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Original article

In vivo kinematics of the first carpometacarpal joint after trapezectomy☆

Cinématique in vivo de l'articulation trapezometacarpienne après trapezectomie

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Abstract

First carpometacarpal osteoarthitis is frequent and surgery may be necessary if medical treatment is not efficient. Trapeziometacarpal arthroplasty, trapeziometacarpal arthrodesis and trapezectomy may be proposed. These surgical solutions may modify the carpometacarpal kinematics of the thumb. However, no clinical tools are currently available to assess these modifications. The goal of our study is to assess the TM kinematics, with an optoelectronic system, in patients after trapezectomy. Ten women, average age 53 (range 45 to 67) underwent trapezectomy with ligamentoplasty for trapeziometacarpal osteoarthritis. An optoelectronic device (Polaris®) was used to analyse postoperative range–of–motion of the thumb. Splints were used in order to isolate the trapeziometacarpal joint and retroreflective markers were placed both on the splints and on the thumb. Mean flexion–extension, abduction–adduction, axial rotation and circumduction were calculated.
Results. – The mean range–of–motion of trapeziometacarpal joint was 50 degrees for flexion–extension, 47 degrees for abduction–adduction and 11 degrees for axial rotation. The mean angle between rotation axes was 90 degrees and the mean distance *d* between the axes was 3 millimeters. Comparisons between patients and healthy subjects showed no significant differences in flexion–extension, abduction–adduction and axial rotation. Circumduction in patients was reduced compared to healthy subjects. No significant differences were noted between the operated side and the contralateral side.
Discussion and conclusion. – Our study showed that this protocol can be used in the postoperative follow-up of patients after trapezectomy. We did not find any significant differences compared to the contralateral side. However, circumduction after trapezectomy was reduced compared to healthy subjects.

Keywords: In vivo kinematics; Trapeziometacarpal; Thumb; Optoelectronic; Trapezectomy

Résumé

Objectifs. – L'arthrose trapézométacarpienne (TM) est fréquente et nécessite parfois un traitement chirurgical en l'absence d'efficacité du traitement médical. Plusieurs interventions sont proposées afin de traiter cette pathologie : l'arthroplastie trapézométacarpienne, l'arthrodèse trapezométacarpienne ou la trapézectomie. Cette dernière du fait de l'exérèse du trapèze peut modifier la cinématique articulaire. Néanmoins, aucune technique ne permet de l'évaluer objectivement en pratique clinique courante. L'objectif de notre étude est d'évaluer les amplitudes de l'articulation trapézométacarpienne chez les sujets ayant subi une trapézectomie.
Patients et méthodes. – Dix femmes d'âge moyen 53 ans (extrêmes 45 à 67) opérées pour une arthrose TM selon une technique de trapézectomie avec ligamentoplastie ont été étudiées à l'aide d'un système optoélectronique. Des attelles furent placées sur la main et le poignet afin de ne mesurer que les mobilités trapézométacarpiennes. Les mouvements de flexion–extension, d'abduction–adduction, de circumduction et d'ouverture latérale furent étudiés. Des guides permettant d'accompagner les mouvements de flexion–extension et d'abduction–adduction furent utilisés afin d'améliorer la reproductibilité. Les mobilités furent comparées au coté opposé non opéré et à une base de sujets sains féminins.

☆ Les Figures 1, 2a et 2b sont déjà parues dans l'article référencé : JN Goubier et al. Normal range–of–motion of tropeziometacarpal joint. Chirurgie de la main 2009;28:297-300.

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Résultats. – Les mobilités moyennes de l'articulation trapézométacarpienne opérée étaient de 50 degrés en flexion–extension, de 47 degrés en abduction–adduction, et de 11 degrés en rotation axiale. L'angle moyen, entre les axes de flexion–extension et d'abduction–adduction était de 90 degrés. La distance *d* moyenne entre les axes était de 3 millimètres. Aucune différence significative n'a été mise en évidence concernant les amplitudes articulaires et les paramètres de l'articulation entre le coté opéré et le coté controlatéral. Néanmoins, les sujets opérés ont une mobilité de circumduction significativement inférieure aux sujets féminins sains.

Discussion et conclusion. – La réalisation du protocole d'analyse cinématique chez des patients opérés d'une arthrose trapézométacarpienne montre que cette analyse est possible dans le suivi clinique postopératoire. Notre étude ne montre pas de modification des mobilités par rapport au coté controlatéral mais une diminution de mobilité concernant la circumduction après trapézectomie par rapport aux sujets sains.

Mots clés : Cinématique in vivo ; Arthrose ; Trapézométacarpienne ; Pouce ; Optoélectronique ; Trapézectomie

1. Introduction

Thumb carpometacarpal kinematics is difficult to assess because of the complexity of the trapeziometacarpal (TM) joint. In routine practice, range–of–motion of TM joint cannot be precisely measured. Therefore, some methods have been proposed in order to quantify thumb movements. However, only the global motion is generally considered and TM joint is not really isolated [1–6]. In vitro studies do not consider all the parameters which may enhance or hinder thumb motion in clinical practice. Therefore the purpose of our study is to measure in vivo the different movements of the first carpometacarpal joint after trapezectomy.

2. Patients and methods

Ten female patients with ''bilateral'' trapeziometacarpal joint arthritis were included in our study. All patients underwent a trapezectomy on one side only. The average age was 53 years (range 45 to 67).

The hand was placed on a splint to immobilize the wrist. A small splint was placed to fix the IP and MCP joints of the thumb in order to analyze only the TM joint (Fig. 1), as in our previous publication [7].

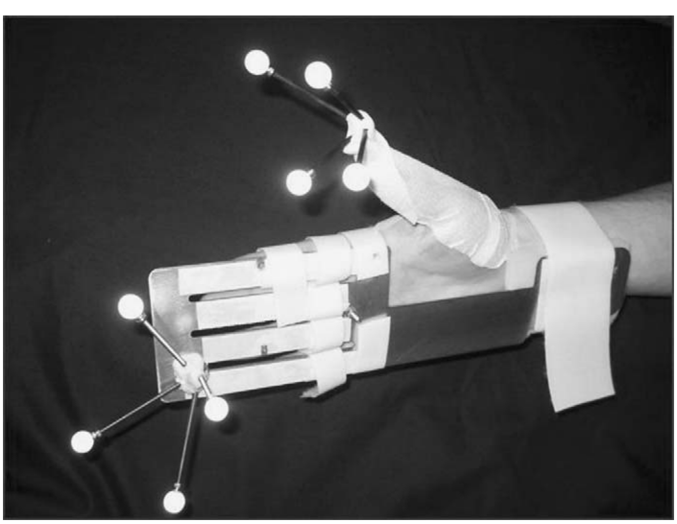

Fig. 1. Splints with retroreflective markers to immobilize all joints except TMC joint.

An optoelectronic system (Polaris®) was used to analyze the movements of the thumb. It was composed of two fixed infrared cameras and retroreflective markers. Retroreflective markers were placed on the two splints. A pen with markers was used to localize bony landmarks of the first metacarpal. Infrared beams were sent by the two cameras and captured after reflection on the markers. Coordinates of the markers were found by the system and range–of–motion values of the thumb were

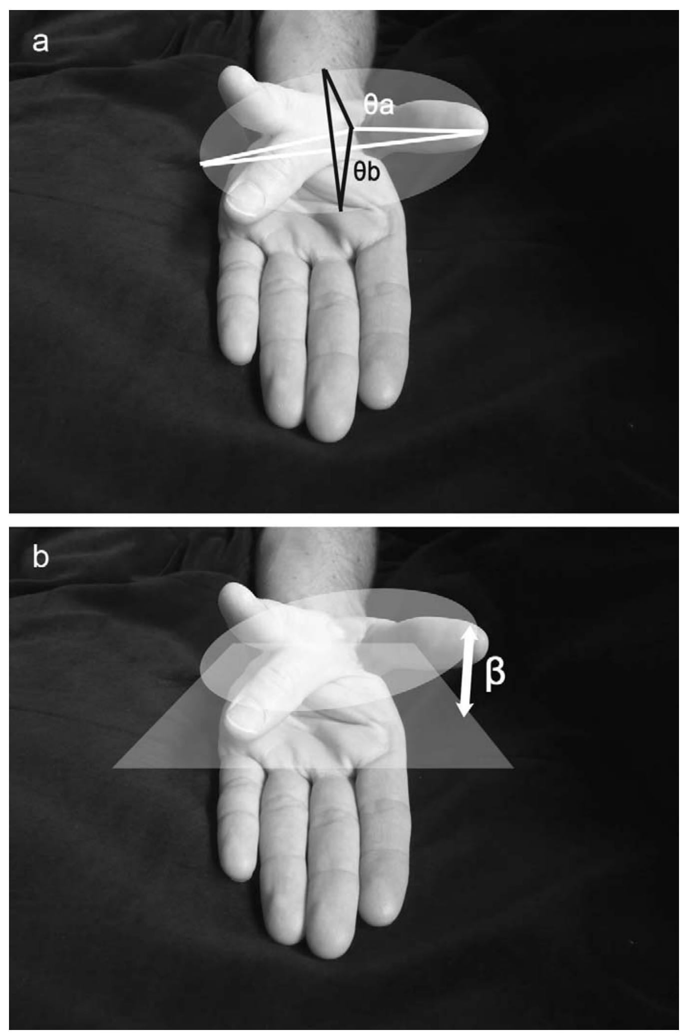

Fig. 2. a: Circumduction is defined with the υa and υb parameters; b: The angle between the surface of circumduction (oval) and plane of the palm (square) is defined with the β parameter.

calculated. Four patterns of movement were analyzed: abduction and adduction, flexion and extension, circumduction (three parameters: ʋa, ʋb and ß described by Cheze et al. [8]) (Fig. 2) and axial rotation. For these movements, ten parameters were analysed; maximal range–of–motion was calculated for each movement. Distance and angles between the different axes of rotation (axes of flexion–extension and abduction–adduction) of the TM joint were evaluated. Axes of rotation were named according to the plane in which the movement took place, flexion–extension and abduction–adduction. Only the axial rotation of the first metacarpal was considered.

All results were compared with the non-operated side with a database of healthy female subjects as previously described (Fig. 3) [7].

3. Results

3.1. Results after trapezectomy

The mean abduction–adduction range–of–motion was 47 degrees (range 24 to 66) (Fig. 3). The mean flexion–extension range–of–motion was 50 degrees (range 26 to 69). The mean circumduction ʋa, ʋb, and ß were 50 (range 39 to 51), 64 (range 38 to 61) and 57.5 (range, 38 to 62) millimetres respectively. The mean angle of axial rotation of the thumb was 11 degrees (range 9 to 19). The mean angle between the axis of flexion–extension and abduction–adduction was 90 degrees (range 133 to 73). The mean distance d between the axes of rotation was 3 millimeters (range, 0 to 11).

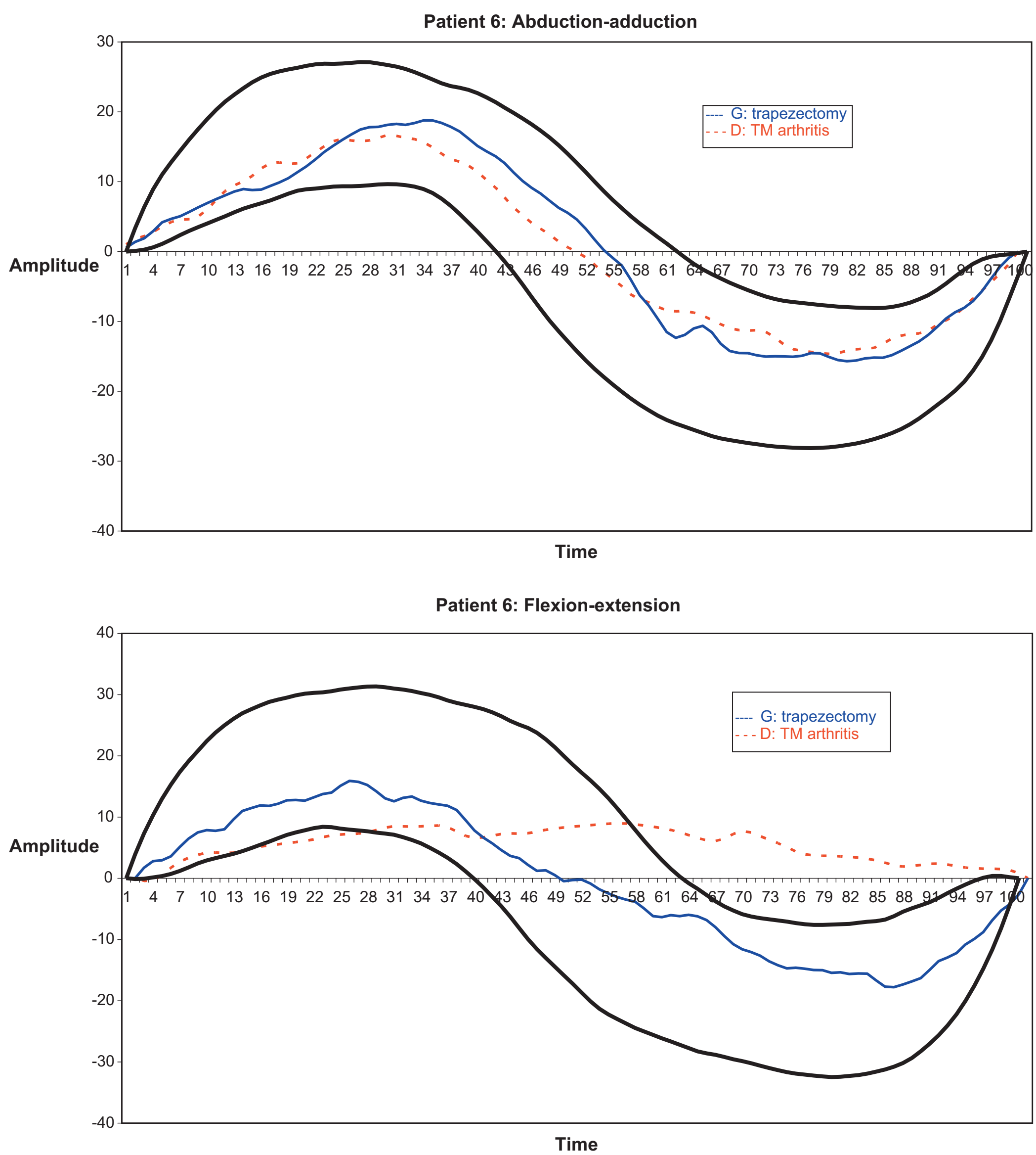

Fig. 3. Recording of flexion–extension and abduction–adduction movement for one patient (blue curve: range–of–motion of the operated side; red curve: range–of–motion of the contralateral side; black curve: range–of–motion of the healthy subjects). The shapes of the curves are related. The amplitude (range–of–motion) is lower in operated and contralateral side than in healthy subjects. However, this difference is not significant.

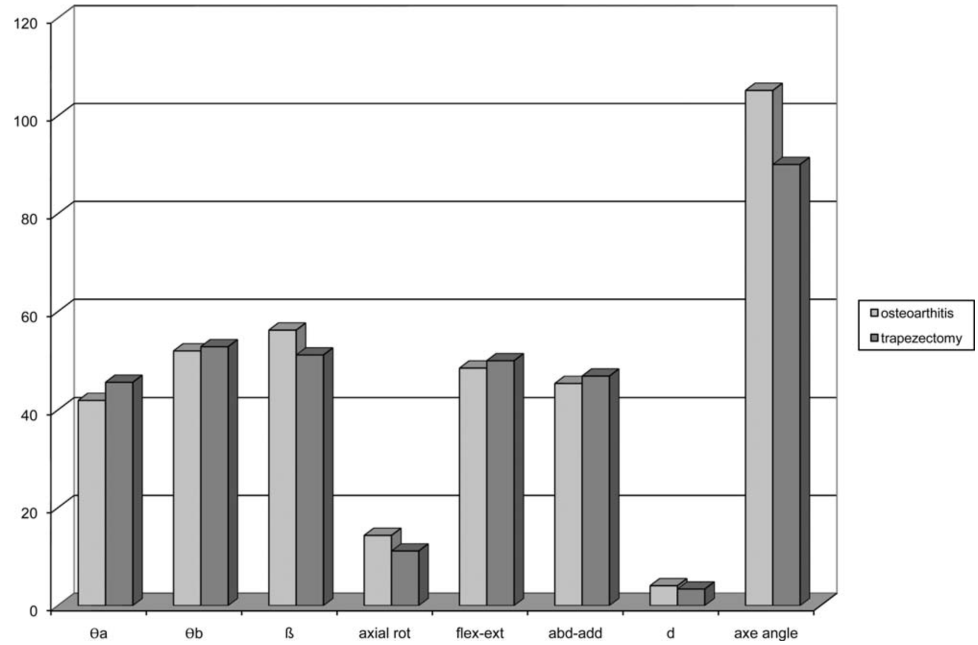

Fig. 4. Kinematics of trapeziometacarpal joint in patients after trapezectomy compared to the contralateral side (osteoarthritis). No significant differences have been found.

3.2. Comparison between trapezectomy side and non-operated side

No significant differences were found between operated and non-operated side concerning flexion–extension, abduction–adduction, circumduction parameters, and axes (Fig. 4).

3.3. Comparison with healthy female subjects

No significant differences were found regarding abduction–adduction, flexion–extension, axial rotation (Fig. 5). For circumduction, only the υb parameter (higher position of the thumb during circumduction) was wider in healthy subjects ($P = 0.03$). The distance and angle between the axes of rotation of flexion–extension and abduction–adduction were not significant.

4. Discussion

Thumb carpometacarpal joint range–of–motion is difficult to assess with clinical tools. Goniometers are not precise enough to evaluate the different angles of the first metacarpal position. Optoelectronic system was first used for gait analysis with the VICON® system [9]. However, we preferred the Polaris® system, more adapted for analysis of small range–of–motion. It is thus particularly adapted for hand studies. In our study, splints were used to fix the MP and IP joints in order to isolate the TM joint for analysis. A small range–of–motion

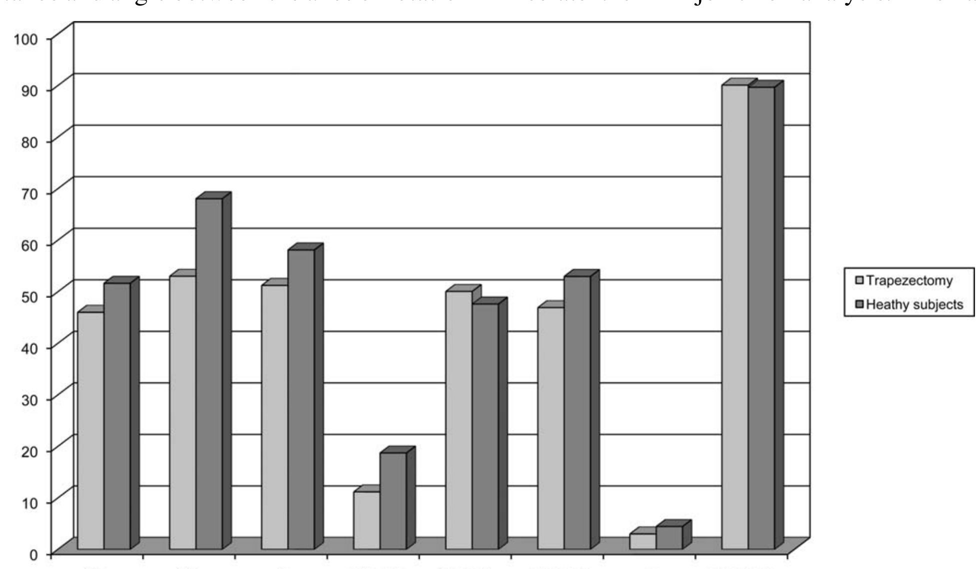

Fig. 5. Kinematics of trapeziometacarpal joint in healthy subjects and in patients after trapezectomy. Only the υb parameter, wider in healthy subject, is significant.

remains despite this precaution. However, we previously showed in a reproducibility analysis, that the variability concerning the position of the splint was not significant [7]. The mobility between splints and skin may be discussed. Kuo showed that there was no significant relative motion between skin markers and the metacarpal [10].

Our study allows comparison of the changes in TM position before and after surgery. Thus this assessment is possible in routine practice. Comparison between operated and non-operated patients showed no significant differences. The trapezectomy, in our protocol, does not modify the kinematics of the TM joint.

When results after trapezectomy were compared with those of a healthy subject, we found no significant differences in flexion–extension, abduction–adduction and axial rotation. Only the υb of circumduction parameter was wider in healthy subjects. The values for axial rotation were lower in our series than in literature. However, our study only considered the rotation of the first metacarpal without range–of–motion of MP or IP joint and combined movement of flexion–adduction. Thus trapezectomy seems to preserve preoperative range–of–motion but does not restore normal mobility. Moreover, the axes of rotation of the TM joint are not modified with trapezectomy despite the anatomical changes.

Moreover, the mean age of the two groups is different (possibly modifying the TM range–of–motion) and was not taken into consideration in our comparison.

Our sample is small and more patients are needed to confirm our results. Comparison with contralateral range–of–motion may be discussed. As a matter of fact, right and left side range–of–motion are generally correlated before surgery because osteoarthritis is bilateral. The differences between the left and the right side are possible and may modify the analysis of the results. Lastly, the variability of the results may be inferior to the variability of our protocol.

>Standard X-rays, fluoroscopy, video electromagnetic and optoelectronic have been used to analyse the TM joint kinematics ex vivo in many publications. However, to our knowledge, only Cheze analysed the in vivo kinematics of the TM joint in one patient with TM arthroplasty and in two patients with TM arthrodesis. And even then, no comparison with normal range–of–motion or the contralateral side were done.

5. Conclusion

Our study showed the modifications of the parameters of kinematics in patients after trapezectomy compared to healthy subjects. No modifications were found between operated and non-operated side. However, these results need to be confirmed with more patients in the trapezectomy group. Moreover, the parameters have to be compared before and after trapezectomy for the same side, for a more precise assessment of the changes in kinematics.

This study shows that the protocol previously described can be used in patients with trapezectomy. Moreover, this protocol could be used after TM arthroplasty to compare with healthy subjects or patients with trapezectomy.

Disclosure of interest

The authors declare that there is no conflict of interest in this publication.

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