

Kinematics of the thumb after different surgical interventions for trapeziometacarpal osteoarthritis

S. Brackertz¹, G. Fischer^{1,2}, I. Schellenberg², M. Calcagni¹, L. Reissner²

¹Division of Plastic Surgery and Hand Surgery, University Hospital Zurich, Zurich, Switzerland

²Department of Orthopedics, Balgrist University Hospital, Zurich, Switzerland

Email: Gabriella.Fischer@usz.ch

Summary

The aim of this study was to describe the kinematics of the thumb and grip strength after different surgical interventions for trapezio-metacarpal (TMC) osteoarthritis. In addition to a restricted TMC motion, we also found compensatory movements in the adjacent thumb joints and a correlation to grip strength. The different surgical interventions showed advantages depending on the evaluated biomechanical outcome.

Introduction

Osteoarthritis of the TMC is a very common degenerative condition. It is associated with pain and restricted motion, which can lead to a severe loss of hand function. There are different established surgical treatments available. These procedures mostly lead to a good pain relief and thumb function [1]; however, the impact of these surgeries on thumb kinematics remains mostly unknown.

Methods

Thirty-six patients (12 male, 24 female, max. age 60 years) who had been treated with Wilson osteotomy (WO, n=10), implant arthroplasty with TOUCH® prosthesis (TP; n=10), ligament reconstruction and tendon interposition (LRTI; n=9) and TMC arthrodesis (n=7) were included after a minimum follow-up time of 1 year. Thumb movements were recorded using an optical motion capture system (Vicon®, 20xVero v2.2) during isolated abduction-adduction, flexion-extension, thumb opposition and circumduction. In addition, the daily activities (ADL) opening a jar, a bottle and turning a key were recorded without additional torque and with maximal strength. A custom made torque meter registered peak torque. Thumb joint angles were calculated based on functional calibration of the joint coordinate systems [2]. The range of motion (ROM) was calculated for each trial and compared between groups using a Kruskal-Wallis test (alpha 0.05).

Results and Discussion

As expected, the flexion-extension ROM of the first metacarpal (MC1) was reduced in patients with TMC surgery, except for the WO group, compared to healthy control (Figure 1). The ROM in the distal thumb joints was not affected. Comparing the different treatment groups, the arthrodesis led to the most affected MC1 movement, whereby presumably most of the movement takes place in the scapho-trapezium/trapezoid (STT) joint, as the TMC is fused.

Similarly, regarding the functional movements, reduced flexion of the MC1 was observed after TMC arthrodesis, whereas no significant difference was found between TP, WO and LRTI. However, compensatory movements in the MCP1

during the ADL were dependent on treatment: while patients after arthrodesis had an increased MCP1 flexion, patients after LRTI showed a more extended MCP1 compared to the WO and TP group. MCP1 hyperextension can lead to pain and deformity of the joint. It was more pronounced when turning a key with maximal force, whereas application of maximal force was associated with less hyperextension when opening a jar. MCP1 hyperextension most often occurred in patients after LRTI (43%) and was less frequent after WO (11%), TP (7%) or Arthrodesis (2%). A significant correlation ($p < 0.003$, average $R = 0.55$) was observed between MCP1 flexion and maximum strength when turning a key or the lid of a jar. Hence, a MCP1 hyperextension possibly is associated also with a loss of grip strength. In contrast, TMC flexion correlated negatively with grip strength ($p < 0.25$, average $R = -0.475$), thus, a neutral to slightly extended TMC seems to be favorable during execution of maximal grip torque.

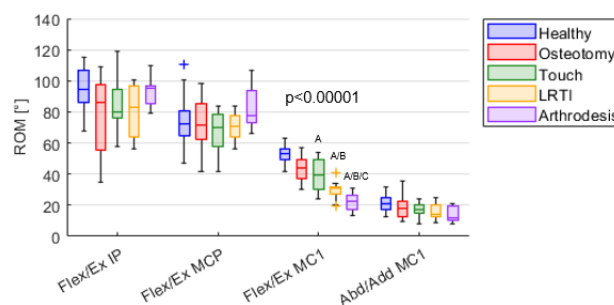


Figure 1: Range of motion for the thumb joints in the isolated movement planes. Significant difference to healthy (A), to osteotomy (B) and to Touch prostheses (C) are observed during TMC flexion-extension.

TMC arthrodesis is mainly performed in young manual laborer, because it still allows high grip strength. However, in our study we only found a significantly increased force during the jar closing task for the patients after TMC arthrodesis.

Conclusions

Restricted TMC mobility was compensated by an increased MCP1 flexion in patients with a TMC fusion whereas an increased extension with susceptibility for hyperextension deformity was observed after LRTI. Overall, MCP1 flexion and TMC extension correlated with better grip strength. This pattern was mostly observed in patients with TMC arthrodesis. Patients after LRTI had the poorest biomechanical outcome, while OT, arthrodesis and TP patients showed advantages depending on the evaluated parameter.

References

- [1] Hamasaki et al. (2021). *J Hand Surg Glob onl*, **3**: 139-48.
- [2] Fischer et al, (2020), *Appl Sci*, **10**: 6436.