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Abstract

We evaluated if trapezium bone reaction was different following implantation of a trapeziometacarpal total joint replacement with hemispherical or conical cup. 53 Keri Medical Touch implants with a hemispherical and 53 with a conical cup were prospectively followed radiographically. We compared radiographs taken immediately and one year after surgery for cup subsidence, tilt, heterotopic ossification, and loosening. Cup subsidence of at least 1mm was detected in 4% of cases for both cup types. Additive bone reaction around the cup of more than 1 mm was present in 62% of conical cups and 47% of hemispherical cups. These were minor and there were no large ossifications with risk of impingement. Minor radiolucency was evident superficially at the implant-bone interface of 13% of the hemispherical cups and 9% of the conical cups. None of these bone reactions were significantly different between both cup designs.

Introduction

Most thumb trapeziometacarpal (TM) total joint replacements follow the principle of a ball-in-socket articulation with a cup placed in the trapezium. These cups are typically made of titanium alloy or chrome-cobalt and are covered with hydroxy-apatite, porous titanium or a combination of both. They rely on press-fit fixation for primary stability and bone ongrowth for secondary long-term fixation. Wolff's law suggests that bone, being a living tissue, remodels itself based on the forces exerted on it [1]. Depending on the amount of strain, bone will resorb, strengthen, or stay in equilibrium. Several bone changes have been observed after cup implantation in the trapezium: cup subsidence, heterotopic ossification, and loosening [2-4]. Cementless cups are available in both hemispherical and conical shapes.

Conical cups, for an equivalent diameter, have a larger surface area for bone fixation compared to hemispherical cups. Stress distribution is also different around both cup designs. Finite element analysis predicted that stress distribution in the trapezium is more ideal and uniform around hemispherical cups [5]. It is not known if these different cup types clinically induce different bone reaction from the trapezium. The goal of our study was to radiographically compare bone reaction of the trapezium after conical and hemispherical cup implantation during the first year after surgery.

Methodology

We prospectively included 101 patients who underwent Touch implant surgery (Keri Medical, Geneva, Switzerland) between 2018 and 2022, 5 of them bilaterally. 53 patients received a hemispherical cup (4 male and 49 female; mean age 65 years, range 47 – 84) and 53 a conical cup (8 male and 45 female; mean age 65 years, range 46 – 83) (Figure 1). Cup type was decided at random and all surgeries were performed by a single surgeon (JD) with experience level 4 according to Tang & Giddins. The cups of the Touch implant are composed of stainless steel. Implant fixation is both primary by a press-fit effect, and secondary by means of a double-layer porous titanium and hydroxyapatite coating, which promotes and accelerates osteointegration. In all patients, a cup with a diameter of 9mm was implanted under fluoroscopic control and parallel to the proximal articular surface of the trapezium. The cups were impacted to the level of the distal articular surface of the trapezium. The medial and lateral horns of the trapezium were resected at the same level. Postoperatively, the thumb was immobilized for 2 weeks. Loading was allowed from 6 weeks after surgery. Postero-anterior and lateral radiographs of the trapeziometacarpal joint following the technique described by Kapandji [6] were taken 2 weeks and 1 year after surgery. They were compared to detect bone changes in the trapezium. First, subsidence was defined as the

difference between the ratio of cup height and trapezium height at both points in time (Figure 2). Second, we inspected the cups for progressive tilting. Third, on radiographs taken 2 weeks postoperative, the size of any residual calcifications was measured in mm relative to the distal rim of the cup. These calcifications are typically remnants of the surgical resection of the horns of the trapezium. Fourth, on radiographs obtained 1 year after surgery, the presence of heterotopic ossification (HTO) was measured. HTO is new bone formation on the distal surface of the trapezium and can surpass the distal edge of the cup (Figure 3). This should not be confused with progressive sinking or subsidence of the cup in the trapezium. Fifth, radiolucent areas around the cup were classified using a previously used standard scoring protocol (Figure 4) [3]. The Wilcoxon signed rank test was used to compare the radiographic measurements of hemispherical and conical cups and a value of <0,05 was considered significant. Correlation between the presence of calcifications immediately after surgery and the development of heterotopic ossifications at 1 year postoperatively was evaluated with Pearson's correlation coefficient.

Results

The results are presented in table 1.

All cups were radiographically well integrated into bone at the last follow-up. We observed minor subsidence of 1mm in 2 cases (4%) with a hemispherical and 2 cases with a conical cup. No cups demonstrated progressive tilting. At 1 year after surgery, HTO at the distal articular surface of the trapezium had developed in 33 conical cups (62%) and 25 hemispherical cups (47%). This difference was not statistically significant (p=0,2408). The correlation between incomplete surgical bony debridement (presence of calcifications at the

distal articular surface of the trapezium) and the occurrence of HTO is weak (0,0593) and not statistically significant (p=0,5460). Minor radiolucency at the superficial edge of the cup-bone interface (stage I loosening) was evident in 7 hemispherical cups (13%) and 5 conical cups (9%). This difference was not significant (p= 0,5107). There were no large radiolucent zones or geodes and no patient underwent revision surgery.

Discussion

Our clinical findings demonstrate that both cup designs have comparable radiographic outcome at one year after surgery. This implicates that they have comparable stability and ability to achieve solid bone ongrowth for long-term fixation. These findings confirm the results of an in vitro biomechanical study where hemispherical and conical cup designs had comparable resistance against axial compression [7].

Similarly, Lussiez [4] evaluated the radiological outcome of hemispherical Maia (Lépine, France) and conical Ivory (Mémometal, France) cups. A radiolucent line without clinical symptoms was observed around 16% of the conical cups and two conical cups were removed due to symptomatic loosening, while these findings were not reported with hemispherical cups. There was no progressive cup tilting and 1 case of subsidence in each group. These results seem to be in favour of hemispherical cups, but follow-up was shorter in this group (3 years) than for the conical cups (5,4 years).

Minor, superficial periprosthetic radiolucency was a common finding in our patient group. This phenomenon is not mentioned in some series of Touch [8] and Ivory [9] implants, but common in other. In a series of 107 Touch prostheses with hemispherical cups and a minimum follow-up of 3 years, a linear radiolucent zone around the cup was noted in nine

cases (8%). This radiolucent zone was stable over time in majority of patients, but in two cases the radiolucent zone around the cup expanded leading to the development of painful loosening [3]. In 96 Maïa TM prostheses with a minimum follow-up of 5 years, partial areas of radiolucency around the cup were present in 7.3% [10]. In another series of the Maïa implants with a follow-up of more than 3 years, radiological signs of loosening were reported in 17,4% [2]. It seems that these small radiolucent zones around the cup are commonly reported, but they do not seem to be systematic predictors of future complications [3]. Therefore, it might not be necessary to classify these as signs of early loosening.

Cup subsidence or migration was uncommon in our series. Lussiez et al. [3] noted some proximal migration of the cup in 11% of their Touch cases with hemispherical cup, but with stable results over time. In a series of 110 Ivory prosthesis with conical cup that was followed for at least 10 years, 50% of the cups had sunk into the trapezium. These changes occurred between the first and the sixth months after surgery. After 6 months, the values remained stable until the last radiological analysis [9]. This suggests that initial proximal cup migration is possible and does not prevent the cup to achieve stable anchoring in the bone and uneventful outcome over time. Conservation of hard subchondral bone at the distal articular surface of the trapezium could improve axial stability of the cup under influence of compressive force [7].

We noted a high incidence of progressive HTO in our series. This phenomenon has also been described in other clinical series. Lussiez et al. in their series of Touch prosthesis with hemispherical cup described postoperative bone formation around the cup in 25% of cases: minor in 22% and major in 3% of cases [3]. In the Maïa series of Toffoli and Teissier [10] this occurred in 16 % with substantial HTO in 3 %. With the same implant, Alkar and Teissier noted minor ossifications in 36,5%, medium in 23,8% and severe and restricting in 3,2% [2]. It

remains unclear what stimulates this excessive bone formation around the cup. We did not find a correlation with cup design, suggesting that the difference in load distribution around hemispherical and conical cups is not a causative factor. Nor did we find a correlation with the presence residual calcifications after surgery.

We conclude that there does not seem to be a different trapezium bone reaction around hemispherical and conical cups until 1 year after surgery. Superficial and small radiolucent lines around the cup are common and typically remain asymptomatic. The frequent occurrence of HTO after TM total joint arthroplasty should raise concern because it could cause impingement and dislocation, and should stimulate further research. Longer radiographic follow-up is needed to see how these changes develop over time.

References

[1] Wolff J., Das gestetz der transformation der knochem. Verlag von August Hirschwald 1892.

[2] Alkar F, Teissier J. La prothèse trapézo-métacarpienne Maia® dans la rhizarthrose : revue de 100 prothèses à plus de 3 ans. Chir Main 2011;30:423. https://doi.org/10.1016/J.MAIN.2011.10.014.

[3] Lussiez B, Falaise C, Ledoux P. Dual mobility trapeziometacarpal prosthesis: a prospective study of 107 cases with a follow-up of more than 3 years. J Hand Surg Eur Vol 2021;46:961–967. https://doi.org/10.1177/17531934211024500.

[4] Lussiez B. Radiological analysis of two types of trapezium cup. About 50 cases. Chir Main 2011;30:S86-S90.

[5] Ledoux P, Lussiez B. Apport de la modélisation par éléments finis dans la conception des cupules trapéziennes. Hand Surg Rehabil 2017;36:451. https://doi.org/10.1016/J.HANSUR.2017.10.072.

[6] Kapandji A, Moatti E, Raab C. La radiographie spécifique de l'articulation trapézo-métacarpienne. Sa technique. Son intérêt. Ann Chir 1980;34:719-26.

[7] Athlani L, Motte D, Bergere M, Mottet J, Beaulieu JY, Moissenet F. Assessment of trapezial prosthetic cup migration: A biomechanical study. Hand Surg Rehabil 2021;40:754–759. https://doi.org/10.1016/J.HANSUR.2021.08.002.

[8] Falkner F, Tümkaya AM, Thomas B, Panzram B, Bickert B, Harhaus L. Dual mobility prosthesis for trapeziometacarpal osteoarthritis: results from a prospective study of 55 prostheses. J Hand Surg Eur Vol 2023;48:566-574. https://doi.org/10.1177/17531934231156280.

[9] Tchurukdichian A, Guillier D, Moris V, See LA, Macheboeuf Y. Results of 110 IVORY® prostheses for trapeziometacarpal osteoarthritis with a minimum follow-up of 10 years. J Hand Surg Eur Vol 2020;45:458-464. https://doi.org/10.1177/1753193419899843.

[10] Toffoli A, Teissier J. MAÏA Trapeziometacarpal Joint Arthroplasty: Clinical and Radiological Outcomes of 80 Patients With More than 6 Years of Follow-Up. J Hand Surg Am 2017;42:838.e1-838.e8. https://doi.org/10.1016/j.jhsa.2017.06.008.

Tables

Table 1: Results (mean ; variance ; minimum - maximum)

Figures

Figure 1. Hydroxy-apatite coated conical (left) and hemispherical (right) cup.

Figure 2. Posteroanterior radiographic view of a hemispherical cup in the trapezium, comparison over time. Subsidence can be detected by comparing the ratio of cup height over trapezium height over time. An increasing ratio indicates subsidence.

Figure 3. Heterotopic ossification around a hemispherical (top) and conical cup (bottom).

Figure 4.
Grading system for radiolucencies around a cup in the trapezium.