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Original article

Carpal height and postoperative strength after proximal row carpectomy or four-corner arthrodesis: Clinical, anatomical and biomechanical study

Hauteur du carpe et force postopératoire après résection de la rangée proximale ou arthrodèse des quatre os médiaux avec scaphoïdectomie : étude clinique, anatomique et biomécanique

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Abstract

Proximal row carpectomy (PRC) and four-corner arthrodesis (4CA) are the two most commonly performed surgical procedures to treat wrist arthritis. Postoperative strength is one of the criteria for choosing between the two techniques. Some authors believe that strength is correlated with residual carpal height. The goal of this study was to determine if postoperative carpal height was predictive of postoperative strength. This study consisted of two parts: a clinical evaluation of grip strength after 4CA or PRC; anatomical and radiological measurements of carpal height before and after 4CA or PRC. Grip strength was better preserved after PRC (87.5%) than after 4CA (76.1%), when expressed relative to the opposite hand ($P = 0.053$). There was a significant decrease in carpal height for the PRC group with a Youm's index of 0.37 versus 0.50 for the 4CA group ($P < 0.0001$). Our clinical results and analysis of the literature indicate that 4CA is not superior to PRC when it comes to grip strength, whereas carpal height is significantly decreased after PRC. The decreased tendon excursion after PRC is balanced by an increase in joint stresses after 4CA.

Keywords: Four-corner arthrodesis; Proximal row carpectomy; Carpal height; Grip strength; Tendon excursion

Résumé

Résection de la rangée proximale du carpe (RRPC) et arthrodèse des quatre os médiaux (A4O) avec scaphoïdectomie sont des interventions couramment pratiquées dans la prise en charge de l'arthrose de poignet. La force postopératoire est un critère de choix entre ces deux techniques. Pour certains, elle est corrélée à la hauteur résiduelle du carpe. L'objectif de l'étude était de déterminer si la hauteur du carpe après intervention était prédictive de la force postopératoire. Cette étude est composée de deux parties : un recueil clinique de la force de poigne après A4O ou RRPC ; une étude anatomique et radiologique mesurant la hauteur du carpe avant et après A4O ou RRPC. La force de poigne était mieux conservée après RRPC (87,5 %) qu'après A4O (76,1 %) comparativement au côté opposé ($p = 0{,}053$). Il existait une diminution significative de la hauteur du carpe pour le groupe RRPC avec un indice de Youm à 0,37 contre 0,50 pour le groupe A4O ($p < 0{,}0001$). Nos résultats cliniques et l'analyse de la littérature ne mettent pas en évidence de supériorité de l'A4O concernant la conservation de la force alors que la hauteur du carpe est diminuée de façon

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significative après RRPC. La diminution de l'excursion tendineuse après RRPC est contrebalancée par l'augmentation des contraintes après A4O expliquant possiblement ces résultats.

Mots clés : Arthrodèse des quatre os ; Résection de la rangée proximale du carpe ; Hauteur du carpe ; Force de poigne ; Excursion tendineuse

1. Introduction

Wrist arthritis mainly manifests itself as a consequence of posttraumatic conditions such as scapholunate advanced collapse (SLAC wrist) and scaphoid nonunion advanced collapse (SNAC wrist). The two main surgical techniques used for wrist arthritis are proximal row carpectomy (PRC) and four-corner arthrodesis with scaphoid excision (4CA). The patient, the condition's severity and the surgeon's preferences are taken into consideration when choosing between these two techniques [1–12]. Other than the extent of the contact area and the configuration of the joint surfaces [13–15], the primary difference between the two procedures in terms of the postoperative anatomy is the residual carpal height (CH) [9,10,16]. Reduced carpal height results in reduced strength [5,7–9,17], because there is less tension on the wrist and finger flexors and extensors [16]. While the possibility of maintaining postoperative strength comes into play when choosing between these two techniques, particularly for patients who perform manual work [7,8,18,19], there is no research showing that one technique is truly superior to the other [1,8,9,11,12,17,20].

Our study had two goals: compare the clinical outcomes of PRC and 4CA, particularly the grip strength, for patients operated in our surgery unit; study the link between carpal height, tendon excursion and strength through an anatomical study in which the preoperative and postoperative carpal height following 4CA is compared with that following PRC.

2. Material and methods

2.1. Comparison of clinical outcomes after PRC or 4CA

The first part of the study was retrospective and included all the patients who underwent PRC or 4CA procedures in our surgery unit between 2004 and 2011, including those who had a history of surgery before the PRC. Patients who had a surgical revision after PRC or 4CA were excluded. The study consisted of two independent groups of patients; although they were not paired, they were comparable. The patients were informed about the study and gave their consent.

In the clinical PRC group, 22 patients were reviewed (4 women, 18 men). The dominant hand had been operated on in 9 of 22 cases (41%). The PRC was performed because of SLAC wrist in 36% of cases (8/22), Kienböck's disease in 36% (8/22), and SNAC wrist in 23% (5/22). The mean overall age was 44.9 years (22–72); the mean age was 38.4 years (24–50) in the Kienböck's disease sub-group and 48.6 years (22–72) in the SNAC/SLAC wrist sub-group. The average follow-up was 50 months (21–77).

In the clinical 4CA group, 11 patients were reviewed (6 women, 5 men). The mean age of these patients was 54.5 years (37–64) and the mean follow-up was 27 months (11–55). The dominant hand had been operated on in 5 of 11 cases (46%). The 4CA was performed because of SLAC wrist in 64% of cases (7/11), and SNAC wrist in 36% (4/11). Screws (5/11), plates (4/11) or staples (3/11) had been used for the arthrodesis. The age difference between the two groups was statistically significant ($P = 0.017$), as was the sex ratio ($P = 0.0413$).

In both groups, the grip strength was measured at the time of review in the operated and nonoperated hands. Strength testing was carried out using a Baseline™ dynamometer (0 to 90 kg) (AREX, Palaiseau, France) that was secured to a table. Patients were seated on an adjustable stool with their elbow flexed at 90°; their arm was held against the chest with a soft, nonstretchy, horizontal strap. They performed three trials of grip strength with 10 seconds rest between trials. The best of the three trials was recorded.

In addition, the joint range of motion was measured with a goniometer (flexion, extension, radial deviation, ulnar deviation, pronation and supination), and the Cooney score [21] and the PRWE (Patient-Rated Wrist Evaluation) [22] were calculated for patients in both groups. The thresholds for the Cooney score were: 0 to 60 (poor), 60 to 80 (average), 80 to 90 (good), 90 to 100 (excellent). The PRWE score ranges from 0 to 100 points, with 100 being the worst possible score.

Standard A/P and lateral radiographs of the wrist were done with the wrist in neutral position. These were used to measure the CH between the lunate facet of the distal radius and the base of the third metacarpal, along with the length of the third metacarpal (M3). Youm's index (CH/M3) was calculated [23,24]; this is a relative measurement of CH that has a normal value between 0.51 and 0.57 (Fig. 1).

The mean and standard deviation values were calculated for each group. The non-parametric Wilcoxon test was used to compare paired data because the sample size was less than 30. Linear correlation coefficients were calculated using Spearman's rho because the sample sizes were less than 30. The non-parametric Kruskal–Wallis test was used to compare unpaired data because the sample size was less than 30. Fisher's exact test was used to compare the distribution of qualitative variables because of the small size of the 4CA group ($n < 30$). For each of the tests performed, the type I error was set at 0.05.

2.2. Comparison of preoperative and postoperative carpal height in cadaver wrists following PRC or 4CA

The second part of the study was carried out on 20 pairs of upper limbs from 5 male and 15 female cadavers with no