SCIENTIFIC ARTICLE

Impact of Osteoarthritis and Total Joint Arthroplasty on the Kinematics of the Trapeziometacarpal Joint: A Pilot Study

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Purpose To quantify the effect of osteoarthritis (OA) and total trapeziometacarpal (TMC) joint replacement on thumb kinematics during the primary physiological motions of the thumb.

Methods We included 4 female patients with stage III TMC OA. A computed tomography–based markerless method was used to quantify the 3-dimensional thumb kinematics in patients before and after TMC joint replacement surgery with the Arpe implant.

Results Trapeziometacarpal OA led to a marked decrease of internal rotation and abduction of the first metacarpal (MC1) during thumb flexion and a decrease of MC1 adduction during thumb adduction. As a compensatory phenomenon, the trapezium displayed increased abduction. The absence of MC1 translation in the ball-and-socket implant seems to induce a decrease of MC1 adduction as well as a decrease of trapezium adduction during thumb adduction, compared with OA and healthy joints. Implant replacement displayed an unchanged MC1 flexion during thumb flexion and seemed to slightly increase MC1 axial rotation during thumb flexion and adduction. Abduction and adduction of the MC1 are limited and compensated by this somewhat increased axial rotation, allowing more efficient thumb opposition.

Conclusions The study highlights that advanced TMC OA mainly restricts the MC1 mobility. We also showed that, whereas total joint arthroplasty is able to restore thumb function, it cannot fully replicate the kinematics of the healthy TMC joint.

Clinical relevance The quantification of TMC joint kinematics in OA and implanted patients is essential to improve our understanding of TMC OA as well as to enhance the functionality of implant designs. *(J Hand Surg Am. 2017;■(■):1.e1-e10. Copyright © 2017 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words Implant, medical imaging, OA, thumb, TMC joint.

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THE BASAL THUMB JOINT OR trapeziometacarpal (TMC) joint is crucial for the extensive mobility of the thumb. With its unique configuration, this saddle-shaped joint contributes to the dexterity of the human hand by allowing both forceful power and precision gripping as well as fine manipulation.[1]

Available treatment options for symptomatic osteoarthritis (OA) of the TMC joint range from nonsurgical treatments[2] to surgical options such as trapeziectomy, with or without ligament reconstruction and tendon interposition, arthrodesis, and total joint arthroplasty.[3–8] Total joint arthroplasty for patients with TMC OA has been performed for more than 40 years,[9,10] mainly using ball-and-socket implants with a fixed center of rotation, to replace the saddle-shaped TMC joint. Although there are numerous retrospective clinical studies investigating various types of TMC joint implants,[7] little is known about the effect of the implant on the *in vivo* kinematics of the TMC joint. Likewise, the impact of OA on TMC joint kinematics remains unclear; only 3 recent studies have investigated the TMC joint kinematics of healthy and OA subjects using a 3-dimensional motion-capture system.[11,12]

Recent medical imaging–based studies on the native TMC joint have revealed that thumb motions (ie, extension, flexion, abduction, and adduction) are associated with a significant amount of axial rotation of the first metacarpal (MC1)[13–15] and also of the trapezium and scaphoid with lower magnitudes.[14] These *in vivo* kinematic studies have demonstrated that thumb flexion entails flexion, abduction, internal rotation, and translation of the MC1, trapezium, and scaphoid. Likewise, thumb adduction leads to adduction, external rotation, extension, and translation of all 3 bones. Therefore, the full range of motion of the thumb depends on the mobility of each joint in the articular chain.

The central aim of this study was to quantify the effect of OA and total TMC joint replacement on the kinematics of the thumb joints during the primary physiological motions of the thumb (extension-flexion and abduction-adduction). First, we assessed the effect of OA on the thumb kinematics by comparing patients with advanced TMC OA to a group of healthy controls.[14] Next, the kinematics of patients with TMC joint arthroplasty were measured and compared with healthy controls to assess the implant's ability to restore the kinematics of the native TMC joint.[14] Finally, we compared the kinematics of the thumb joints before and after TMC joint replacement surgery. Our hypotheses were (1) OA affects the kinematics of the MC1 and trapezium and (2) the ball-and-socket implant design cannot fully replicate the native TMC joint kinematics.

METHODS

Subject selection

The study protocol, conformed to the ethical guidelines of the 1975 Declaration of Helsinki, and was approved by the Medical Ethical Commission of our university (# B322201420166). After providing informed consents, 4 patients from the patient base of the senior hand surgeon (F.S.) were recruited. Considering the high incidence of TMC OA in postmenopausal women[16] and to avoid an age- or sex-related impact on the results, only women volunteers of 50 years or older were included in this study. Before enrolment, each subject underwent a clinical examination of both hands by a board-certified orthopedic hand surgeon (P.D.A) to rule out other pathological conditions. Each patient was also subjected to a radiological assessment of the affected side to assess the stage of TMC OA according to the Eaton-Littler classification.[17,18] The inclusion criteria were (1) female sex; (2) age older than 50 years; (3) thumb pain (symptomatic); (4) Eaton stage III on x-ray; and (5) eligible for TMC joint arthroplasty with a ball-and-socket implant. The following comorbidities were considered as exclusion criteria: traumatic injury to the thumb, previous thumb surgery, inflammatory arthritis, metabolic bone disease, and any signs of scaphotrapezotrapezoid OA. Each subject completed the Disabilities of the Arm, Shoulder, and Hand (DASH) and the Patient-Rated Wrist Evaluation (PRWE) questionnaires before and after TMC joint implant replacement surgery. The mean age of our series (1 right and 3 left thumbs) was 60.8 years (range, 51–71 years; Table 1).

A second cohort of 16 healthy female subjects (mean age, 59.5 years; range, 50–82 years), which were recruited among the university staff and acquaintances, served as a control group. This healthy control group was also used in a previous study on thumb joint kinematics and contact biomechanics.[14,19,20] Subjects in the healthy control group had no clinical or radiological signs of TMC OA and were subjected to the same scanning protocol as the 4 patients.

Surgical protocol

All patients were treated in the same hospital (AZ Groeninge, Kortrijk, Belgium), by the same hand surgeon (F.S.), using the Arpe ball-and-socket prosthesis (Biomet, France). The lateral (dorsoradial)