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Rigid locked nail fixation for pediatric tibia fractures - Where are the data?

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Abstract

Tibial shaft fractures are common injuries among the pediatric and adolescent population. Conservative treatment remains the preferred treatment. However, over the last two decades, there has been an increasing trend of operative fixation in pediatric tibia fractures, commonly with intramedullary nail fixation (IMN). Elastic stable intramedullary nails (ESIN) are heavily used especially in skeletally immature patients as they are physeal respecting and the technique for insertion is familiar. Alternatively, reamed locked intramedullary nails (RIMN) have gained traction in adolescents and skeletally immature pre-adolescents. When identifying publications germane to intramedullary fixation of pediatric tibia fractures, the majority investigated clinical and radiographic outcomes associated with ESIN. We were able to identify only one study specifically examining RIMN in this population, albeit other studies included patients treated with RIMN. In parallel, there has been considerable progress in the field of skeletal maturity estimation with criteria based on different anatomic regions. However, little data exists for trauma purposes as no gold standard system had been accepted and proven to be precise for determination of potential growth remaining around the knee or for quantifying the risk of damage to the proximal tibial physis. Systems devised have been either unvalidated or unnecessarily complex or both. In order to achieve more informed treatment choices and optimal patient outcomes when using IMN fixation in pediatrics, simple to use, validated plain film-based methodology is needed to define skeletal maturity for the proximal tibia. Additionally, further examination of outcomes and the role of RIMN in this population are warranted.

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Key words: Pediatric; Trauma; Skeletal maturity; Reamed nail; Intramedullary; Fixation

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Core tip: Little data exists to support the use of reamed intramedullary nails (RIMN) in adolescents and skeletally immature pre-adolescents. However, RIMN is used as the cornerstone of fixation for skeletally mature patients and older skeletally immature patients. Although we are not aware of any papers or case reports of RIMN use which resulted in growth arrest or recurvatum deformity in the pediatric population, surgeons are reluctant to use this nail design in younger patients. Clinical data regarding RIMN and a reliable and easy to apply skeletal maturity measure for the proximal tibia are needed for better decision making in such cases.

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INTRODUCTION

Tibial shaft fractures are the third most common pediatric fracture^[1,2]. They represent the second most common reason for orthopedic inpatient admission to children's hospitals^[3-6].

Conservative treatment with closed reduction and cast immobilization remains the treatment modality of choice in children and adolescents with tibial shaft fractures^[2,7-14]. In cases where the fracture pattern is assumed to be length unstable, open, or with soft tissue not amenable to casting, operative fixation may be chosen as the preferred treatment strategy^[6,15].

Over the last two decades, there has been an increasing trend toward operative fixation in pediatric tibia fractures. Currently, tibia fractures account for 12% of all surgically managed pediatric fractures^[1,2]. An intramedullary strategy is a commonly employed technique for tibial fracture fixation in children as it confers a bridge fixation with a long working length and encourages callus formation^[4,5,9]. In the early 1980s, Ligier *et al*^[16] reported that of placement of two curved rods in a straight bone would produce forces which opposed one another and obtain and maintain reduction of that bone. Their work in Nancy region of France and their publications^[17,18] had popularized the usage of their elastic nails "Nancy nails" all around the world. Even today, elastic nails are an attractive option as they avoid physeal violation and offer a familiar technique to pediatric orthopedists that can be performed quickly and safely^[2,4,6,11,19]. However, elastic stable intramedullary nails (ESIN) are theorized to provide a non-optimal solution for length unstable fracture patterns^[19]. Additionally, as children become larger and more "adult-like" elastic nails may provide less reliable results. The transition in the age where this occurs is currently unclear. As such, many clinicians transition to more adult style fixation as the child ages, and tibia fractures are no different.

A rigid, locked nail (Figure 1) also termed reamed intramedullary nail (RIMN) confers rotational stability and adds the ability to treat more proximal and distal fractures via the usage of blocking screws and other advanced nailing strategies (Figure 2). Additionally, weight bearing may be allowed sooner than with ESIN, and hardware may need to be removed less often^[5,6,9,11,19-22]. The insertion technique of RIMN however, adds risk for growth arrest at the proximal tibial physis and thus theoretically the risk of late recurvatum deformity in the sagittal plane^[2,9,15,19,22].

Many studies have already evaluated the indications, techniques, and outcomes regarding the usage of elastic nails to treat these fractures. Perhaps surprisingly, a single study was identified examining the results of RIMN in pediatric patients. This study from the United Kingdom included 53 patients aged 13-16 years, treated with RIMN for tibial shaft fractures. Among these patients, thirty-six of these adolescent patients had open tibial physes at the time of intramedullary nailing. All 36 patients were re-imaged between 2 and 12 years after treatment to examine the effect of intramedullary nailing on tibial growth. The researchers reported excellent results with 100% union rates and no evidence of tibial shortening or partial growth arrest of the proximal tibial physis^[23]. Although a low level of evidence, the study is at least

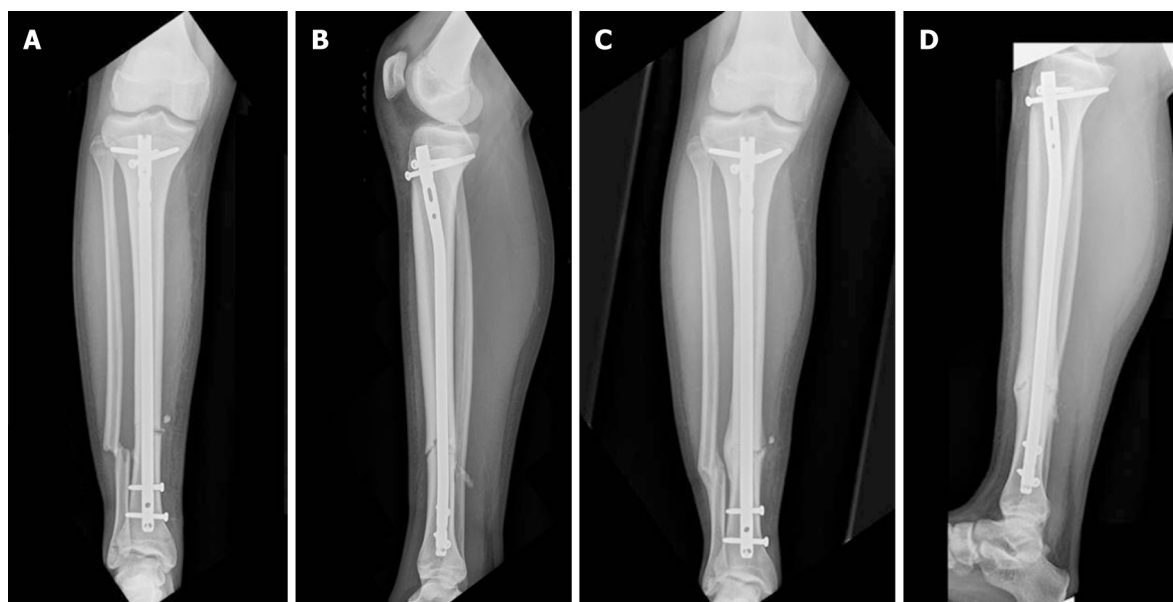


Figure 1 The use of reamed intramedullary nail in a pediatric tibia shaft fracture. A: AP view of the post-op result, B: LAT view of the post-op result, C: AP view during follow-up, D: LAT view during follow-up.

suggestive that this approach is safe at short term follow up. The treatment of choice for the intramedullary strategy in many children, particularly in patients in the midst of the adolescent growth phase remains unclear. This lone article suggests that no appreciable growth arrest will occur, but we currently cannot say with confidence that there is no risk. Additionally, no reliable method exists to estimate skeletal maturity based on a tibia film, which renders retrospective study of this question difficult if not impossible.

There has been considerable progress in the field of skeletal maturity, and many methods exist to estimate growth remaining. Sanders published many studies on the subject, particularly as it relates to the estimation of scoliosis progression as it relates to growth centers in the shoulder and hand^[24,25]. Similar data are not available in an accessible form for the knee to assess growth or growth arrest. Systems for estimating growth around the knee are either MRI based^[26], non-validated, or too complex to be accessible to the average orthopedist^[27,28]. As such, no gold standard system had been adopted to be precise for determination of potential growth remaining around the knee or for quantifying the risk of damaging the proximal physis. Currently orthopedists may use the fluoroscopy found in the OR to screen their patient's hand for a gross assessment of general skeletal maturity. However even with this screening tool, no clinical data exists to guide the decision of "when is too young" to perform RIMN.

CONCLUSION

It is in our belief that the use of plain-film X-ray specifically around the knee joint, with new and improved skeletal maturity prediction methods (most probably based on the proximal tibia changes during maturation), would result in a more accurate estimation of skeletal maturity in this area. This in turn, could lead to a better understanding of the potential for harm in violation of the proximal tibial physis, at various stages of development. Creating such classification may also allow a common language when studying the question or consulting a colleague in a clinical scenario. Using this method, tibias treated with RIMN could be assessed retrospectively and assessed for growth arrest by the age estimated by the X-ray. In this fashion, a clearer picture could be obtained regarding which nail design to employ at a given development level of the child. The evidence-based clarifications and comparison between the type of nails would help us view the broader picture of using IMN fixation in pediatrics and will allow better treatment choices and more optimal patient outcomes.

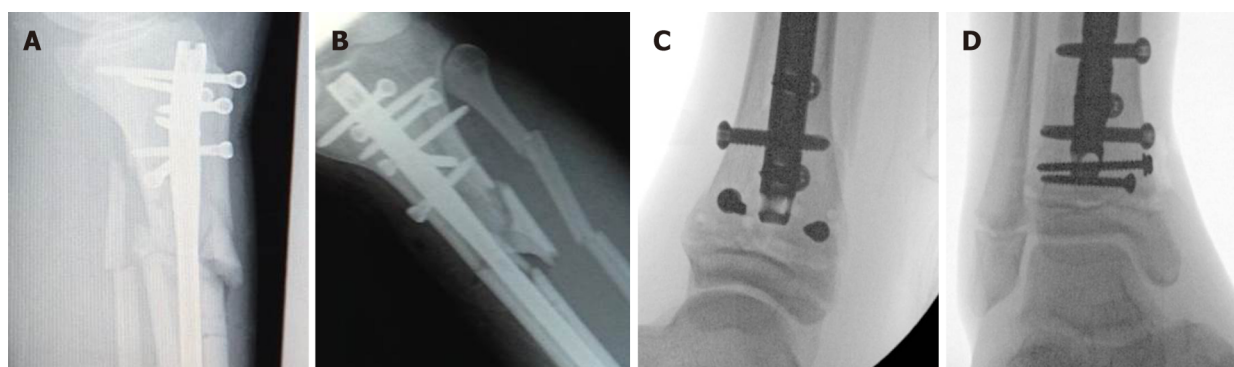


Figure 2 The usage of blocking screws and other advanced nailing strategies. A and B: Proximal tibia views; C and D: Distal tibia views.

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Subtraction hemiarthroplasty in basal joint arthritis: A case report

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Abstract

BACKGROUND

Basal joint arthritis is a common disease which is especially present in post-menopausal women. A variety of procedures have been described once conservative treatment has failed. The purpose of our study is to present a novel surgical technique based on a clinical case with three-year follow-up which is highly effective, even after failure of previous procedures.

CASE SUMMARY

We present a case of a 39 year-old-woman who suffered from recurring, persistent, sharp left thumb pain for several years. After two operative procedures, she presented again with intolerable, sharp pain over the trapeziometacarpal joint, and wished to proceed with a pain relieving procedure or arthroplasty. Intraoperatively, the articular surfaces appeared well, without any bare areas of bone or eburnation, resulting in the decision to perform a "subtraction hemiarthroplasty". A shortening osteotomy of the os trapezium was performed by removing a slice of 8-9 mm bone, without damaging the joint cartilages. The osteotomy was stabilized using two screws, the ligament and capsular tissue was suture imbricated, and a cut down on the translation and a dorsal radial ligament reconstruction were performed. Three years after the final procedure, a long-term follow-up demonstrates excellent results, pain free with full range-of-motion.

CONCLUSION

Subtraction hemiarthroplasty with ligament tightening imbrication and reconstruction of the radial ligament led to excellent results in motion and pain.

Key words: Basal joint; Arthritis; Trapeziometacarpal; Subtraction hemiarthroplasty; Carpometacarpal joint; Thumb; Case report

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Core tip: Even after failure of two index procedures, the subtraction hemiarthroplasty technique with ligament tightening imbrication and reconstruction of the radial ligament can lead to excellent results in both motion and pain. This can be a good alternative to a more aggressive treatment approach, such as arthroplasty, arthrodesis, or hemitrapeziectomy, and should be considered in select patients.

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INTRODUCTION

Basal joint arthritis is a common problem especially in post-menopausal women, however symptoms are present in a few of these cases^[1,2]. The trapeziometacarpal joint is a biconcave saddle joint which enables a variety of movements – flexion, extension, abduction, adduction, pronation, supination and opposition, which is why degenerative diseases may be predisposed. It is stabilized by multiple ligaments, of which the beak and dorsoradial ligament seems to be the most important^[3,4]. A weakening of the ligaments may lead to a movement of the point of maximal contact from volar-ulnar to dorsoradial^[5]. Because of the complexity of the joint, many different treatments exist, ranging from conservative to operative. In mild symptomatic patients, an analgesic therapy, such as custom-made splinting, physiotherapy or even local intra-articular steroid injection, may be the treatment of choice. In the event that these techniques fail and the patient still suffers from intolerable pain, an operative treatment may be considered. A standard literature search (PubMed) results in 426 relevant articles. The procedures range from osteotomy, arthrodesis, partial or complete trapeziectomy with or without reconstruction of the ligaments and tendon interposition, to implant arthroplasty, spacers, interposition arthroplasty with resurfacing or joint replacement. Even within the different groups, the types vary tremendously, similar to choosing a prosthesis^[3]. According to the review on surgery for thumb osteoarthritis published by Wajon *et al*^[6], no gold standard for treatment currently exists. Within the 11 included and reviewed studies, no procedure demonstrated any superiority in terms of clinical outcome. Additionally, Wajon *et al*^[6] found that no comparable study exists evaluating surgery versus non-surgical interventions.

We present a novel surgical technique based on a clinical case with three-year follow-up which is very effective, even after failed previous procedures.

CASE PRESENTATION

Chief complaints

A 39-year old female and former softball coach presented with persistent thumb pain of her left side since 2008.

History of present illness

An arthroscopy of the left basal joint with debridement of fibrillated cartilage and partial synovectomy was indicated and performed at our institution in May 2012. Intraoperatively, a cartilage damage of up to 25% of the articular surfaces (metacarpal as well as trapezium) was identified. The joint was stable under direct examination and stress testing. In December 2014, she presented again with a complete preservation of the scaphoidtrapezium joint and intolerable sharp, persistent pain at the trapeziometacarpal joint. The maximum peak of pain was localized over the palmar aspect of the joint with progression when pinching and grasping.

History of past illness

The patient underwent a volar plate capsulodesis and stabilization, utilizing a free tendon graft at a different institution in 2008, which brought her approximately 2.5 years of pain relief and a return to previous sport activities. Her typical pain level progressed from a VAS 2 out of 10, to 6 out of 10, with a maximal peak at the basal joint of her thumb. As a result an intra-articular steroid injection was performed

leading to a pain relief for few months in 2012.

Physical examination

Clinically, a tenderness could be identified, localized over the trapeziometacarpal joint, with a slight hyperflexibility (5 to 10 degrees of hyperflexion).

Imaging examination

Her radiographs revealed signs of arthrosis, like subchondral sclerosis, and slight joint space narrowing as illustrated in [Figure 1](#).

Because of severe limitations in daily life and in activities, she wished to proceed with a pain relieving procedure. A variety of options were discussed, from arthroplasty, hemiarthroplasty of the trapezium, deletion or shortening of the trapezium to tendon interposition graft and/or soft tissue ligament imbrication with reconstruction, all depending on the intraoperative findings.

TREATMENT

Surgical technique

This was an outpatient procedure performed under regional anesthesia – supraclavicular block. The patient was placed in a supine position and the arm placed on a hand table. The left arm was sterilely prepped and draped followed by inflation of the pneumatic tourniquet to 250 mmHg pressure. The previous incision from the Wagner approach^[7] was utilized again and extended along the flexor carpi radialis tendon for a few centimeters proximally. The skin flaps, which were still at place without detachment of the metacarpal nor the trapezial attachment, were elevated. The tendon graft of the previously performed reconstruction, as well as numerous non-absorbable sutures, were removed. In the following step, an arthrotomy of the trapeziometacarpal joint was performed and the cartilage was visualized. Even though subchondral sclerosis could be identified in radiographs, the articular surfaces were well-appearing, without any bare areas of bone or eburnation. Therefore, we decided to maintain the articular surfaces by shortening of the central third of the trapezium and then re-transplant and fix the articular surfaces in a contour position against the first metacarpal. To ensure the correct level of osteotomy, image intensifier was utilized. A sagittal saw was used to perform the osteotomy of the os trapezium and remove a slice of approximately 8-9 mm of the bone, without damaging the cartilage. Afterwards, the articular surfaces were readjusted and stabilized using a bone reduction clamp. Two drill holes were created by utilizing a 1.1 mm drill bit, followed by a countersink to allow the 1.5 mm titanium screw heads to be countersunk below the articular surface. The length of the screws was measured to be 9 mm and the titanium screws were placed and tightened. Control under the image intensifier was performed demonstrating a good reduction and excellent fixation without protrusion of the hardware in any plane ([Figure 2](#)).

Because of the resection of the tendon autograft reconstruction and shortening of the os trapezium, an instability of the joint was identified and the capsule was suture imbricated using an absorbable 3-0 Biosyn (Biosyn TM) for figure-of-eight sutures. To stabilize the joint, a cut down on the translation and a dorsal radial ligament reconstruction to prevent over-translation was made, leading to a stable joint when simulating the pinch. Furthermore, sutures between the reconstruction and the adjacent thenar muscles were performed using absorbable 3-0 Biosyn (Biosyn TM). The tourniquet was released, circulation was tested and hemostasis was assured with a bipolar cautery. Finally, the incision was closed using a 5-0 Nylon suture and sterile dressings were applied as well as a well-padded fiberglass splint protecting the reconstruction.

FINAL DIAGNOSIS

Some degree of basal joint arthritis with a stable trapeziometacarpal joint after subtraction hemiarthroplasty. Radiographs reveal healing of the osteochondral segment. The screws are in position and have not caused adjacent wear or symptoms. The patient has zero pain as well as excellent motion and function.

OUTCOME AND FOLLOW-UP

Clinical follow-up controls were performed after 1.5, 3, 6 and 10 wk. In the first

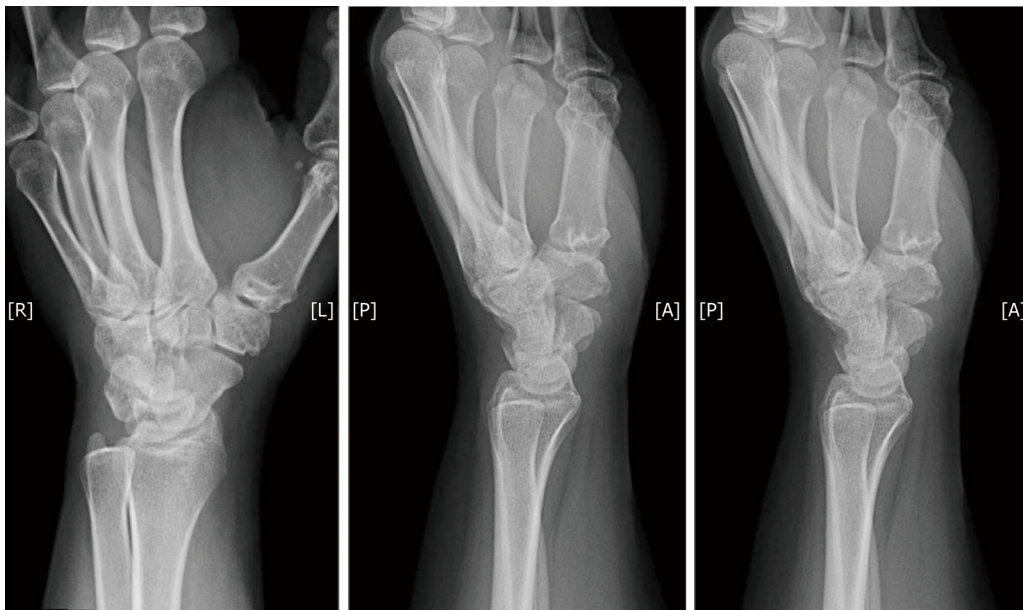


Figure 1 X-ray of patients' left hand in three planes showing signs of basal joint arthritis of her thumb.

follow-up, the patient reported very little pain. Half of the sutures were removed and the thumb was placed in a fiberglass thumb gauntlet splint. Another 10 days later (3 weeks post-op) the splint was removed and she began mobilizing it. The remaining sutures were removed and the wound was healed. The motion was already satisfactory with only minimal pain. The radiographs performed on that day showed that the screws were still in place and some bony healing of the osteotomy site. At 6 wk post-op, the motion was excellent and the thumb was entirely stable (Figure 3). Therefore, we decided to start occupational therapy and performed a final follow-up 10 wk after.

Three years after performing the subtraction hemiarthroplasty, the patient returned for a long-term follow-up visit. The patient reported no pain and had excellent range of motion of the thumb. The DASH score was a 5.8, with a VAS rating of 1 at rest, and 3 with activity. The range of motion and grip strength was similar to the unaffected side.

DISCUSSION

The carpometacarpal joint of the thumb is a saddle joint which allows movements in palmar abduction, adduction, flexion, extension, opposition and reposition. Each articular surface is concave in one direction and convex in the other^[8]. The most common affected surface in osteoarthritis is the distal surface, which articulates with the volar "beak" of the thumb metacarpal, where the anterior oblique ligament of the trapezium inserts^[9,10]. The trapezium consists of a deep groove for the flexor carpi radialis tendon on the palmar side. According to the literature, between 3 and 16 ligaments have been described to participate in the stabilization of the carpometacarpal joint^[11]. The dorsoradial ligament seems to be very important, especially to prevent dorsal subluxation of the trapeziometacarpal joint, once the anterior oblique ligament is stripped off the volar cortex^[12].

When loading the carpometacarpal joint in a healthy population a volar translation of the first carpometacarpal joint, internal rotation and flexion on the distal trapezial surface could be illustrated. In grasping objects, the metacarpal bone translates ulnar, combined with flexion and abduction relative to the distal trapezial surface; Likewise, extension couples with adduction^[11,13].

The technique which we describe seems to alter the force acting on the distal surface of the os trapezium. However, due to insufficient reports in the literature, the exact mechanism cannot be outlined in detail. To our knowledge, no study or case report exists investigating the angle of the carpal bone, specifically the angle after performing the subtraction hemiarthroplasty. Intraoperatively, the articular surfaces of the first metacarpal and os trapezium were well-appearing, without any bare areas of bone or eburnation, which is prerequisite to perform a procedure like this. On the radiographs, a derogation of the radial side of the os trapezium can be identified after

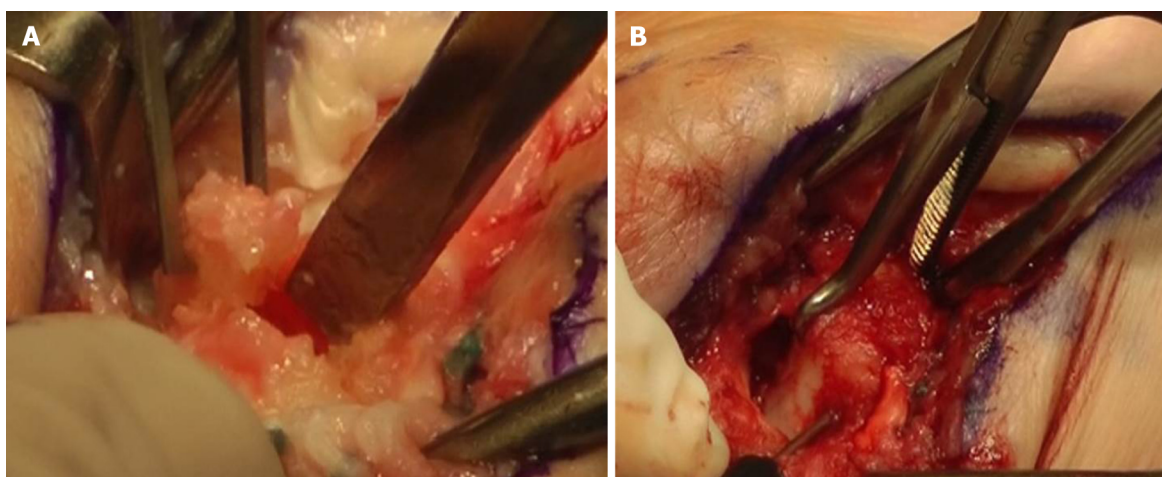


Figure 2 Intraoperative images of the osteotomy. A: Osteotomy indicated with the chisel after partial trapeziectomy; B: Indicating bone reduction clamp and screw insertion from distal to proximal.

the subtraction hemiarthroplasty, which may reduce pain and improves functional outcome. To rebalance the joint, ligament tightening imbrication and dorsal radial ligament reconstruction are required. Meanwhile, preserving the articular cartilage allows one to maintain the complete range of motion with only a few limitations. This idea is similarly used in other techniques such as partial trapeziectomy, with or without interposition.

CONCLUSION

The subtraction hemiarthroplasty with ligament tightening imbrication and reconstruction of the radial ligament leads to excellent results in this case, even after failure of two prior surgeries. It enables full range of motion, free of pain, in the carpometacarpal joint. Based on this case report with long term follow up, further research should be performed, such as a case series in selected patients with good articular surfaces of the first metacarpal and os trapezium.

EXPERIENCES AND LESSONS

Our case presents a new technique to treat early stages of basal joint arthritis. Patients can present in severe, late stages of the disease in outpatient clinic where joint persevering surgeries are unlikely to succeed. These include partial or complete trapeziectomy, with or without reconstruction of the ligaments and tendon interposition, implant arthroplasty, spacers, interposition arthroplasty with resurfacing, or joint replacement. To our knowledge, this case is unique and describes the excellent long term functional outcome including full range of motion after joint preserving surgery – subtraction hemiarthroplasty – even after failure of two prior surgeries.

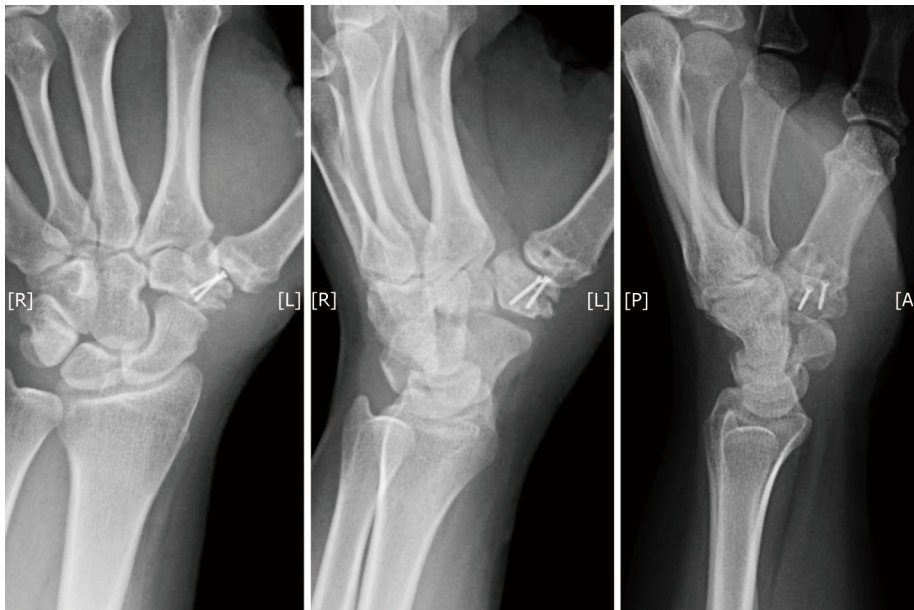


Figure 3 Postoperative x-rays after subtraction hemi-arthroplasty.

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