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Cost–Benefit Analysis in the Surgical Management of Thumb Carpometacarpal Osteoarthritis: Dual-Mobility Total Joint Replacement Versus Trapeziectomy with Ligament Reconstruction and Suspension Arthroplasty

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Abstract

Background: Trapeziometacarpal (TM) osteoarthritis (OA) is a common condition, especially among postmenopausal women, often requiring surgical intervention when conservative treatment fails. In recent years, dual-mobility prostheses have been increasingly used as an alternative to traditional trapeziectomy with suspension arthroplasty. However, limited data exist regarding their comparative cost-effectiveness in public healthcare systems. Purpose: The aim of this study was to compare the cost–benefit ratio and clinical outcomes of two surgical techniques for TM OA: trapeziectomy with suspension arthroplasty and total joint arthroplasty with a dual-mobility prosthesis. Methods: We conducted a retrospective cohort study of 116 hands treated between 2020 and 2024. Patients were divided into two groups based on the surgery they received: trapeziectomy with suspension arthroplasty or implantation of a dual-mobility TM prosthesis. Clinical outcomes were assessed using VAS, DASH, Kapandji score, grip strength, and pinch strength at 12, 36, and 48 months postoperatively. A cost analysis was performed based on hospital reimbursement (Diagnosis-Related Group) and estimated productivity loss. Results: Both techniques yielded significant improvements in pain and function. Patients who were operated on with a prosthesis showed faster recovery and better early outcomes, while the trapeziectomy group had lower direct surgical costs and fewer complications. At 48 months, clinical scores were comparable. The overall cost–benefit ratio favoured trapeziectomy with suspension arthroplasty, while TM prosthesis's higher costs were justified due to improved short-term functional recovery. Conclusions: Both surgical techniques achieved satisfactory long-term clinical outcomes. The prosthetic option allows for quicker recovery and reduces indirect social costs, while suspension arthroplasty remains more cost-effective for direct costs. These findings highlight the importance of balancing clinical benefit and economic sustainability in surgical decision-making for TM osteoarthritis. Level of Evidence: Level III, retrospective comparative study.

Keywords: dual mobility; trapeziometacarpal osteoarthritis; trapeziometacarpal prosthesis; thumb; first carpometacarpal joint

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1. Introduction

Trapeziometacarpal (TM) osteoarthritis (OA) is an extremely common condition, particularly affecting postmenopausal women [1–3]. Symptoms such as pain and the progressive decline in hand function significantly impair patients' quality of life [3]. This results in substantial social and economic costs, especially considering the increasing life expectancy and the rising proportion of elderly individuals in the general population. The management of this condition involves pharmacological treatments, orthotic supports, medical consultations, radiographic assessments, and work absenteeism [4].

Conservative treatments such as nonsteroidal anti-inflammatory drugs (NSAIDs) and splint immobilisation often fail, making surgical intervention necessary [5,6]. Numerous surgical techniques have been described in the literature, but none has proven superior to the others [4,6]. Among these, trapeziectomy with suspension arthroplasty is one of the most widely adopted [7]. In recent years, the use of dual-mobility TM prostheses has gained popularity as a surgical alternative due to their association with a faster return to daily activities, improved strength, and effective pain relief, compared to other surgical options [8,9].

In countries where healthcare is publicly funded, such as Italy, it is crucial to assess both the cost and the effectiveness of available treatment options for this condition. The Italian National Health System, like others in Europe, operates through a fixed-reimbursement model based on Diagnosis-Related Groups (DRGs), which corresponds to a predefined reimbursement tariff intended to cover costs related to operating room time, implanted devices, length of hospital stay, and other resources [10]. Each hospital admission is coded using the International Classification of Diseases (ICD) for diagnoses and procedures, which determines assignment to a specific DRG [11].

The primary aim of our study is to compare the cost-effectiveness ratio of two different surgical techniques for treating TM OA, specifically examining two groups that underwent surgery with two different techniques: the TM joint replacement with a dual-mobility implant versus trapeziectomy with suspension arthroplasty, as described by Altissimi [12]. The secondary objective is to evaluate the clinical and radiographic outcomes of the two patient cohorts.

2. Materials and Methods

We conducted a retrospective cohort study of 116 hands treated for TM OA between January 2020 and December 2024. A total of 69 patients underwent surgery with TM joint replacement (Group A), while 60 were operated on with trapeziectomy and suspension arthroplasty (Group B). Those with bilateral OA received staged procedures at least 6 months apart; each hand was analysed independently.

The surgical choice was dictated by radiological staging, according to Eaton–Littler [13,14]. Each patient was informed about different techniques, the immobilisation period, the rehabilitation timeline, potential complications, and return-to-work intervals, and informed consent was obtained. The dual-mobility TM prosthesis was considered the first choice for patients with II or III Eaton–Littler stage, while trapeziectomy with suspension arthroplasty was indicated for IV stage patients.

2.1. Patient Selection

Inclusion criteria were persistent thumb-base pain that negatively affected quality of life despite at least three months of conservative treatment (NSAIDs, orthoses, and intra-articular injections), radiographic signs of TM OA, and active work employment.

Exclusion criteria were the presence of previous fractures of the trapezius, first metacarpal, or phalanges or previous dislocations of the TM, or the other thumb joint; the

presence of preexisting comorbidities in the same hand, such as carpal tunnel syndrome, trigger finger, De Quervain's syndrome, or previous surgery on the carpal bones, such as proximal raw carpectomy. Additional exclusion criteria used in selecting patients for implantation of TM prostheses were stage IV according to Eaton–Littler, poor bone stock, or a trapezius height of less than 8 mm on preoperative radiographic examinations.

Group A received a dual-mobility TM prosthesis (Touch®, KeriMedical, Geneva, Switzerland, or Maïa®, Lepine Genay, France) implanted following the manufacturer's surgical technique manual, consistent with contemporary standard practice. Group B underwent trapeziectomy and suspension arthroplasty with half flexor carpi radialis tendon, fixed on the first metacarpal base with an anchor (Kerifix®, KeriMedical, Geneva), according to the Altissimi technique [12].

2.2. Postoperative Protocol

Both groups followed standardised postoperative protocols. For Group A, a soft dressing was applied for one week after surgery, with early active motion thereafter. If needed, physical therapy was prescribed to each patient with a specific frequency based on thumb ROM, thenar tone, and functional recovery. For Group B, three weeks of immobilisation in a wrist–thumb orthosis were prescribed, followed by graded physiotherapy (3–5 sessions/week as indicated) consisting of thumb ROM exercises and grip/pinch strengthening, until criteria were met (full ROM and thenar muscle tone/recovery).

2.3. Postoperative Evaluations

Clinical and radiographic evaluations occurred preoperatively and postoperatively at 1, 3, 6, and 12 months, and then yearly after the first year of follow-up for all patients. Outcomes included Visual Analogue Scale (VAS), Disabilities of the Arm, Shoulder, and Hand (DASH), Kapandji score, radial-abduction range of motion (ROM), hand grip strength, pinch strengths (key and tip pinch) measured with a Jamar® dynamometer (Patterson Medical, Warrenville, IL, USA), patient satisfaction (0–10), and return-to-work (RTW) days.

Radiographically, the trapeziectomy group was assessed for first metacarpal collapse over the scaphoid; the TM joint replacement group was assessed for radiolucent lines or loosening of the cup or the stem (according to Lussiez staging [4]). Any clinical correlation with pain or functional decline was noted.

2.4. Cost-Effectiveness Evaluation

Direct medical costs were calculated from the perspective of the Italian National Health Service, via Areas® software version 3. These included implant expenditure, operative materials, hospital stay, and follow-up. Reimbursement for each procedure was derived from the Italian Diagnosis-Related Group (DRG) system, which assigns a fixed tariff to each hospitalisation episode based on diagnosis and procedure codes, regardless of the actual resources consumed.

The cost of the material is about €1700 for the Touch® and the Maïa® prostheses (KeriMedical, Geneva, Switzerland and Groupe Lépine, Genay, France), and about €230 for the KeriFix® anchor (KeriMedical, Geneva, Switzerland).

Indirect costs, "productivity loss", were computed as RTW days × Italian average gross income/day. Rehabilitation costs were based on the Lazio regional tariff.

2.5. Statistical Analysis

Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were reported as absolute numbers and percentages. The distribution of continuous variables was assessed using the Shapiro–Wilk test. Variables demonstrating deviation from normality were analysed using non-parametric statistics. Therefore,

comparisons between groups were performed using the Mann–Whitney U test for continuous variables and the chi-square test for categorical variables. Visual inspection of data distributions confirmed comparable distribution shapes between groups, supporting the interpretation of Mann–Whitney U results as differences in central tendency. Exact *p*-values are reported whenever available. Statistical significance was set at $p < 0.05$.

3. Results

3.1. Patient Demographics

TM joint replacement group (Group A): A total of 64 patients (51 women, 13 men) underwent surgery; five received bilateral procedures, for a total of 69 hands treated. The mean age was 58.5 ± 5.7 years (range 45–69). The dominant hand was the one receiving surgery in 42 patients (60.9%), while the contralateral one was in 27 (39.1%). The mean preoperative Eaton–Littler stage was 2.69 ± 0.46 (range 2–3).

Trapeziectomy and suspension arthroplasty group (Group B): A total of 58 patients (47 women, 11 men) underwent surgery for a total of 60 thumbs (2 received surgery bilaterally). The mean age was 60.0 ± 5.2 years (range 52–67). The dominant hand was involved in 35 cases (58.33%) and the non-dominant in 25 (41.67%). The mean Eaton–Littler stage was 2.76 ± 0.43.

No significant differences were observed between the two groups in age, gender distribution, dominant side, or radiographic stage ($p > 0.05$ for all) (Table 1).

Table 1. Demographic data and baseline characteristics of the study population.

Variable	Group A—Dual-Mobility TM Prosthesis (*n* = 69 Hands)	Group B—Trapeziectomy + Suspension Arthroplasty (*n* = 60 Hands)	*p* Value
Patients (hands)	64 patients (69 hands)	58 patients (60 hands)	—
Sex (F/M)	51/13	47/11	>0.05
Mean age (years)	58.5 ± 5.7 (45–69)	60.0 ± 5.2 (52–67)	>0.05
Dominant hand involved	42 (60.9%)	35 (58.3%)	>0.05
Non-dominant hand involved	27 (39.1%)	25 (41.7%)	>0.05
Bilateral procedures	5 patients	2 patients	—
Eaton–Littler stage (mean ± SD)	2.69 ± 0.46 (II–III)	2.76 ± 0.43 (II–IV)	>0.05
Employment status	All active workers	All active workers	—

Values are expressed as mean ± standard deviation (range) or number (percentage). Statistical significance was set at $p < 0.05$. No statistically significant differences were observed between groups at baseline.

3.2. Clinical Outcomes

Both treatment groups exhibited significant improvements in pain and strength compared to baseline ($p < 0.05$). However, patients undergoing prosthetic replacement achieved faster (1–3 months) and more substantial gains in pain relief, DASH scores, range of motion (ROM), and strength than those treated with trapeziectomy and suspension arthroplasty, whose improvements were more gradual and evident between 3 and 6 months. By 12 months postoperatively, over 95% of trapeziectomy and suspension arthroplasty patients had achieved a VAS score ≤ 2 and DASH ≤ 35, thresholds that prosthesis patients had already reached by the first month. Notably, grip strength and pinch strength (key and tip pinch) remained significantly better in the prosthesis group throughout the entire follow-up period ($p < 0.05$). At final follow-up, patient satisfaction was high in both groups (prosthesis: 9.15 ± 0.67; trapeziectomy and suspension arthroplasty: 8.89 ± 0.93; $p > 0.05$), and no patient reported limitations in performing activities of daily living.

All clinical results are summarised in Table 1.

3.3. Radiographic Outcomes

Regarding Group A, we documented four cases of radiolucency around the stem (5.8%), three of which were grade I and one was grade II. All of them were recorded between the 6th and the 12th month of follow-up. Six other cases of radiolucency around the cup (8.7%) were reported; all of them were grade I. None of these cases had any clinical correlation. No cup or stem migration, subsidence, dislocation, or heterotopic ossification was recorded. The remaining 59 implants showed complete osteointegration.

Regarding Group B, all patients demonstrated first MC collapse compared to the contralateral thumb, with a mean collapse of 6.4 mm (range 4.0–8.5 mm). In 67% of cases, the collapse was higher than 3.9 mm. No correlation between collapse magnitude and pain or function was found.

3.4. RTW and Costs

All patients in both groups were able to fully resume their preoperative work activities. For both procedures, the DRG code identified was 228 ("Major interventions on the thumb or joints or other procedures of the hand or wrist with complications"), which carries a fixed reimbursement of €1686 in the Lazio region, regardless of the implant used. However, the implant cost alone for the prosthesis group—€1700—already exceeds the DRG reimbursement, even before accounting for hospitalisation, instrumentation, operating room time, or pharmacological expenses, further highlighting an economic disadvantage from a reimbursement standpoint.

The cost of postoperative rehabilitation, calculated under code 93.11.3 of the DRG system of the Lazio region (10 sessions of complex individual motor rehabilitation), was €8.52 per session. In Group A, the mean number of physiotherapy sessions per patient was 1.45 ± 3.94 (range 0–20), with 86.96% of patients requiring no rehabilitation, resulting in an average cost of €12.35. Conversely, all patients in Group B underwent rehabilitation, with a mean of 22.33 ± 7.45 sessions (range 10–40), corresponding to a cost of €190.25, €177.90 more per patient compared to Group A, a cost that was entirely borne by the public healthcare system.

According to the 2024 BES ("Benessere equo e sostenibile") report by the MEF (Ministry of Economics and Finances), the Italian gross per capita income in 2022/23 was €25.370/year, equating to €69.51/day [15]. Based on this, the average loss in productivity due to time off work was €2206.25 in Group A (mean absence: 31.74 ± 9.18 days) versus €6153.72 in Group B (mean absence: 88.53 ± 27.97 days), representing a 64.15% higher burden ($p < 0.005$).

When excluding equal-cost variables such as DRG reimbursement and operating room time, and focusing solely on differential costs, the prosthesis group yielded a net cost saving of €4125.37 per patient. This includes higher implant costs but is outweighed by reduced rehabilitation needs and a markedly lower loss of productivity, making prosthetic arthroplasty a more economically sustainable approach in the medium term.

3.5. Complications

Regarding patients in Group A, we recorded seven cases of De Quervain's syndrome (10.14%) and transient dorsal thumb paraesthesia in four patients (5.80%). Three of the patients affected by De Quervain's were treated successfully with local corticosteroid injection; one required first-compartment release and tenolysis. All neurological symptoms resolved spontaneously.

In Group B, we documented seven cases of transient dorsal thumb paraesthesia (11.67%) and flexor carpi radialis tendinopathy in six patients (10.0%), who were managed non-operatively with physical therapy which resolved all symptoms.

No deep infections, implant dislocations, persistent pain, or revision surgery were recorded in either group.

4. Discussion

This study compared total joint replacement with a dual-mobility trapeziometacarpal (TM) prosthesis and trapeziectomy with suspension arthroplasty according to the Altissimi technique [12].

Although trapeziectomy with suspension arthroplasty remains the most frequently performed procedure and is widely regarded as the gold standard, there is still no consensus in the literature regarding the superiority of one technique over another [16]. This is largely due to the lack of high-quality comparative studies. In recent years, the introduction of new-generation TM prostheses, particularly those with dual-mobility designs, has shifted the surgical landscape and demonstrated promising short-term outcomes.

Current evidence shows that both techniques yield excellent clinical outcomes, functional improvement, pain relief, and high patient satisfaction, each with distinct advantages and limitations. However, prosthetic replacement was associated with a faster and more substantial recovery in terms of pain relief, ROM, hand function, and strength, particularly in the early postoperative phase [17,18].

Our results are consistent with these findings. In our study, patients who underwent prosthesis implantation demonstrated superior outcomes in terms of pain and function during the first six months after surgery. These differences diminished over time, and by 12 months, both groups showed comparable results, except in grip and pinch strength, where the prosthesis group maintained a clear advantage throughout follow-up. Importantly, no cases of implant loosening, dislocation, or fracture were observed, although radiolucent lines were detected in a small percentage of prosthesis patients.

As confirmed by the present results and prior studies, collapse of the first metacarpal is a common postoperative finding, which may lead to mechanical impingement, reduced pinch strength, or pain [19]. Even though trapeziectomy and suspension arthroplasty is a reliable and effective technique with low complication and revision rates, it remains an invasive procedure that involves excision of the trapezium and can negatively impact thumb biomechanics, in some cases causing carpal instability [16].

Both techniques carry surgical risks, but prosthetic arthroplasty introduces unique concerns, including aseptic loosening, polyethene wear, dislocation, and trapezial fractures. Nevertheless, recent evidence suggests that the dual-mobility design significantly reduces the risk of dislocation, particularly when the prosthetic cup is accurately positioned. Modern implants have shown excellent survival rates, exceeding 95% at 10-year follow-up in some series, with low revision rates and favourable functional outcomes [9,20,21].

Although the follow-up period in this study was relatively short, the results are encouraging; TM prostheses demonstrated rapid and effective pain relief, as well as improved hand strength and function, with a significantly shorter time to return to work compared to trapeziectomy and suspension arthroplasty. Furthermore, prosthetic arthroplasty is a less invasive option, as it preserves the trapezium and avoids major alterations to thumb biomechanics [7].

Economically, prosthetic arthroplasty was associated with higher direct costs due to the implant, which exceeded the Italian national DRG reimbursement. However, the analysis of indirect costs revealed a markedly different scenario. Patients treated with a prosthesis required less postoperative rehabilitation and returned to work significantly earlier—nearly

two months sooner than those who underwent trapeziectomy and suspension arthroplasty ($p < 0.005$). This translated into a 64% reduction in productivity loss, which represented the most substantial contributor to overall cost differences between the two approaches. When both direct and indirect costs were considered, the prosthesis group achieved a net saving of more than €4000 per patient, despite the higher upfront expenditure.

These findings highlight the need for a broader, value-based evaluation of surgical options. In a public healthcare system governed by fixed reimbursement codes, such as DRGs, economic constraints may inadvertently favour lower-cost procedures, even when they do not provide the most efficient overall use of healthcare resources or the most favourable return-to-function for patients.

Our data challenge this paradigm. Although prosthetic arthroplasty entails higher initial costs, its ability to facilitate faster recovery, reduce rehabilitation needs, and minimise work absenteeism results in superior cost-efficiency from both a societal and healthcare system perspective. These advantages are particularly relevant in working-age populations, where indirect costs can heavily outweigh direct medical expenses.

Therefore, TM prostheses should not be viewed as a cost-prohibitive or second-line option but rather as a viable—and in selected patients, potentially preferable—surgical option.

Furthermore, incorporating indirect costs and productivity outcomes into reimbursement frameworks may support their adoption and align surgical decision-making with principles of value-based healthcare.

Limitations

This study has several limitations. First, the retrospective design and absence of randomisation introduce potential selection bias. Surgical allocation was partially influenced by Eaton–Littler radiographic staging, which may have resulted in differences in disease severity between cohorts. Second, although follow-up reached four years in some patients, the duration remains insufficient to fully evaluate long-term prosthetic survival. Third, the economic analysis combined healthcare system and societal perspectives, which may limit direct comparison with studies using a single analytic framework. Finally, the sample size remains moderate and further multicentre prospective investigations are warranted.

5. Conclusions

Both trapeziectomy with ligament reconstruction and suspension arthroplasty and dual-mobility trapeziometacarpal prosthetic arthroplasty demonstrated reliable clinical outcomes in the treatment of thumb carpometacarpal osteoarthritis. Prosthetic arthroplasty was associated with faster functional recovery, improved early strength, and an earlier return to work, whereas trapeziectomy remains a well-established and economically sustainable procedure when only direct healthcare costs are considered. When indirect societal costs are included, prosthetic arthroplasty may provide economic advantages in selected working-age patients. However, given the retrospective design and potential selection bias related to treatment allocation based on disease stage, these findings should be interpreted cautiously and confirmed through prospective studies with longer follow-up.

Moreover, our findings highlight the need for the Italian public healthcare system to reconsider the reimbursement structure for these procedures. Although TM prostheses may appear economically disadvantageous at first glance, they offer significant savings by reducing productivity loss, underscoring their broader cost-effectiveness in a comprehensive health-economic perspective.

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