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# Treatment Options for Thumb Carpometacarpal Joint Osteoarthritis with an Update to the Arpe™ Prosthesis

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***Keywords:*** *Thumb carpometacarpal joint; Osteoarthritis, Treatment options; Total joint replacement*

**Abbreviations:** TCMJ: thumb carpometacarpal joint; OA: osteoarthritis; LR: ligament reconstruction; TI: tendon interposition; K-wires: Kirschner-wires; UHMWPE: ultra-high molecular weight polyethylene; STTJ: scaphotrapeziotrapezoid joint; TMPJ: thumb metacarpophalangeal joint; TIPJ: thumb interphalangeal joint; TWA: total wrist arthroplasty; THA: total hip arthroplasty; UHR: ulnar head replacement

## Introduction

Thumb carpometacarpal joint (TCMJ) osteoarthritis (OA) is the most common site of non-traumatic OA in the hand with a 6:1 female-to-male ratio starting in the 5th to 6th decade of life, although this difference decreases with age 75 year and older with 40% in women and 25% in men [1-2]. Noted that TCMJ OA can be associated with patients' self-reported depression and other comorbidities at the upper extremity [3].

Biomechanically, the TCMJ is best described as a “twisted saddle” with 2 axes for extension-flexion and abduction-adduction only, and there are several volar and especially the major strong dorsal ligaments which provide joint stability [4]. The mean range of motion in TCMJ of healthy subjects is 27.3° to 41° for extension-flexion, 51° to 66.9° for abduction-adduction, and 10° to 21° for axial rotation, associated with significant differences between females and males, but no differences between right and left hands; and the maximum estimated contact area on the trapez and 1st metacarpal bones is in palmar abduction whereas the minimum is in adduction [5, 6]. Key pinch as well as object grasp demonstrate a coupled motion: for key pinch the first metacarpal bone undergoes volar translation-internal rotation-flexion, for object grasp the first metacarpal bone undergoes ulnar translation-flexion-abduction [7].

Thumb’s circumduction, that requires a “third functioning axis” for pronatoric rotation (i.e. opposition), is a result of evolution in hominid species as a functional adaption to stand upright, freeing the torso and upper limbs without any essential changes in its anatomically determined articulation, respectively [7]. Unfortunately, the great mobility that is seen in-vivo in these 3 functioning axes like a “cardan joint” makes that joint intrinsically unstable and TCMJs OA is “*the price of an opposable thumb*” [8]. One study revealed that TCMJ in women are less congruent, have smaller contact areas, and are likely to experience higher contact stresses than joints in men for similar activities in daily living that involve similar joint loads; although the articular contact area is not significantly different when accounting for thinning of the cartilage layer with age or disease [9]. Wolf et al. found that women have more TCMJ laxity than men, and they suspect a correlation with womens' serum relaxin hormone and matrix metalloprotease-1 levels in development of TCMJ OA [10]. Cooley et al. reported a higher rate of overall hand OA in women who had an earlier onset of menarche and later menopause, implying greater exposure to reproductive hormones [11]. Ludwig et al. suggest a correlation between development of TCMJ OA and an alteration of the ligamentous mechanoreceptors [12]. Rust et al. reported a significant increase of dorsoradial subluxation at the TCMJ in subjects with age older than 46 years [13], and Koff et al. found that cartilage wear at the articular surface of trapez bone initially started in the dorsoradial quadrant and then progresses to the volar quadrants in late-stage of TCMJ OA [14]. Kuo et al. reported a decrease of TCMJ workspace with ageing but without significant differences in gender [15]. Furthermore, early stage of TCMJ OA is associated with a statistically significant decrease of bone density both in trapez bone and first metacarpal bone base, but in the absence of any comparable changes at the capitate, 3rd metacarpal, or distal radius bones [16]. Moreover, abnormal biomechanical loading such as found with the adduction-extension deformity of the thumb is to be considered as another risk factor for development of TCMJ OA as well [17]. It has also been described that long-standing occupational static-dynamic stress conditions such as observed in female miners aged over 50 years with a history on their jobs more than 10 years can result in symptomatic TCMJ OA [18].

However, newer studies revealed that the radiographic staging for severity of TCMJ OA by Eaton-Littler (1973) and Eaton-Glickel (1987) alone are likely unable in decision making which treatment should be done. Thus, it has been recommended to introduce a new classification that incorporates more the preoperative patient's disability; and diagnosis and treatment should be based on the surgeon's qualitative assessment combining history, physical examination, the patient's claims in activities of daily living, and radiographic evaluation [19-21].

### Treatment options for TCMJ OA (excluding total TCMJ replacement)

Treatment options for TCMJ OA are mostly involve the conse-

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rvative approach, denervation, arthroscopy, an excisional procedure (trapeziectomy with or without ligament reconstruction and/or tendon interposition (LRTI)) that is the most frequent procedure worldwide, TCMJ arthrodesis, and total TCMJ replacement [22, 23]. However, recent evidence of conservative treatment suggests only some effect of orthoses and intra-articular hyaluronate or steroid injections, and there is a lack of information in the literature on reliable long-term results [24]. Denervation of the TCMJ with or without additional joint lavage and capsular imbrication can be an option for earlier stages of OA, but there is a lack of information in the literature on reliable long-term results as well [25, 26]. TCMJ arthroscopy is a minimally invasive method that includes joint lavage (i.e. debridement), capsular shrinkage, and partial or total trapeziectomy with or without tendon interposition for patients who have not responded to conservative treatment in terms of pain relief [27]. However, it has only a small effect on grip strength and no effect on pinch strength, the overall complication rate is reported to be 4%, and in 17% of cases a secondary TCMJ arthroplasty is required within an average of 11 months after the initial arthroscopy respectively [28, 29]. In order to avoid postoperative destabilization of TCMJ after arthroscopy, the dorsal ligaments should be carefully preserved [30].

Despite recent evidence suggests that neither ligament reconstruction (LR) with tendon interposition (TI) or one of both procedures alone confers any additional benefit over trapeziectomy alone, only 3% of hand surgeons in USA performed that simpler procedure in 2010 [31-34]. The main problems of an excisional procedure are deterioration of pinch strength with time based on proximal shortening of the thumb, mechanical pain related to instability or bone impingement with or without neuropathy of the superficial branch of radial nerve, high incidence of flexor carpi radialis tendinitis, and clumsiness associated with patient's trouble doing activities such as threading a needle, sewing, buttoning a blouse or shirt, turning over the pages of a newspaper, or picking up small objects [32, 33, 35-42]. It must be noted that there are not always sufficient options for surgical treatment in the future if patients are unsatisfied after an excisional procedure [Figure 1]. Three studies revealed that a revision procedure including re-LRTI or re-suspension with the use of the mini TightRope after a failed primary excisional procedure can be associated with a complication rate up to 27%, poor outcome, and incomplete pain relief [43-45]. Whether tendon interposition with or without ligament reconstruction nor additional Kirschner (K)- wire transfixation is able to avoid the proximal shortening of the thumb compared to trapeziectomy alone, hence, the loss of pinch strength in conjunction with a reduced physical functionality after resection-interposition arthroplasty should be discussed preoperatively with the patient to meet the expectations and to offer the best suitable treatment option [Figure 1] [46, 47].

Another option would be TCMJ arthrodesis with or without bone grafting if a stable thumb and heavy power grip is needed by a younger patient and if OA in the other two thumb joints is not present [48, 49]; but the loss of function after that procedure should be discussed preoperatively with the patient to find a decision whether surgical treatment for TCMJ OA is desired [50]. The TCMJ arthrodesis reduces pain, provides grip and pinch strength, and revealed satisfactory outcomes [31, 51, 52]. The main problem is reported to be the non-union rate of 20% when using K-wires for fixation [53]. Due to the high complication rate, TCMJ arthrodesis is not recommended for women aged 40 years and older [54, 55]; and the patient's satisfaction is only high in 88 % of cases when osseous fusion was obtained [56]. Noted that 2 comparative studies did not reveal superiority of TCMJ arthrodesis over an excisional procedure in terms of pain and function, and the number of this procedure declined yearly in USA with an overall decrease of 19% from 2005 to 2011 [57-59]. After TCMJ arthrodesis, patients often compensate the loss of circumduction by developing increased range of motion in scaphotrapeziotrapezoid joint (STTJ), and thumb metacarpophalangeal and interphalangeal joints (TMPJ / TIPJ) that can be associated with overload-related pain or discomfort [Figure 2A-D] [60]. The TCMJ arthrodesis is also recommended as primary procedure in case of irreducible Z - deformity with closure of the first web and hyperextension at the TMPJ [61]; another options in that case would be a motion-preserving TCMJ procedure combined with a sesamoidesis to the first metacarpal head [62], volar TMPJ capsulodesis [63], or TMPJ arthrodesis if ankylosis can be corrected by tightening the adductor muscle [64].

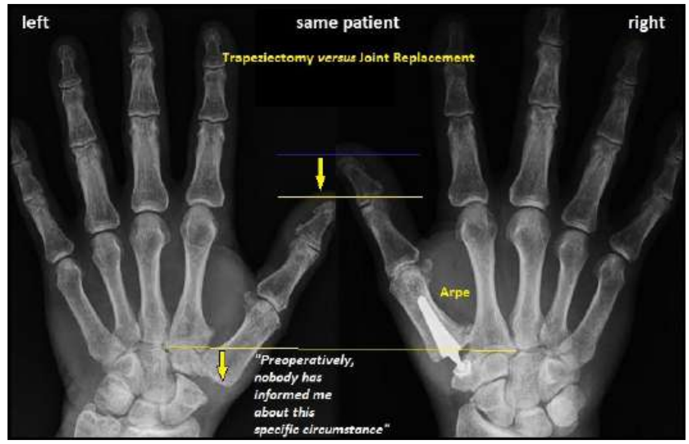


**Figure 1:** A 67-year-old active male with a previously performed excisional procedure at his left TCMJ in another hospital, received in our hospital a total TCMJ replacement using the ArpeTM prosthesis at his right thumb. Note the pronounced proximal shortening of the left thumb as compared to his right thumb (transverse lines and arrows) that led to marked deterioration of pinch strength. The patient was unhappy that this feature was not communicated him before surgery by the surgeon of the another hospital. The excisional procedure at the left thumb does not allow a conversion to another salvage procedure anymore.

## Total TCMJ replacement

The "optimal treatment" for TCMJ OA would be the in-vivo transformation of biomechanically determined "cardan joint" to an intrinsically stable "ball joint" with a third central axis for pronatoric rotation to perform a powerful circumduction by an endoprosthesis, and the first unconstrained cemented ball-and-socket type was introduced by de la Caffiniere and Aucouturier [65]. Total TCMJ replacement aims to preserve length of the thumb which is important for balancing of the soft tissues [Figure 1], reduces pain, improves grip and pinch strength, and results in excellent patient's satisfaction including faster re-employment if the implants not be failed; and there is a trend toward the increasing use of this procedure in USA utilizing the newer implants since 2007 [23, 31, 66-71]. However, the main problem of total TCMJ replacement is long-term surveillance (*i.e.* aseptic loosening) of its cups [72, 73]. To analyze the reasons for these high failure rates, it is necessary to explore the biomechanical imbalance across the long lever of the first metacarpal bone onto the small surface of the trapez bone, which is anatomically determined; and the different topographic load-bearing regions on the surface of trapez bone as well. A tip pinch of 1 kg will generate 12 kg joint compression; and for the power grip, the load may be as high as 120 kg [68].

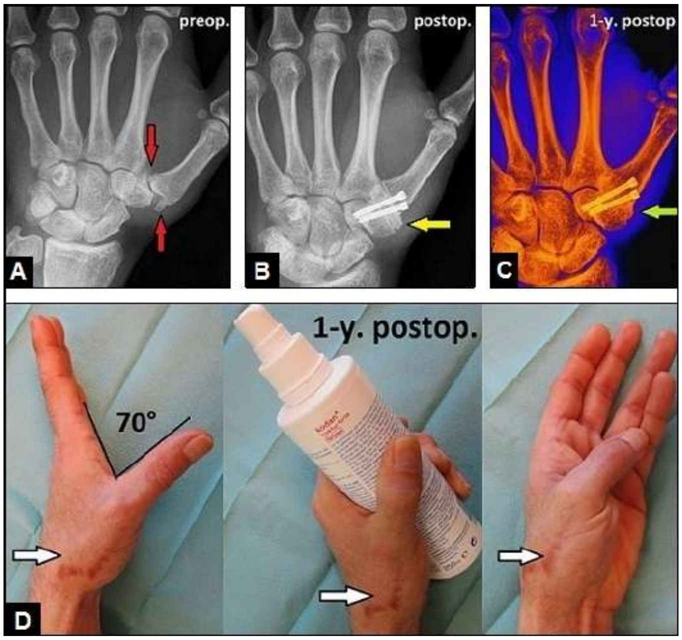


**Figure 2:** (A) A 28-year-old male presented with advanced stage of left TCMJ OA (arrows). (B) Same patient, treated by TCMJ arthrodesis using 2 headless compression screws (arrow). (C) Same patient, complete union of TCMJ arthrodesis 1 year postoperatively (arrow). (D) Same patient, functional outcome 1 year postoperatively. The procedure was done with 45° angulation of the thumb to the hand plane accompanied with maximum of thumb's abduction of 70° that provides a sufficient and powerful object grasp. Note that the loss of thumb's circumduction is compensated by flexion in TMPJ and TIPJ that led to intermittent discomfort and pain in these joints when performing his high-load occupational loads as a mechanic.

When using non-cemented screw cups, it is also recommended to insert it without threading of the trapez bone to improve the primary insertion-related stability that is an important prerequisite for its secondary bony anchorage, and additional cementation appears not to be required [74-76]. The question whether a press-fit non-cemented hemispherical cup is to be or is not to be preferred over a screwed non-cemented cylindrical cup remains topically unanswered. Another problem could be the misinterpration of radiographs with no visible extended cystic lesions in trapez bone and assessment of trapez bone density which can only be assessed safely utilizing computed tomography scans [77, 78]. The most common contraindications for a non-cemented total TCMJ replacement are poor bone stock, irreducible Z - deformity of the thumb, joint hyperlaxity, unstable soft tissue with or without infection, nerve palsies, highly loaded claims at work and leisure, and reduced compliance of patients. Discrete concomitant radiographic degenerative changes in STTJ in the absence of its clinical manifestation appear not to be a contraindication for total TCMJ replacement [79]. Total TCMJ replacement allows additional wrist procedures such as four-corner fusion or proximal row carpectomy, total wrist arthroplasty (TWA) [Figure 3], and can also be an option for primary treatment of comminuted fractures at the base of the 1st metacarpal bone [80-82]. A main complication after TCMJ replacement is instability or dislocation of the implants with or without loosening of the cups which is mostly based on technical errors by the surgeons at time of insertion of implant such as primarily failed positioning of the cup [Figure 4A-C] or utilizing an intercalated head-neck component which is too short potentially leading to longitudinal instability [Figure 5A-C].

**Figure 3:** A 55-year-old active male presented with multiple primary OAs received combined replacements of wrist, distal radioulnar joint, and TCMJ using the Arpe™ implant.

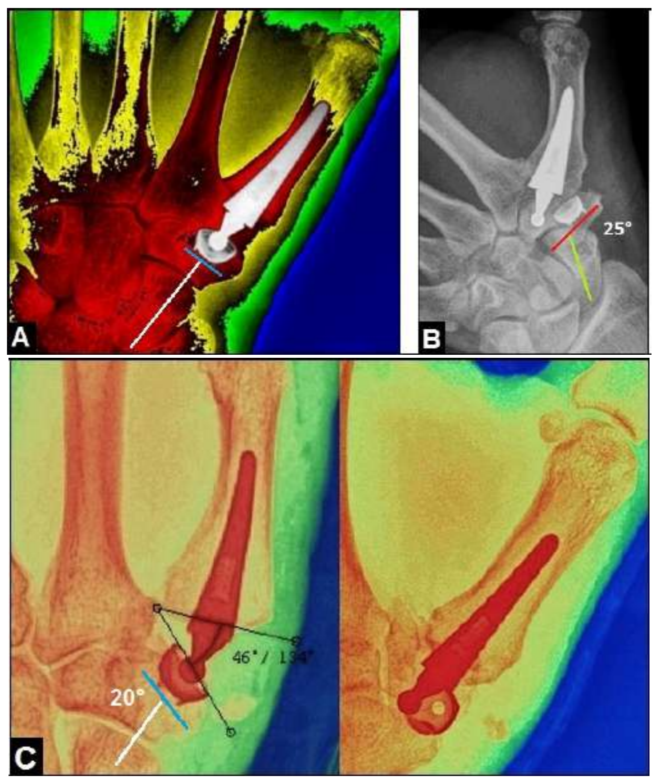


**Figure 4:** (A) Stable implantwithcorrectly placed Arpe™ cup in the centre of range of motion that is parallel to the proximal articular surface of trapez bone and approximately 90° perpendicular to the central axis of scaphoid bone in the posterior-anterior (PA) view (lines). (B) Unstable Arpe™ implant with dislocation due to primarily failed placement of the cup. (C) Unstable Arpe™ implant with breakout of the cup accompanied with dislocation due to primarily failed placement of the cup.

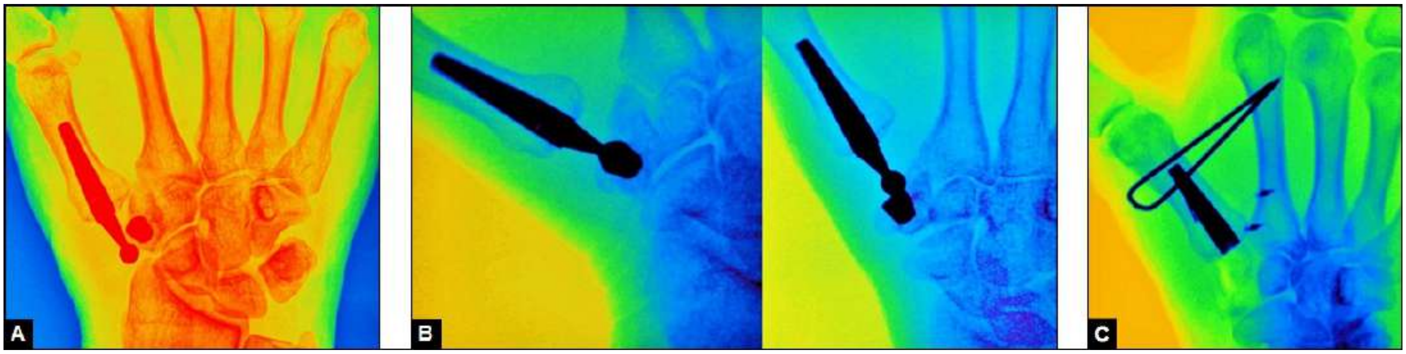


**Figure 5:** (A) Dislocation of a Elektra prosthesis. (B) Same patient, dynamic investigation by fluoroscopy demonstrating longitudinal instability of implant due to insertion of an intercalated head neck component which was too short. (C) Same patient, revision procedure with trapeziectomy combined with ligament reconstruction using a micro anchor and additional K-wire transfixation. Note that stem did not have to be removed because it concluded with the base of the 1st metacarpal bone.

It is still widely known from the literature that prosthetic titanium alloy stems show superiority in terms of osseointegration over all other materials for total hip, knee, shoulder, elbow, and ankle arthroplasties; and an ultra-high molecular weight polyethylene (UHMWPE) bearing seems to be the favorable articulation in order to avoid wear which is one of the most important cause for implant failure. Ceramics have the least amount of wear particles, but its osseointegration ratio is poor, hence, early complications such as migration or dislocation of the Moje Acamo ceramic implant with its various modifications at the TCMJ are common [Figure 6A-C], but not all of these complications are symptomatic and do not need revision surgery [83]. However, regarding to the exclusively only published poor outcomes with the use of the Moje Acamo ceramic prosthesis [23, 84-88], it has been noted by Giddins in 2012 that this implant should be withdrawn from the marketplace, but the manufacturer has not responded so far [89, 90].

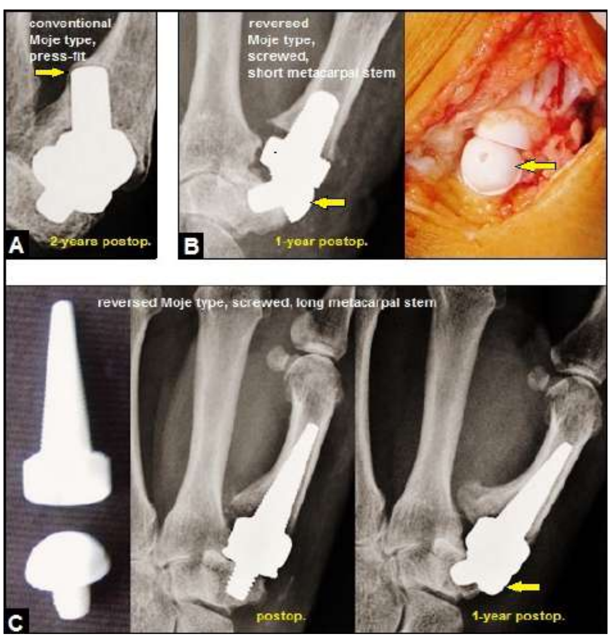


**Figure 6:** (A) Cortical migration of the metacarpal component of a conventional Moje ceramic prosthesis 2- years postoperatively (arrow). (B) Loosening and dislocation of the trapezial component of a screwed "reversed" Moje ceramic prosthesis with a short metacarpal stem 1-year postoperatively (arrows). (C) Loosening and dislocation of the trapezial component of a screwed "reversed" Moje ceramic prosthesis with a straight long metacarpal stem crossing the intramedullary cortical isthmus 1-year postoperatively (arrow).

It is still widely accepted that metallic wear subsequently leading to metallosis to the surrounding soft tissue when using an implant utilizing a metal-on-metal articulation was the main cause for its failure for example at the wrist [91]. This feature is absolutely comparable with the use of such an implant (Elektra) at the TCMJ in which metallic wear potentially leads to metallosis [Figure 7A-C], pseudotumor, elevated serum chrome and cobalt values, and metal allergy [23, 87, 90, 92-95]. The outcome of Elektra implant is reported to be critical. Regnard reported satisfactory results with 83% for in-vivo functional survival rate in 100 patients at a mean 54-months follow-up; however, there were seven perioperative fractures, 5 traumatic and 2 atraumatic postoperative dislocations, two early cases of metacarpal implant subsidence, 15 cases of cup loosening and one metal allergy [96]. On the other hand, radiological evidence of loosening has been reported in 47% of cases at 2-years follow-up [97], and the revision rates increased from 24 to 44% in 39 patients between 36 and 72 months [98]. Maybe that chrome nitride-coated metal implants for total TCMJ replacement can reduce the amount of metallic wear in future [99]. However, metal allergy is also observed in single cases at small joints in human when using a UHMWPE-metal-articulation [100].

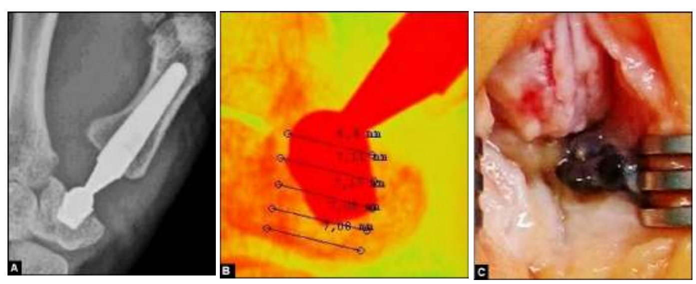

**Figure 7:** (A) Postoperative radiograph demonstrating correct placement of the Elektra prosthesis. (B) Same patient 1-year postoperatively, there was a non-traumatic loosening and dislocation of the cup. (C) Same patient intraoperatively, as cause for loosening metallosis was found.

## Update to the Arpe™ prosthesis for total TCMJ replacement

The non-cemented ball-and-socket Arpe™ prosthesis (Zimmer Biomet Holdings Inc., Warsaw, Indiana/USA) was introduced in 1991 and is unchanged one of the most favorable implant currently [Figure 8A-D] [23, 73, 101].

It has a metal-on-UHMWPE articulation, and the design resembles a "small hip prosthesis" . The hemispherical titanium alloy and hydroxyapatite coated cup (available with 9 and 10 mm in diameter, retentive or non-retentive) is designed for pressfit insertion, and it has

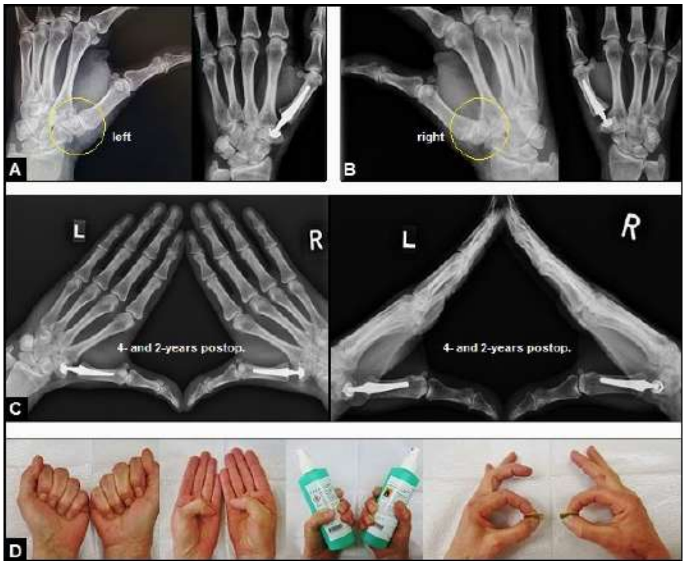


**Figure 8:** (A) A 52-year-old active female presented with advanced stage of left TCMJ OA (circle) received an Arpe$^{TM}$ prosthesis. (B) Same patient, equal situation and procedure at the right TCMJ. (C) Same patient, excellent restoration of abduction of both thumbs in the hand plane as well as perpendicular to the hand plane. (D) Same patient, excellent functional recovery of both hands.

three spikes on its ground for that one in-vitro study demonstrated a high primary stability regarding bending strengths, and an "additional crown" could raise its stability regarding torsion strengths [102]. The titanium alloy and hydroxyapatite coated stem (available with 4 various sizes in diameter) reproduces the anatomical shape of the first metacarpal medullary space. The intercalated cobalt-chrome head-neck components with 4 various lengths are available in form of a straight or an angled design [Figure 9]. The problem of a ball-and-socket implant is that the central axis of cup is colinear to the axis of stem resulting in physiological load-bearing for thumb adduction only, whereas the dominant contact pattern for volar abduction and opposition is observed on the central-volar aspect of trapez bone surface [6]. To minimize the risk of loosening or dislocation, the Arpe$^{TM}$ cup should be placed in the centre of range of motion that is parallel to the proximal articular surface of trapez bone in the PA view [Figure 4A], accompanied with its angulation of 7° flexion relative to the proximal surface of trapez bone in the lateral view, and these results were confirmed with the use of the Maïa prosthesis, however, its cup has 4 spikes on its ground [103, 104]. A specific contraindication for the Arpe$^{TM}$ prosthesis is a collapsing trapez bone with height below 11 mm, and a Z-deformity of the thumb with closure of the first web and hyperextension in the TMPJ which cannot be reduced by tightening the adductor muscle [Figure 10A] [61]. Another specific contraindication for the Arpe$^{TM}$ prosthesis is a dysplastic slope (*i.e.* angle between the longitudinal axis of the 2nd metacarpal bone and the plane of the articular surface of trapez bone) greater than 120° that does not allow a correct alignment of the cup to the 1st metacarpal bone [Figure 10B], for those conditions are primarily recommended either an additive open wedge osteotomy of trapez bone with or without bone grafting, or a subtractive closed wedge osteotomy of the base of the 1st metacarpal bone, or a combination of both procedures when ait becomes symtomatic [105-107]. One disadvantage associated with the Arpe$^{TM}$ prosthesis is that the UHMWPE insert is fixed to the cup, hence, if polyethylene wear occurs, the cup has to be removed or revised even it may not be loosened [108].


**Figure 9:** Design of the Arpe$^{TM}$ prosthesis with its 3 components (collage, note the straight design of the intercalated head-neck component in this Figure).

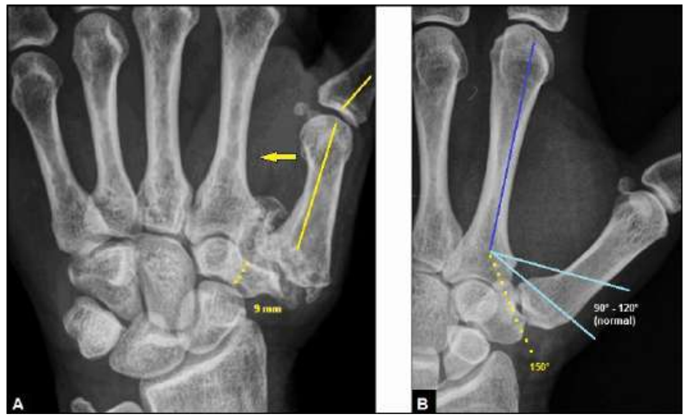


**Figure 10:** (A) A collapsing trapez bone with height of 9 mm only which is unable to insert a 9 or 10 mm Arpe$^{TM}$ cup. Note the additional Z-deformity of the thumb with adduction contracture in TCMJ accompanied with hyperextension in TMPJ (arrow, lines) which is to be considered as contraindication for inserting an Arpe$^{TM}$ prosthesis if the deformity is irreducible by tightening the adductor muscle.(B) A dysplastic trapez bone with a slope of 150° (yellow pointed line in relation to the blue line) that does not allow a correct alignment between the cup and stem of the Arpe$^{TM}$ prosthesis. The normal slope is 90° to 120° (light blue lines in relation to the blue line).

The initial publishedshort-term results of 10 independent studies with the Arpe$^{TM}$ implant were excellent with a survival ratefor in-vivo functioning implantsin up to 95%[109-118], and it wasconfirmed in further independent 4 mid- to long-term follow up'sin up to 97% [108, 119-121] and in 1 long-term follow-up with 93.9% [122]. None of other ball-and-socket prostheses revealed such an excellent long-term surveillance, and these results are absolutely comparable with those of the standard reference of 93.1% for total hip arthroplasty (THA)[123]. However, due to the translation of the centre of range of motion from central to central-volar on the articular surface of trapez bone during thumb's circumduction in unaffected TCMJs, the ball-and-socket Arpe$^{TM}$ prosthesis is unable to restore completely motion in the anatomically determined axes of TCMJ in healthy subjects, thumb's abduction and adduction are limited unchanged but these features are compensated by an increased axial rotation during opposition [124]. The "off-label" use of the Arpe$^{TM}$ prosthesis in a "reversed manner" as salvage procedure after a failed trapeziectomy is reported to be critical[125].

Based on the 12fold higher load amplification in TCMJ during axial loading of the thumb accompanied with translation of the centre of rotation during thumb's circumduction in TCMJ, subsidence of the Arpe$^{TM}$ cup with or without its loosening and/or dislocation is not always avoidable. However, revision surgery is not required if there is only subsidence in the absence of any clinical symptoms [Figure 11A-B].

One question is not clearly answered currently: should an anatomically shaped hydroxyapatite coated stem inserted into the 1st metacarpal bone press-fit or not press-fit in order to prevent subsidence or loosening? Apard and Saint-Cast noted that in order to obtain longitudinal stability of the Arpe™ stem in the funnel-shaped intramedullary space of the 1st metacarpal bone it should be slightly larger than the intramedullary space that provides strong cortical contact especially at the isthmus [119]. In contrast, Duerinckx et al. noted with the use of the Maïa prosthesis, which is the further development of the Arpe™ prosthesis, that press-fit insertion of the stem is not required in order to avoid "stress-shielding", none of 87 stems which were inserted without cortical contact showed subsidence 1 year after surgery [126]. However, these results cannot be transferred to the Arpe™ stem with its overall smooth surface macrostructure because the Maïa stem has fish-scale surface macrostructure proximal [127]. Moreover, how is "stress-shielding" to define? Bone resorption (i.e. periprosthetic osteolysis) are frequently observed juxta-articularly (i.e. metaphyseal) around the prosthetic components after TWA [Figure 12A], after ulnar head replacement (UHR) (Figure 12B), and THA [128]. These radiographic findings do not correlate with the amount of evident loosening, and it seems to be stabilize within 3 to 8 years postoperatively [129-131]. That phenomenon is probably not new. Julius Wolff, a german orthopaedic surgeon (†1902), first described in 1862 that cortical bones primarily became atrophic in lesser loaded regions whereas it became hyperthrophic in higher loaded regions, and resulted secondarily in a steady-state over time ("Wolff's law") [132]. Hence, bone resorption as result of "stress-shielding" juxta-articularly can be probably discussed as well as a result of stable and sufficient osseointegration of press-fit inserted stems into the diaphysis.


**Figure 11:** (A) Correct placement of an Arpe™ prosthesis without any signs of subsidence or loosening of the cup at the 1-year follow-up. (B) Same patient at the 6-year follow-up. There is marked subsidence of cup into the trapez bone in the absence of dislocation and without any further signs of loosening (yellow line and points in comparison to the blue line and points at the 1-year follow-up). The patient does not report discomfort, hence, revision surgery is not required at this time.

## Salvage options after a failed total TCMJ replacement

For a failed primary total TCMJ replacement, total exchange TCMJ replacement with or without additional bone grafting or cementation, an excisional procedure with or without removal of the metacarpal stem [Figure 5C], or TCMJ arthrodesis are the salvage procedures [23, 61, 73, 87, 108, 119, 122, 125, 133-136]. After a failed total exchange TCMJ replacement, an excisional procedure continues to be a salvage option, the outcome of an excisional procedure after a failed total TCMJ replacement is reported to be identical to those after a primary procedure [137, 138].

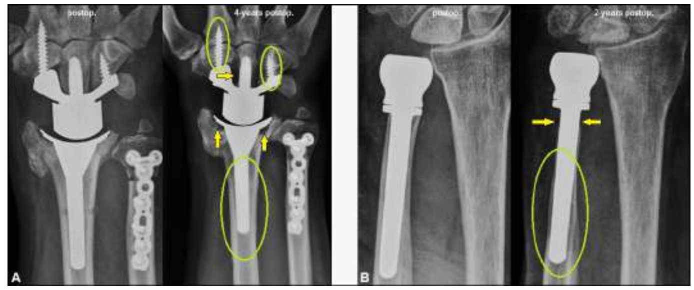


**Figure 12:** (A) A 4-year follow-up of a non-cemented TWA with a press-fit insertion of the radial stem into the distal radius diaphysis, and fixation of the carpal plate with 2 locking screws. Note the bone resorption juxta-articularly around the radial component accompanied with bone resorption around the capitate peg of carpal component (yellow arrows). In contrast, whether the radial component nor the carpal plate showing evident loosening in their main loading zones (green ovals). The patient does not report any discomfort, hence, revision surgery is not required at this time. (B) A 2-year follow-up of a non-cemented UHR with press-fit insertion of the stem into the distal ulna diaphysis. Note the bone resorption around the collar of implant (yellow arrows) whereas the stem does not show further signs of loosening (green oval). The patient does not report any discomfort, hence, revision surgery is not required at this time.

## Conflict of interests

The author declares that he has none conflict of interests concerning this article.

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