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Technical note

The 10 commandments for successful trapeziometacarpal total joint arthroplasty

Joris Duerinckx [a,b]

[a] Departement of Orthopaedic Surgery and Traumatology, Ziekenhuis Oost-Limburg, Synaps Park 1, 3600 Genk, Belgium
[b] Hasselt University, Faculty of Medicine and Life Sciences, Campus Diepenbeek, Agoralaan, Gebouw D, 3590 Diepenbeek, Belgium

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ABSTRACT

Trapeziometacarpal total joint replacement with a ball-and-socket prosthesis is a promising procedure, but a meticulous surgical technique is mandatory to achieve good outcomes. Certain key steps can be considered commandments for successful total joint arthroplasty.

Replacing a painful trapeziometacarpal (TMC) joint with a ball-and-socket prosthesis was introduced over 50 years ago. Continuous improvements in implant design and surgical technique made it a succesful procedure. Ten-year survival analyses demonstrate promising outcomes, with survival rates ranging from 85% to 95% across various prosthetic designs [1–3]. In several countries its popularity has already surpassed alternative treatment options such as trapeziectomy and arthrodesis.

However, complications are possible. Dislocation was the most common complication with single-mobility implants [4], but the adoption of the double-mobility concept has dropped the dislocation rate to 0.5% [5]. Double-mobility implants consist of two articulations, a small one between the neck extremity and the polyethylene (PE) and a greater one between the PE and the trapezial implant. This design effectively increases stability by enlarging the head diameter compared to single mobility implants. Follow-up data up to 8 years are promising [6]. Other possible complications include loosening, cup migration, periprosthetic fracture [7,8] and implant failure [9]. Insufficient experience with the surgical procedure appears to be an important factor [10]. Therefore, we will highlight ten essential elements for a successful total joint arthroplasty.

1. Set proper indications

The primary indication for TMC prosthesis surgery is isolated TMC osteoarthritis (OA) in patients who have failed conservative treatment.

1.1. Asymptomatic STT joint

Radiographic imaging of the thumb is used to confirm the diagnosis and to evaluate disease severity [11]. Interestingly, degenerative changes at the scaphotrapeziotrapezoidal (STT) joint are present in up to 48% of patients with TMC OA [12]. While these pathologies share an anatomical connection through the trapezium, they are distinct diseases: the TMC joint is part of the thumb and the STT articulation belongs to the wrist joint [13]. STT OA is associated with other forms of wrist OA in 17% of cases [14] and is often asymptomatic [15]. To determine whether the STT joint is painful, several clinical tests can be performed: pain localized over the STT joint in the anatomical snuffbox or palmar wrist crease and pain provoked by extreme wrist flexion, extension, or radial deviation. STT OA can also be associated with flexor carpi radialis (FCR) tendinitis, causing pain during resisted wrist flexion. If uncertainty remains, diagnostic injection of the STT joint with local anesthetic and corticosteroid, or a Spect CT scan may be considered (Fig. 1). A clinical study demonstrated that in patients showing pan-trapezial osteoarthritis on X-rays, if symptoms are limited to the TMC joint, total joint replacement can provide good medium-term results [16].

1.2. Patient age

As a general principle, all conservative treatment options should be exhausted before considering implant surgery. Younger patients pose a particular concern, as their likelihood of requiring future revision surgery is higher. Implant survival declines steadily over time, with rates dropping to approximately 50% at 30 years [17]. This figure should be carefully weighed against the patient's expected lifespan.

E-mail address: joris.duerinckx@zol.be.

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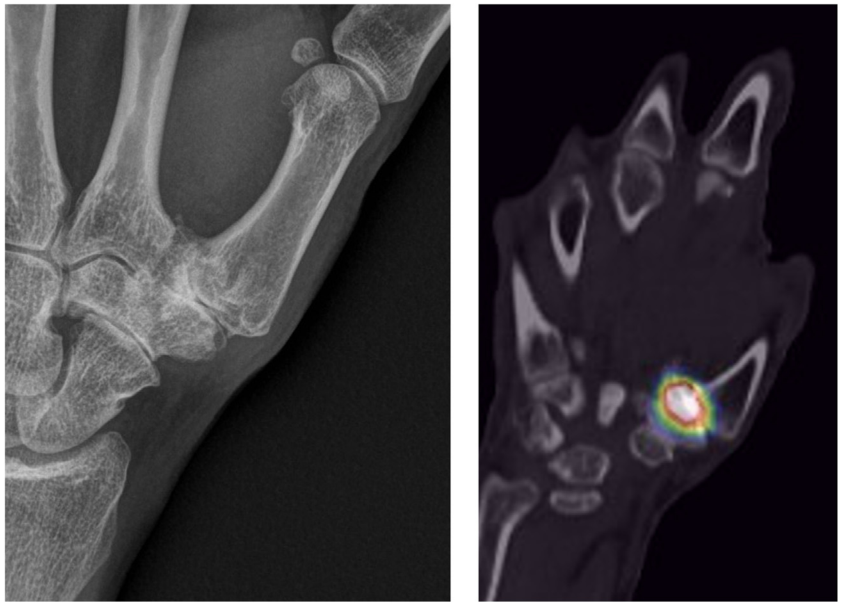

Fig. 1. Radiographic view of pantrapezial osteoarthritis. Spect CT scan demonstrates only hypercaptation at the trapeziometacarpal joint without involvement of the STT joint.

1.3. Manual work

In a multicenter retrospective study including 240 TMC double-mobility implants in 211 patients, 68% performed manual work before surgery and 94% of patients returned to their full-time job within 6 weeks. Prosthetic survival rate was 97% with mean follow-up of 6,9 years [18]. Another series did not find a significant difference in time to return to work between between office workers and labourers [19]. However, increased loading can be expected to lead to earlier wear-related problems. In a series of single-mobility Ivory (Stryker, Kalamazoo, MI, USA) implants, survival rate was significantly lower in the male group than in the female group. Causes of failure were extreme PE liner wear, metal neck fracture and cup loosening due to trapezium bone collapse [9]. Higher muscle mass and grip strength in males might explain the significant difference in implant survival between sexes.

1.4. Allergy

Allergy is an immune-mediated disease. Allergic reactions to metals such as nickel, cobalt, and chromium are common conditions affecting between 3% of males and 17% of females in developed countries and nickel is the most common contact allergen in the world [20]. This is in part due to its frequent use in many household and personal care products, and in part due to flexible pathways of immune activation. Nickel is also commonly added to other metals in alloys for total joint replacement to increase strength and improve corrosion resistance. Although metal allergies have been implicated in total joint replacement failure, its importance and contribution are not well understood yet. Symptoms such as pain, limited range of motion and loosening are common to joint failure, but can also be caused by infection or mechanical issues, and are not specific to metal allergy as the culprit. Most TMC prosthesis are now available with in nickel-free components to use in patients with proven allergic sensitization to nickel.

2. Verify trapezium height

The normal trapezium height is 16.07 ± 1.8 mm in men and 14.84 ± 1.8 mm in women [21]. A minimum trapezium height of 8 mm has been recommended to ensure adequate bone stock [22], although 6 mm measurements on preoperative radiographs typically seem to be sufficient in clinical practice (Fig. 2). Most cups have a height of less than 5 mm, which allows complete seating without the risk of proximal cup penetration into the STT joint. When in doubt, a CT scan with 3D reconstructions can assist in the precise preoperative assessment of trapezial dimensions.

3. Verify bone quality

Because TMC OA predominantly affects older women, osteopenia and osteoporosis are common. The intramedullary canal of the metacarpal can be impacted with progressively larger broaches to achieve press-fit fixation. This is not possible for the trapezium. Preserving the dense subchondral bone of the distal articular surface of the trapezium improves compressive resistance [23]. In cases of poor bone quality, impacted bone grafting may be added, provided the cortical shell of the trapezium remains intact. Using a larger-diameter cup also enhances stability [23].

4. Remove osteophytes and loose bodies

Any impingement, such as from prominent osteophytes or loose bodies, risks impairing motion, causing pain, or creating a lever arm for implant dislocation. The medial intermetacarpal osteophyte of the trapezium is the most common structural feature in TMC OA [24] and its size correlates with disease stage [25]. Osteophytes also appear on the lateral margin of the trapezial articular facet. Metacarpal osteophytes appear later, usually on the dorsal and volar margins of the metacarpal facet. Osteophyte development increases with age, occurring equally in men and women [26].

The volar beak osteophyte of the thumb metacarpal has to be removed to improve trapezium exposure and to prevent impingement during thumb flexion (Fig. 3).

The medial osteophyte of the trapezium wedges between the first and second metacarpals and must be removed completely to prevent bone impingement during thumb adduction in the new biomechanical configuration after TMC prosthesis placement. Lateral osteophytes are less biomechanically important, but widen the trapezium. This can

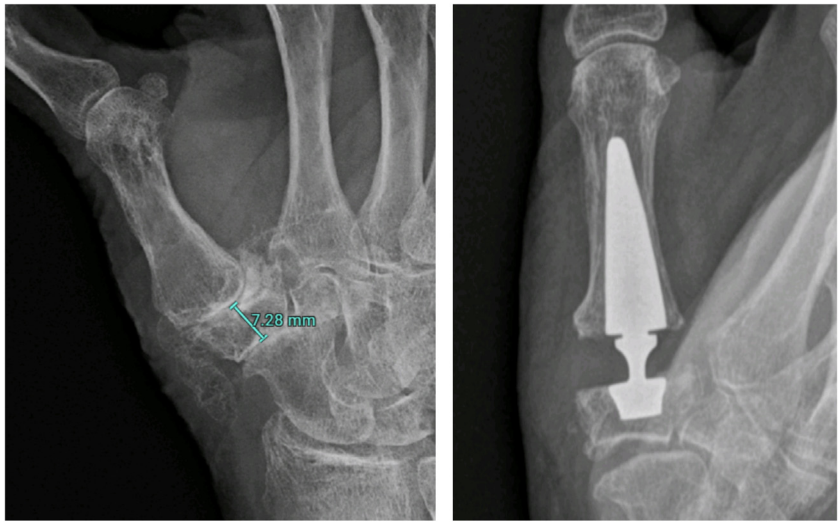

Fig. 2. Radiographic measurement of trapezium height and postoperative radiograph after insertion of conical cup with depth of 4.3 mm.

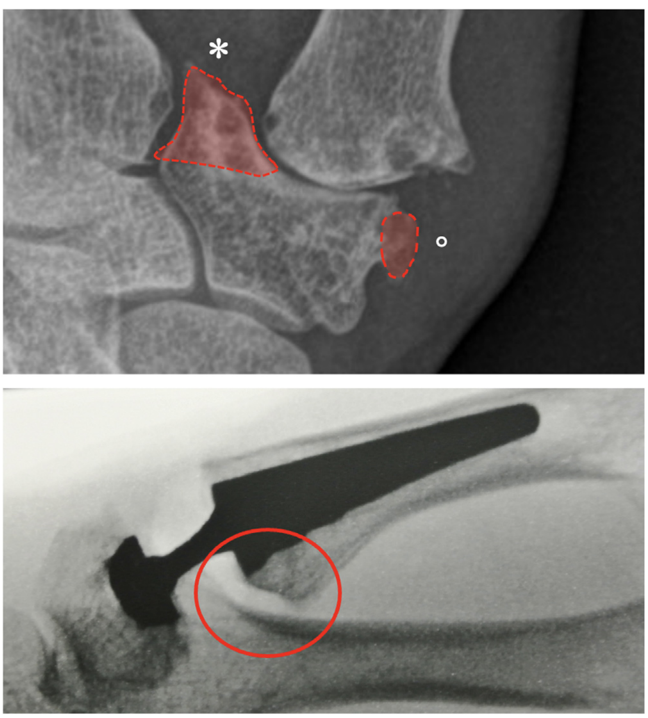

Fig. 3. Top: radiographic anteroposterior view of the trapeziometacarpal joint with delineation of osteophytic enlargement of the medial intermetacarpal (*) and the lateral (°) horn of the distal articular surface of the trapezium. These should be removed. Bottom: lateral radiographic view after trapeziometacarpal total joint replacement demonstrating proper removal of the metacarpal volar beak.

mislead the surgeon regarding its true center. It is only after resection that the actual usable area of the trapezium can be appreciated and the cup can be properly centered [27].

5. Release the intermetacarpal ligament

Replacing the TMC joint with a ball-and-socket prosthesis reduces the complex biomechanics of the native saddle joint to a single center of rotation within the trapezium. This fundamental alteration can transform the native ligaments into constraining bands, thereby limiting the mobility of the implant. Of particular importance is the release of the intermetacarpal ligament, which connects the bases of the thumb and index metacarpals (Fig. 4). Because the axis of abduction–adduction shifts proximally from the metacarpal base to the trapezium, the intermetacarpal ligament may function as a tether, hindering full opening of the first web space. Releasing this ligament not only liberates the base of the thumb metacarpal but also facilitates optimal exposure of the trapezium. Double-mobility prostheses provide adequate primary stability of the TMC joint, such that capsular closure at the end of the procedure is no longer essential for initial implant stability prior to the development of postoperative scarring [28].

Fig. 4. Intra-operative view demonstrating exposure of the trapeziometacarpal joint through a transverse dorsal capsulotomy. Release of the intermetacarpal ligament that connects the base of thumb and index metacarpal.

6. Place the cup central or slightly lateral

An eccentric cup increases the risk of trapezium fracture and compromises the initial stability required for bone ongrowth. Cup placement should generally be as central as possible [29]. However, anatomical variations may require adjustments. The lateral height of the trapezium, which is what is usually considered, and the available height can differ significantly as the latter depends on the shape of the trapezoid articular surface with the trapezium (TRAST). In some cases, it may be necessary to consider lateralization or suspension of the prosthetic cup to prevent perforation of the joint with the trapezoid (Fig. 5). Lateralization is possible regardless of choice of implant, while suspension of a hemispheric implant jeopardizes its

Fig. 5. Penetration of the cup into the articulation with the trapezoid.

stability (related to implant design). In this setting, conical implants are recommended [30].

7. Avoid impingement between Neck and Cup

The stem should align with the anatomical axis of the metacarpal.

Correct cup placement is less straightforward because the trapezium is deformed by degenerative joint disease and can be dysplastic. Cup malposition is strongly associated with revision risk [31]. To minimize the risk of impingement and dislocation, Duerinckx described that the cup should be placed parallel to the radiographic line that corresponds with the proximal articular surface of the trapezium (PAST) [32] (Fig. 6).

In case of severe osteoarthritis, typically with a Z-deformity of the thumb column, chronic dorsal subluxation of the base of the thumb metacarpal has eroded the trapezium by sliding dorsally along this slope. In these cases, a cup that is well-oriented because it is parallel to the PAST will not be sufficiently covered on its dorsal side (Fig. 7). In these situations, preoperative planning based on CT-scan is useful and a conical cup should be used to achieve adequate press-fit stability [27].

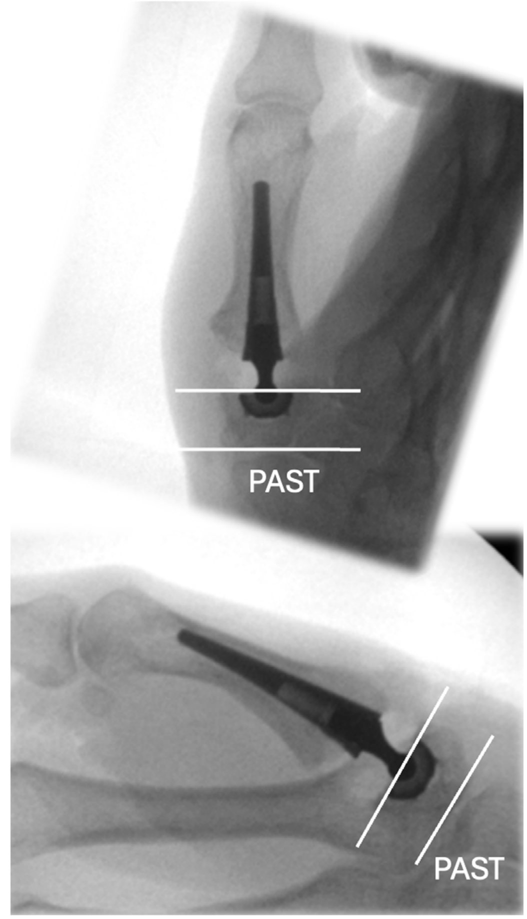

Fig. 6. Radiograph demonstrating cup alignment parallel with the proximal articular surface of the trapezium (PAST) on posteroanterior and lateral view.

The choice between angled and straight necks is also important. Angled necks better replicate normal thumb alignment [33]. However, they increase the risk of intraprosthetic impingement during thumb extension, which can cause metallosis and cup loosening [27]. If this occurs, converting to a straight neck or adjusting cup orientation usually resolves the issue.

By the end of the procedure, full passive thumb motion should be possible without intra-prosthetic impingement or bone friction. It is also important to ensure implant stability in the position with the palm flat on the table and the thumb in maximal retropulsion (often called the yoga test).

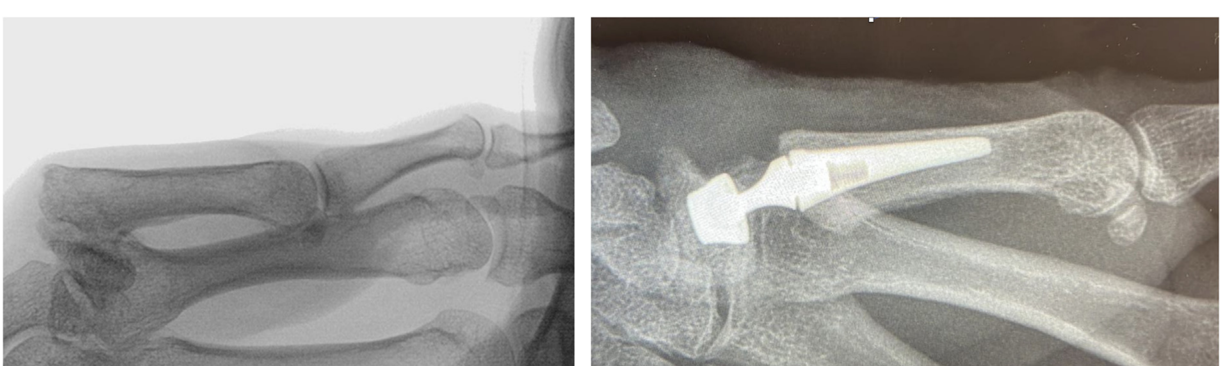

Fig. 7. Lateral radiograph of severe trapeziometacarpal osteoarthritis with chronic dorsal subluxation of the base of the first metacarpal and erosion of the dorsal side of the trapezium (left). Postoperative situation with correct conical cup centering and inclination. Due to insufficient bone stock, the dorsal side of the cup is partially exposed (right).

8. Use fluoroscopy

Various radiographic views have been described to evaluate the articulations of the thumb base. Several are particularly useful for TMC total joint arthroplasty: Robert's frontal view, Kapandji frontal and lateral view and Bett frontal view [34].

Intraoperative fluoroscopy allows assessment of the implant components and correcting their position if needed. Furthermore, it can visualize remaining osteophytes that could cause impingement, and guide restoration of normal thumb length. Cannulated reamers are preferred, as placement of the guide pin can be checked with fluoroscopy before reaming is initiated. This technique ensures accuracy with minimal radiation exposure [35].

9. Allow laxity

Similar to other total joint replacements, the TMC joint should not be overtightened. Excessive lengthening of the thumb column would increase mechanical forces on the implant and can also impair thumb range of motion [36]. Intraoperative laxity of 3–4 mm while applying longitudinal traction with the thumb in neutral position is considered ideal [37]. This represents the optimal balance between thumb length, mobility, and initial stability before postoperative scar formation (Fig. 8). Another method consists of making a mark with a surgical pen on the palmar surface, between the thumb and index finger, before the operation. This allows to check at the end of the procedure if the length of the thumb has been preserved. Thumb laxity can also be assessed dynamically during wrist flexion and extension with the tenodesis effect as described by Dreant [38]. However, all these clinical tests remain surgeon-dependend.

Thumb length can also be evaluated radiographically. Duché and Trabelsi introduced the concept of the first metacarpal (M1)–second metacarpal (M2) arch, which serves as the equivalent of Shenton's line in the hip [39]. While attractive, it can be difficult to visualize this arch perfectly during surgery.

When the thumb is lengthened and tension is too high, neck length can be shortened or the stem can be impacted further into the metacarpal.

10. Be aware of your learning curve

The learning curve of this procedure is estimated at 30–40 cases [10,40]. Although early outcomes do not significantly differ from later cases [40], it is recommended to follow in-depth training on anatomical specimen, visit experienced surgeons and have an experienced colleague assist you during your first cases. You should maintain a high case volume to further refine your surgical technique.

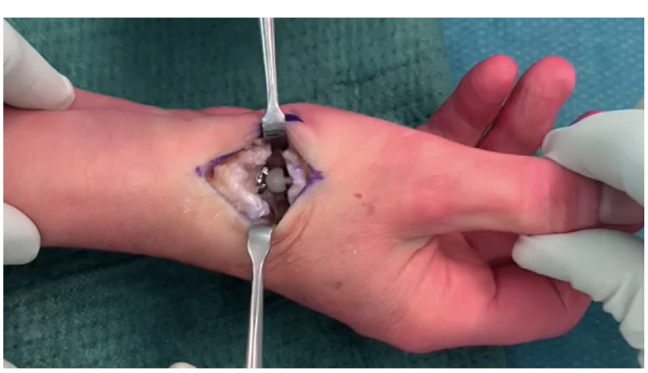

Fig. 8. Longitudinal traction on the thumb for intraoperative assessment of the laxity of a double mobility implant. Laxity of 3–4 mm allows almost dislodging of the head of the implant and is considered ideal.

Match case selection to your experience: begin with straightforward cases—patients with minimal osteophytes and good bone stock—before advancing to more complex situations.

In conclusion, the commandments for a successful TMC total joint arthroplasty include appropriate patient selection, thorough radiographic evaluation, and alignment with the surgeon's level of experience. These must be combined with meticulous surgical technique, including debridement of osteophytes and loose bodies, accurate implant placement, and the preservation of adequate laxity. These principles should be regarded as fundamental to achieving optimal outcomes. Other procedural variables—such as the choice of laterodorsal versus lateropalmar approach, the type of capsulotomy, whether to close or resect the joint capsule, and variations in rehabilitation protocols—were not addressed, as current literature suggests they do not significantly influence postoperative results.

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

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Declaration of competing interest

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