Hand Surgery and Rehabilitation 42 (2023) 86–89

Available online at ScienceDirect www.sciencedirect.com

Elsevier Masson France EM|consulte www.em-consulte.com

Case report

3D-planned corrective osteotomy of metacarpal arch disruption after Motec® wrist prosthesis

Ostéotomie corrective planifiée en 3D d'un déséquilibre de l'arche métacarpienne après prothèse de poignet Motec®

A. Durdzińska Timóteo, T. Voser, S. Durand *

Centre Hospitalier Universitaire Vaudois, Department of Plastic and Hand Surgery, Avenue Pierre-Decker 4, 1005 Lausanne, Switzerland

ARTICLE INFO

Article history:
Received 11 August 2022
Received in revised form 27 September 2022
Accepted 12 October 2022
Available online 3 November 2022

Keywords:
Wrist arthroplasty
Osteoarthritis
Metacarpal arch
Carpometacarpal joint

Mots-clés:
Arthroplastie du poignet
Arthrose
Arche métacarpienne
Articulation carpo-métacarpienne

ABSTRACT

We report two cases of metacarpal arch disruption after Motec® total wrist arthroplasty, with hyperextension of the third metacarpal and dorsal protrusion of the head. Correction osteotomies of the adjacent metacarpals using preoperative 3D surgical planning were successful. This report seeks to shed light on the origin of this deformation and to recommend some operative precautions. It is important that surgeons should be aware of the existence of this complication, as disruption of the transverse metacarpal arch affects both grasp and hand esthetics.

Level of evidence: IV.

RÉSUMÉ

Nous décrivons deux cas de perturbation de l'arche métacarpienne après pose de prothèse de poignet Motec®. La déformation apparait comme une hyperextension du troisième métacarpien avec protrusion dorsale de la tête. Des ostéotomies de correction des métacarpiens adjacents après planification 3D préopératoire ont été réalisées et ont corrigé la déformation. Dans cet article, nous avons cherché à apporter des éléments de réponse concernant l'origine de cette déformation, à recommander certaines précautions et à alerter les chirurgiens sur cette complication qui entraîne des conséquences à la fois fonctionnelles et esthétiques.

Niveau de prevue. – IV.

1. Introduction

Prosthetic surgery in the lower limb is a well-established gold-standard treatment with predictable and good results, survival over 95% at 10 years, and exceeding 30 years for most prostheses [1]. Prosthetic surgery of the upper limb is much less effective. Wrist replacement, first attempted in the 1980s, proved particularly challenging, since one prosthesis is supposed to replace two complex articulations – radiocarpal and midcarpal – composed of 7 bones. Other important articulations are in close proximity, and the bone stock available for fixation is limited [2]. Outcomes used to be quite discouraging because of a high medium-term incidence of loosening and wear of the prosthesis, and an implant survival rate of 75%–90% at 5 years, only in low-demand patients [3].

The new generation Motec® implant improved fitting, especially of the distal component that is positioned in the third metacarpal, leading to less implant loosening and periprosthetic osteolysis. The 10-year survival rate is encouraging, at 80% [4]. However, with the rising number of cases of wrist arthroplasty, surgeons are faced with new challenges and complications [5].

The transverse metacarpal arch is defined by the position of the metacarpal heads, joined by the deep transverse intermetacarpal ligament. This structure adapts the form of the hand to a flat or concave surface and helps prehension and grip strength.

We present two cases of transverse metacarpal arch disruption after Motec® implantation and discuss pathophysiology and treatment.

* Corresponding author.
E-mail address: sebastien.durand@chuv.ch (S. Durand).

https://doi.org/10.1016/j.hansur.2022.10.007

2. Case reports

2.1. Patient 1

A 63-year-old male developed painful post-traumatic osteoarthritis of the wrist (Fig. 1c). Non-operative treatment and two intra-articular corticosteroid injections were not effective. The patient underwent total wrist arthroplasty (Motec® wrist joint prosthesis; Swemac, Linköping, Sweden). Postoperatively, we observed dorsal protrusion of the long finger metacarpal head (Fig. 1a) and a depression in the palm at the level of the third metacarpal head. The patient experienced pain in the palm and difficulty grasping, which limited the use of his right hand and grip strength (12 kg on the operated side and 55 kg contralaterally). Finger range of motion was not impacted. The patient's main demand was esthetic.

3D triangular surface models of the left and right hand were derived from CT data of the patients' bones using Revolution® (GE Healthcare™, Waukesha, WI, USA) with standard parameters such as 120 kVp tube potential and 1 mm axial resolution. The pathological and the healthy contralateral bones were segmented using Mimics® (Materialise™, Leuven, Belgium). The uninjured contralateral side was used as the reconstruction template. Using specific CASPA® software (Balgrist CARD AG™, Zurich, Switzerland), the third metacarpal bone was mirrored and superimposed on the healthy contralateral side (Fig. 1c & 1b) and 3D deformity measurements were made. The guides for the correction osteotomies of the second, fourth and fifth metacarpals were manufactured by Medacta™ (Castel San Pietro, Switzerland) by selective laser sintering. The guides were made of polyamide (PA-12) and were subjected to conventional steam pressure sterilization before surgical use [6].

Two longitudinal dorsal incisions were made, one over the second metacarpal bone and another over the fourth interosseous metacarpal space. 3D correction of the metacarpal arch was attempted by single-cut osteotomy of the second, fourth and fifth metacarpal bones with bone grafting from the iliac crest and fixation with a variable-angle-locking phalangeal base compression plate (reference 0 × .130.354, DePuy-Synthes™, West Chester, PA) for the second metacarpal bone and a locking condylar compression plate (reference 447.349, Depuy-Synthes™, West Chester, PA) for the fourth and fifth metacarpal bones (Figs. 1f & 1g). This procedure provided correction of the transverse metacarpal arch. A removable wrist splint was prescribed for 4 weeks and the patient then started early hand therapy with finger and wrist motion.

Postoperative rehabilitation was uneventful. At 6 months after surgery, bone fusion was achieved, with stable correction of the transverse metacarpal arch (Fig. 1b). The patient was free of pain; grip strength was 35 kg on the right side and 55 kg contralaterally. Range of motion of the right wrist was 60° in flexion and 50° in extension. The patient was very satisfied with the esthetic outcome.

2.2. Patient 2

A 48-year-old woman presented with rheumatoid arthritis affecting both wrists and the distal radioulnar joint (Fig. 2c). She had previously undergone trapeziometacarpal arthroplasty (Touch® prosthesis, Kerimedical™, Les Acacias, Switzerland) with a good clinical result. For 2 years, the patient received intraarticular corticosteroid infiltrations in both wrists every 3 months, in vain. Due to persistent pain, she underwent total wrist arthroplasty with a Motec prosthesis. The operation did relieve the pain, but the

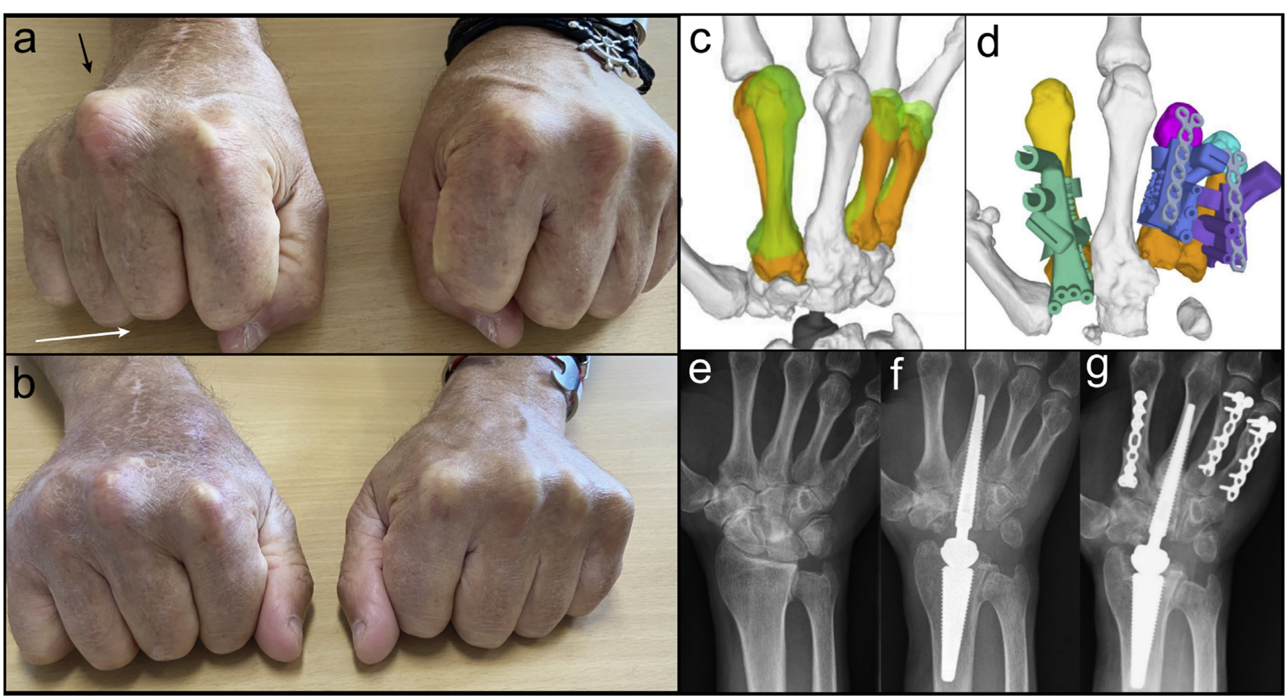

Fig. 1. Patient 1. Clinical results at 6 months after total wrist arthroplasty. Note the dorsal protrusion of the third metacarpal head (*black arrow*) with relative shortening of the proximal phalanx (*white arrow*) of the middle finger (a). Disappearance of the dorsal protrusion of the third metacarpal head and good correction of transverse metacarpal arch 6 months after metacarpal osteotomies; note the correction of the relative length of the middle finger's proximal phalanx and skin remodeling over the metacarpal head (b). Preoperative 3D surgical planning (c, d). The third metacarpal bone of the right hand is mirrored and superimposed on the healthy contralateral side. *Orange*: pathological left side. *Green*: mirrored contralateral side. *White*: healthy bones. 3D deformity in rotation and translation were measured according to the x,y,z axes and the guides for 3D correction were then manufactured according to the 3D deformity measurements (d). Anteroposterior X-ray of the right wrist before operation with radiocarpal and midcarpal joint osteoarthritis (e), after Motec prosthesis arthroplasty (f) and after 3D correction of the transverse metacarpal arch (g).

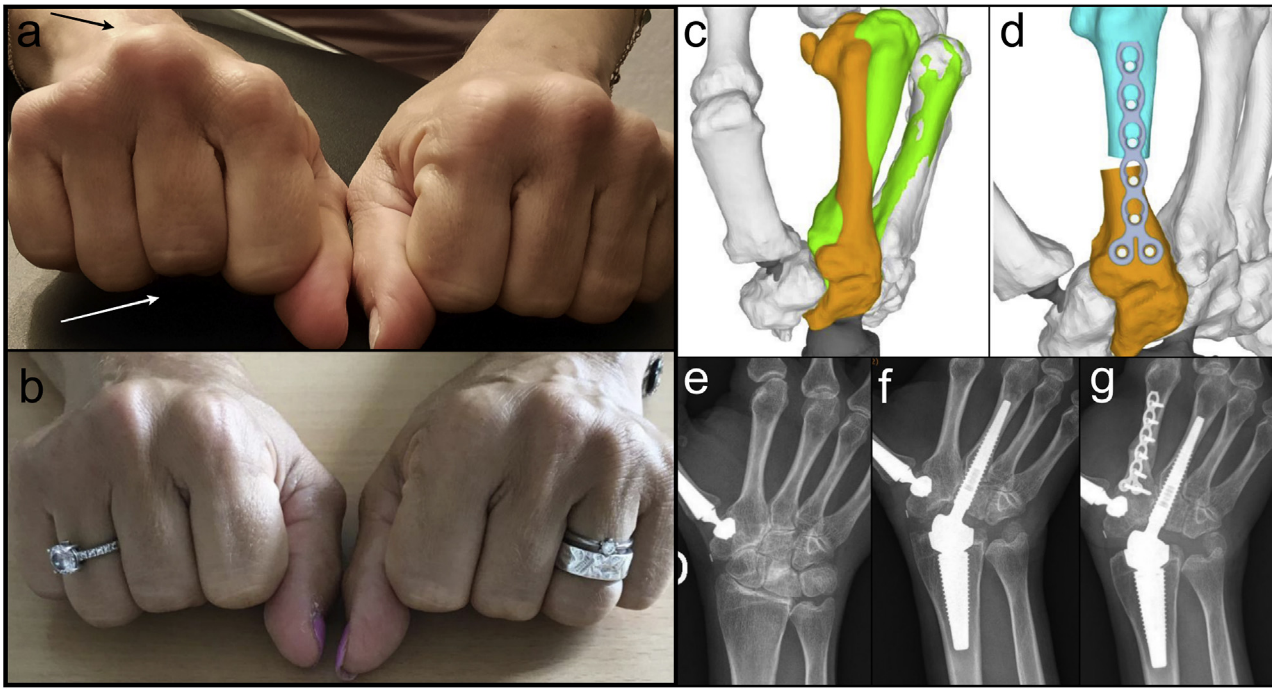

Fig. 2. Patient 2. Clinical results at 6 months after total wrist arthroplasty (a). Note the dorsal protrusion of the third metacarpal head (*black arrow*) with relative shortening of the proximal phalanx (*white arrow*) of the middle finger compared to the contralateral side. Disappearance of the dorsal protrusion of the third metacarpal head and good correction of transverse metacarpal arch 3 months after second metacarpal osteotomy; note the correction of the relative length of the middle finger's proximal phalanx (b). The third metacarpal bone of the right hand is mirrored and superimposed on the healthy contralateral side. Only the second metacarpal appears to require a correction in this case (c, d). *Orange*: pathological left side. *Green*: mirrored contralateral side. *White*: uninvolved bones. *Blue*: 3D simulation of second metacarpal correction. Anteroposterior X-ray of the right wrist before operation with radiocarpal and midcarpal joint osteoarthritis (e), after Motec prosthesis arthroplasty (f) and after 3D correction of the transverse metacarpal arch (g).

transverse metacarpal arch became deformed, with hyperextension of the third metacarpal and dorsal protrusion of its head (Fig. 2a). The range of motion of the right wrist was 5° in flexion and 30° in extension. Grip strength was 6 kg on the right side and 11 kg contralaterally. The deformation was spotted and appeared slight during the arthroplasty surgery but became more pronounced postoperatively (Fig. 2b), probably due to muscle relaxation under locoregional anesthesia flattening the metacarpal arch. We performed the same 3D planning as for the first patient; only the second metacarpal appeared to require corrective osteotomy in this case (Figs. 2c, d). At 3 months after surgery, bone fusion was achieved (Fig. 2g) and patient was free of pain and very satisfied with the esthetic outcome.

3. Discussion

In these case reports, the 2 patients showed dorsal protrusion of the long finger metacarpal head and disruption of the metacarpal arch after Motec® total wrist arthroplasty. It is important that surgeons should be aware of the possibility of such a complication, as disruption of the transverse metacarpal arch affects grip and hand esthetics. Correction osteotomies of the adjacent metacarpals were performed, using preoperative 3D surgical planning. These procedures provided correction of the transverse metacarpal arch and better functional and esthetic outcomes. Flexion osteotomy of the third metacarpal head could have been an alternative, but strong fixation seemed difficult in the presence of the stem of the total wrist arthroplasty.

Joint mobility within the distal carpal row and between the capitate and the third metacarpal is very limited. The trapeziocapitate and capitohamate interosseous ligaments are 2 complexes of 3 individual ligaments: dorsal, deep and palmar interosseous. In the intact joint complex of the capitohamate joint, the average dorsopalmar rotational displacement is approximately 9° in each direction. The deep ligament of the capitohamate joint provides 51% of the rotational resistance with dorsal rotation of the capitate [7].

The intermetacarpal ligament complex consists of 3 parts: dorsal metacarpal, palmar metacarpal and interosseous ligament, oriented in a V-shaped configuration interlinking the metacarpal bases [8–10]. The metacarpal bones are secured to the distal carpal row by the palmar and dorsal carpometacarpal ligaments. As dorsal closing wedge osteotomy of the third carpometacarpal joint is situated in the middle of a stiff construct with almost no inherent mobility, dorsal closing requires mobilization either between capitate and hamate/trapezoid or between the third metacarpal bone and the other metacarpals. If only the third metacarpal rotates in extension compared to the other metacarpals, this could induce dorsal protrusion of the third metacarpal head, as seen in our two cases. This complication is unusual and we were unable to reproduce it using a Motec® prosthesis on 9 fresh frozen cadaveric specimens (data not shown).

The original surgical technique of the Motec® wrist joint prosthesis considers the volar angle of the third carpometacarpal joint to be approximately 10°. A 10° wedge of bone should be then resected to align the capitate and the third metacarpal bone and allow the distal implant to be introduced through the capitate into the intramedullary canal of the third metacarpal bone, to obtain fusion. Bone fusion between capitate and third metacarpal is important to secure the distal screw [4]. In a recent epidemiological study, the angle between the axis of the capitate and third metacarpal bone in the sagittal plan ranged from 20.1° flexion to 6.2° extension (mean 7.3°, SD 5.1°) [3]. Measuring the angle of the dorsal cortex of both bones is likely a more appropriate way to predict the correction needed during Motec® arthroplasty. Our preliminary study on 20 CT scans showed substantial differences between these two methods, with a mean flexion angle of 27 ± 6.4° (data not shown).

A maximum 9° dorsal rotation of the capitate can be obtained without ligament disruption [7]. When the flexion angle between capitate and third metacarpal is greater than 9°, sectioning the deep interosseous ligament of the capitohamate and trapeziocapitate is theoretically necessary to align the capitate and third metacarpal. If these articulations are not mobilized, mobilization is between the metacarpal bases in order to allow capitate-metacarpal alignment. Due to the geometry of the capitohamate and trapeziocapitate joints, sectioning these ligaments is not easy. Many surgeons use oscillating saw to free the space between capitate, hamate and trapezium, in order to mobilize the capitate sufficiently. The consequences of this modification of the original surgical technique are, however, unknown, and may lead to painful osteoarthritis between the bones of distal carpal row.

Intraoperatively, if the dorsal protrusion of the third metacarpal head is severe, we recommend removing the distal screw. The first option is to open the dorsal wedge osteotomy and reposition the implant more dorsally into the capitate. The second option is to release the capitate to increase its dorsal rotation.

Preoperative 3D planning of Motec® wrist arthroplasty could be an interesting option. Measuring the dorsal rotation angle of the capitate necessary to align with the third metacarpal is important. The introduction point through the capitate could be located preoperatively.

The absence of previous studies about this complication and the present small sample size allow little information concerning epidemiology and pathophysiology. Future research on the Motec® prosthesis should include details of operative technique and postoperative evaluation of third metacarpal hyperextension in order to evaluate the real prevalence of this complication.

Human and animal rights

The authors declare that the work described has been carried out in accordance with the Declaration of Helsinki of the World Medical Association revised in 2013 for experiments involving humans as well as in accordance with the EU Directive 2010/63/EU for animal experiments.

Informed consent and patient details

Written informed consent was obtained from the patients for their anonymized information to be published in this article.

Disclosure of interest

There is no potential conflicts of interest.

Funding

The authors received no financial support.

Author contributions

All authors attest that they meet the current International Committee of Medical Journal Editors (ICMJE) criteria for Authorship.

The content has not been published or submitted for publication elsewhere.

All authors have contributed significantly and all authors are in agreement with the content of the manuscript.

Acknowledgements

None.

References

[1] Ferguson RJ, Palmer AJ, Taylor A, Porter ML, Malchau H, Glyn-Jones S. Hip replacement. Lancet 2018;392:1662–71.
[2] Reigstad O, Røkkum M. Wrist arthroplasty using prosthesis as an alternative to arthrodesis: design, outcomes and future. J Hand Surg Eur 2018;43:689–99.
[3] Venter RG, Burger MC, Ikram A, Lamberts RP. Bony anatomy of the third metacarpal and relationship with the capitate: a computed tomography study. Surg Radiol Anat 2019;41:1319–24.
[4] Reigstad O, Holm-Glad T, Bolstad B, Grimsgaard C, Thorkildsen R, Røkkum M. Five- to 10-year prospective follow-up of wrist arthroplasty in 56 nonrheumatoid patients. J Hand Surg Am 2017;42:788–96.
[5] Karjalainen T, Pamilo K, Reito A. Implant failure after Motec wrist joint prosthesis due to failure of ball and socket-type articulation - two patients with adverse reaction to metal debris and polyether ether ketone. J Hand Surg Am 2018;43:1044.e1–e.
[6] Roner S, Vlachopoulos L, Nagy L, Schweizer A, Fürnstahl P. Accuracy and early clinical outcome of 3-dimensional planned and guided single-cut osteotomies of malunited forearm bones. J Hand Surg Am 2017;42:1031.e1–e.
[7] Ritt MJ, Berger RA, Bishop AT, An KN. The capitohamate ligaments. A comparison of biomechanical properties. J Hand Surg Br 1996;21:451–4.
[8] Al-Qattan MM, Robertson GA. An anatomical study of the deep transverse metacarpal ligament. J Anat 1993;182:443–6.
[9] Dzwierzynski WW, Matloub HS, Yan JG, Deng S, Sanger JR, Yousif NJ. Anatomy of the intermetacarpal ligaments of the carpometacarpal joints of the fingers. J Hand Surg Am 1997;22:931–4.
[10] Nanno M, Patterson RM, Viegas SF. Three-dimensional imaging of the carpal ligaments. Hand Clin 2006;22:399–412.