pediatric population, derotating osteotomies that only included patients with congenital pathologies, osteotomies or intra-auricular fractures.

This work is carried out in accordance with the standards of the Ethics Committee of ``*Hospital de Clínicas*``. The images of patients in this publication have their informed consent.

CLINICAL CASE

We present a female patient, 27 years old, right-handed. She does administrative work. No personal background to highlight.

She presented blunt trauma to her left hand in the context of a volleyball game, with a fracture of the proximal phalanx of the 5th finger.

The x-ray at the initial moment showed a single diaphyseal line at the level of F1 of the 5th finger of the left hand, long oblique, with displacement of the distal fragment towards the radial and proximal fragments, presenting a certain degree of rotation. She does not present joint involvement. She underwent orthopedic treatment for 6 weeks.

She consulted 4 months later with metacarpophalangeal joint (MTC) attitude in hyperextension and semi-flexion of approximately 15 degrees proximal interphalangeal joint (PIFP) of the 5th finger and hint of supination.

On palpation she had no pain at the fracture site.

Upon mobilization of the AIFP, she had flexion limitation of 70 degrees.

On active flexion, digital crossing of the 5th finger towards the 4th is evident.

In the x-ray at 4 months, there are elements of bone consolidation.

A diagnosis of malunion of F1 of the 5th finger is made; This may be due to an inappropriate or insufficient reduction or a displacement of the reduction.

An F1 rotation degree of approximately 30 degrees is estimated.

The patient underwent physiatric treatment for 3 months to recover joint mobility. Subsequently, surgical treatment was performed through derotating osteotomy and osteosynthesis.

Preoperative planning of the osteotomy and osteosynthesis was performed by three-dimensional printing of a full-scale model of the phalanges and the 5th metacarpal. The patient had a rotation of 30 degrees, which is at the limit for the MTC osteotomy of the 5th finger.

During preoperative planning, an osteotomy was performed in the proximal 1/3 of F1 of the 5th finger with an oscillating saw in a three-dimensional impression model and in the proximal ¼ of the metacarpal.

Through the impression, both corrections were evaluated, verifying a better result in the F1 osteotomy.

In the case of the metacarpal osteotomy, a large rotation (approximately 45 degrees) had to be performed to achieve an adequate correction of the digital crossing, which we consider would not be possible given the limitation produced by the soft tissues, especially the deep transverse ligament, and given the imbalance that this could cause at the level of intrinsic muscles and digital flexo-extensor function. It also caused a greater ulnar deviation of the 5th ray

Osteotomy at the F1 level produced a more natural change in the digital cascade.

Based on what was evidenced, it was decided to perform a transverse osteotomy at the F1 level.

The surgical procedure was performed under general anesthesia. First, the approach was carried out in the dorsal region of the proximal phalanx, a longitudinal tenotomy of the extensor apparatus and a planned distal osteotomy were performed.

Adequate position was verified through tenodesic maneuvers, fixing the new position with a temporary K nail. Osteosynthesis with pre-molded screwed plate. It was not necessary to perform tenolysis or capsulotomy procedures.

Immobilization was performed with a plaster splint for 10 days and then physiotherapy began with active mobilization exercises.

There were no complications in the immediate postoperative period. In the long postoperative period, she presented pain when performing physical therapy and tension caused by the extensor apparatus of the fingers. Regarding her attitude, she has a 5th finger with slight ulnar deviation. In motor terms he showed clear improvement, correcting the rotational deformity as he did not suffer from digital crossing but presenting a maximum flexion of the PIP of 60 degrees. Despite this, the patient reported great improvement in performing daily tasks, recovering her grip strength.

Currently the patient continues under a treatment plan led by physiotherapists to increase her degree of flexion.

DISCUSSION

Corrective derotating hand osteotomy is a reconstructive procedure that can be performed in these cases at the level of the original fracture, the proximal phalanx or at the level of the corresponding MTC.

It is proposed that treatment through osteotomies must ideally be performed early, before 10 weeks, through the recreation of the fracture focus, with elimination of the immature callus, new reduction and adequate stabilization, avoiding tendon adhesions or secondary joint contractures. of the poor union process.

If surgery is not possible before 10 weeks, it is recommended to wait at least 3 months and focus this time on maximizing digital mobilization. [3]

Preoperatively, digital trophism, the absence of infection, the quality of the skin with a view to coverage of the osteosynthesis material, sensitivity, passive joint mobility, and flexor and extensor function must be evaluated.

An imaging study must be requested to assess the malunion.

Corrective osteotomies can be divided as simple or complex. Complex osteotomies are those that must associate procedures of: capsultomy, tenolysis, nerve reconstruction or flaps for coverage.

Corrective osteotomy of the rotated proximal phalanx is technically challenging. It can be performed in the proximal 1/3 of F1 or at the original fracture site.

Performing a derotating osteotomy at the level of the original fracture can be difficult given that the outline of the original fracture can be indistinguishable, especially at the level of spiral fractures.

Performing the osteotomy at the F1 level implies exposure of the extensor apparatus with an approach to it through a longitudinal tenotomy. The use of osteosynthesis plates at this level has a greater risk of rigidity due to the intimate relationship between the extensor apparatus and may produce adhesions. Secondary surgeries to remove osteosynthesis material due to pain and/or tenolysis are very common in these cases. [1]

Osteotomies at the F1 level can be performed at the base or subcondylar region. It is recommended to perform it at the base level since there is a greater probability of rigidity at the level of the AIFP than at the AMCF.

On the other hand, we have metacarpal osteotomies to correct rotational deformity after F1 fractures. It was described by Weckesser in 1965, the technique includes osteotomy in the proximal quarter of the MTC and fixation with an osteosynthesis plate. The advantages of this technique are that it presents a lower risk of tendon adhesions and rarely requires secondary tenolysis. [4]

The great limitation for the application of this procedure is the degree of rotational correction that can be achieved, variable between the different fingers, mainly due to the deep transverse ligament.

In this regard, a cadaveric study evaluated the maximum rotation of the MTC. Since the proximal phalanx is not fixed to the MTC, rotation of the MTC will not be equivalent to correction of the phalanx. The correction of the phalanx is approximately 70% less than the rotation of the MTC (the ratio varies from 0.67 to 0.77). It was shown that corrections of up to 19° can be achieved in the index, middle and ring fingers. Correction in the little finger is limited to 20° of pronation and 30° of supination.

In this study, two factors that could limit MTC rotation were considered: the position of the AMCF after osteotomy and the deep MTC ligament.

As the MTC rotates, the joint also rotates; it was believed that excessive rotation could limit flexion in this joint due to altered congruity and contact area of the articular surfaces. Since no significant loss of flexion was observed at that joint, it was considered that this was not a factor limiting rotation.

To determine if the deep transverse metacarpal ligament was a limiting factor in metacarpal rotation, in this cadaveric study, repetition of the rotation of the metacarpal and phalanx was performed in 11 hands after sectioning the ligament. Ligament release increased maximal rotation in the metacarpals and resulted in a similar increase in phalangeal rotation in all fingers tested.

These results prove that the deep transverse metacarpal ligament limits maximum rotation in the metacarpal and phalanx.

However, the consequence was noted: a loss of the transverse palmar arch and instability at the level of the MCP joint. For this reason, ligament resection is not recommended as a way to obtain greater metacarpal rotation. [5]

Osteotomy through the phalanx must be considered when further correction is necessary.

Inadequate correction gives rise to obvious dissatisfaction, so careful patient selection and treatment must be carried out.

The most frequent complications of corrective derotating osteotomies are: persistent deformity, delayed union, pseudoartorsis, infection, persistent or increased stiffness, chronic pain, exposure of osteosynthesis material. Patients must be selected with discretion and full consideration of the relative benefits and risks for each particular deformity and corrective procedure.

Weckesser described the treatment of 6 MTC and 2 proximal phalanges with rotational deformities in which he performed a transverse extra-articular derotating osteotomy with fixation with Kirschner nails at the base of the MTC, presenting excellent results. It was necessary to associate flexor tenolysis at the level of both fractures in F1.[4]

Pieron corrected a 5th finger deformity with 15 degrees of pronation, caused by an extra-articular long oblique fracture of the F1 of a violinist's non-dominant hand. He performed an extra-articular osteotomy near the base of the 5th MTC, fixing it with a stabilization plate, presenting excellent results. [6]

Menon presented complete correction of 11 of 12 rotatory malunions (3 metacarpal and 9 phalangeal) from 15 to 30 degrees, using an extra-articular proximal metacarpal transverse osteotomy fixation with Kirschner pins. He carried out a minimum follow-up of 6 months. There were no cases of stiffness after surgery.[7]

Stepped osteotomies have also been described to correct rotary metacarpal and phalangeal deformities. Stepped osteotomies allow less room for simultaneous angular correction. Manktelow and Mahoney[8] presented cases with good functional recovery through diaphyseal metacarpal osteotomies using stepped osteotomies in 10 patients with a rotational malunion of the metacarpal.

Pichora et al. performed 23 graded corrective osteotomies, 7 metacarpal and 16 phalangeal, at the site of malunion with rotational deformities in 18 patients. It was necessary to combine capsulotomy and tenolysis in 11 digits. In all cases the deformity was corrected. Follow-up was at least 3 months. Some patients had additional stiffness.[9]

Sanders and Frederick presented good results, performing 3 extra-articular metacarpal and 7 phalangeal osteotomies in 10 patients, achieving correction of the rotational deformity and an average improvement of 30 degrees in the flexion arc of movement. They were followed for an average of 30 months (range: 12-60 months). Whenever possible, plate fixation was preferred to wire fixation. [10]

Van der Lei et al. [11] performed corrective extra-articular osteotomies for angular, rotational, or combined deformities greater than 15 degrees in six metacarpals and nine phalanges. The metacarpal osteotomies were fixed with osteosynthesis plates, the phalanges with a K nail at first, then with cerclage wire. Patients were followed for a mean of 4.5 years (range: 1-11 years). Thirteen of the 15 patients (87%) had complete correction of their deformity and were very satisfied. In two patients who had osteotomy performed at the level of the phalanx, additional surgery was required to correct residual deformities. There were no other complications from the surgery. Better results were obtained in patients in whom stable fixation was used since it offered the possibility of early mobilization.

Buchler conducted an evaluation of a historical cohort of 59 corrective proximal phalanx osteotomies performed at the malunion site in 57 patients. Forty-five (76%) of the osteotomies had satisfactory correction of the deformity. Twenty-six (96%) of the 27 patients with simple malunion did not present complications due to adhesions and 21 (65%) of 32 patients with complex malunion required capsulotomy and tenodesis in the same surgical procedure and presented excellent or good results. Rigid fixation allowed early mobilization which contributed to an earlier and more complete functional recovery. Of patients, 89% achieved a net gain in active range of motion and only 4% lost motion. Patients with complex malunion had more stiffness before osteotomy than those with simple malunion and consequently regained more motion after osteotomy and adhesion release than patients with osteotomy alone.

No significant complications occurred after corrective osteotomy in this series.[3]

Trumble and Gilbert performed 11 extra-articular F1 osteotomies in patients with complex phalangeal malunions of the fingers requiring tenolysis or capsulotomies. The osteotomies were fixed with miniplates. Patients gained an average of 15 movement at the proximal interphalangeal joint and 10 at the distal interphalangeal joint. [12]

In 2017 in the journal HAND an article was published by Stefanie Hirsiger that analyzes corrective osteotomies in the phalanx and metacarpal in patients with malunion with a preoperative evaluation with CT to guide treatment. Results were presented for 6 patients where 8 osteotomies were performed (in MTC and phalanges). Three-dimensional reconstruction was used using the contralateral hand as a model. The degree of reduction necessary with the osteotomy was precisely measured. Excellent results were obtained. [13]

RESULTS

There are different articles that talk about corrective derotating osteotomies with good results.

Despite the great limitation of articles and clinical cases, a preference was seen regarding MTC osteotomy compared to phalanx osteotomy. Although the latter provides greater correction, proximity to the flexor and extensor tendons can cause adhesions and loss of digital movement, presenting a greater risk of distant complications. Osteotomy at the base of the MTC as an alternative to correct faulty rotation of the fingers has presented excellent results. This technique places the osteotomy further away from the tendon sheath, reducing the risk of adhesions and is also an area less prone to psuedoarthrosis. In cases where the malunion can not be corrected by a MTC derotating osteotomy due to exceeding the degree of rotation, an osteotomy at the level of the phalanx can be chosen. However, there is no article that specifically compares these two techniques.

Despite this, in cases of complex osteotomies where the osteotomy was performed at the level of the proximal phalanx associated with capsulotomies and/or tenolysis, authors such as Buchler3 et al. and Trumble and Gilbert 11 concluded in their work that corrective osteotomies of the proximal phalanges are safe and heal reliably. They presented good results, improving both proximal and distal interphalangeal movement. Therefore, in procedures where complex osteotomies with capsulotomies and tenolysis are required, it could be the treatment of choice since it also uses the same approach.

Osteotomy at the base of the metacarpal would be the preferred option for mild rotational phalangeal deformities that do not require release of adhesions.

No published articles were found that compare transverse derotating osteotomies with stepped osteotomies, although it has been proven that stepped osteotomies have a lower correction capacity in cases of malunion that present, in addition to rotation, a defect in angulation.

Regarding the type of fixation, most articles opt for stable fixation with plates and screws to achieve early mobilization and rehabilitation in patients.

Only one article was found that uses CT and three-dimensional reconstruction for assessment with a view to surgical treatment. It presents precise results, with a detailed analysis of the deformation achieving an exact correction.

CONCLUSION

Extra-articular derotating osteotomy is a simple technique used in cases of poor union of the proximal phalanx, with evident functional and aesthetic alteration with good results. It can be performed at the base or fracture site of the proximal phalanx or the adjacent MTC. In all cases, the treatment must be individualized and the choice of the osteotomy site must be considered depending on the time of evolution, degree of rotation, and whether it is a complex malunion or not.

The evaluation with CT and previous 3D reconstruction allows a specific evaluation for each patient. It allows the surgery to be previously planned by evaluating the osteotomy site, the degrees of rotation necessary for adequate correction and the premolding of the plate, thus facilitating and shortening surgical time. It could be especially useful in cases where the degree of correction is limited, allowing both osteotomies to be compared preoperatively to assess which would provide the best result.

As limitations of this work, we consider that the studies included in the review were limited by small samples.

In addition, there are no studies that compare osteotomies in the proximal phalanx with those in the metacarpal or transverse osteotomies with stepped ones. Only 1 work was found that uses preoperative assessment with CT and 3D reconstruction.

We highlighted the importance of creating new articles that contribute to local cases to contribute to decision-making.

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ANNEXES

Image 1: Frontal x-ray at the time of trauma

Image 2: preoperative digital cross-linking

Image 3: full-scale model with three-dimensional reconstruction with 4th and 5th rays in flexion and extension.

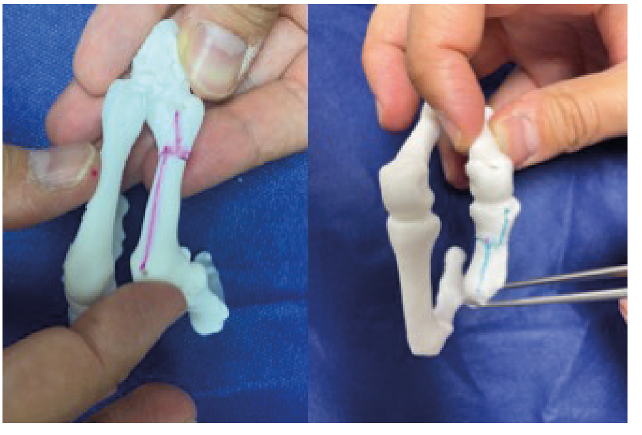

Image 4: Osteotomy in three-dimensional model at the level of the MTC and F1

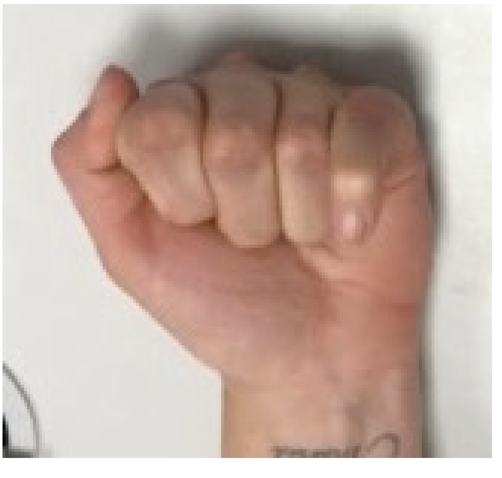

Image 5: Postoperative at 6 months. Digital Cross-linking Connection