Accuracy of a new computer assisted midcarpal wrist fusion technique (computer assisted three corner arthrodesis CA-3CA). Control study comparing postoperative results vs. computer planning (n=8)

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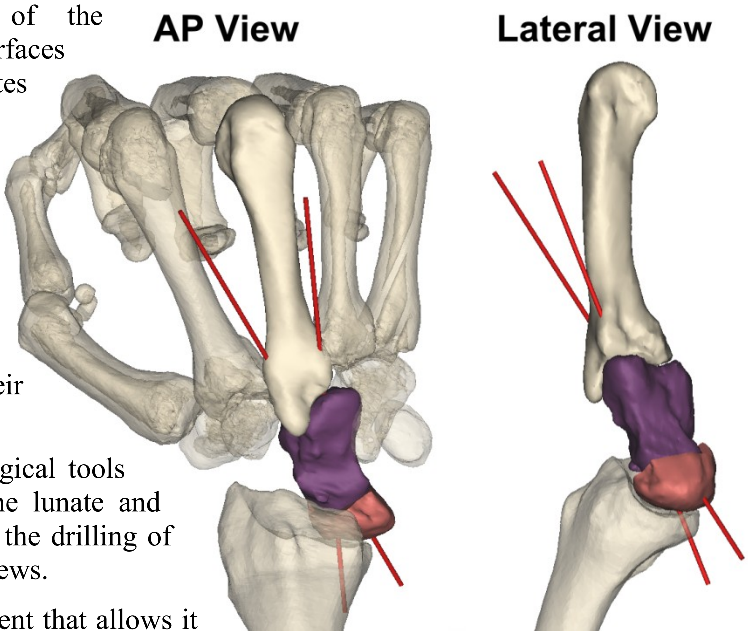
Purpose: Midcarpal wrist fusion with preservation of some wrist movement, has undisputed advantages over total wrist fusion as a salvage procedure for degenerative SLAC (scapholunate advanced collapse) wrist. However different techniques of midcarpal fusion have been proposed for similar pathology. Furthermore none of these techniques appear to have been upgraded so far by the systematic use of computer planning or intra-operative computerized guidance. As four-corner arthrodesis (4CA) proved to have a relatively high complication rate and a high socio-economic cost (hospital stay, sick leave) we set out to develop an alternative midcarpal fusion technique under the form of a computer assisted three corner arthrodesis (CA-3CA) (1). The 3 corner arthrodesis (3CA) is essentially joining the capitate and lunate following resection of the scaphoid and triquetral bones. Two headless compression screws (HCS), which are introduced from distal to proximal, provide for stable internal fixation and early controlled mobilisation. We developed a CAS protocol to optimize the surgical technique. The protocol is based on the most acknowledgeable idea that the capitolunar alignment of a healthy wrist in clenched fist position is also the optimal fusion position. We therefore defined a standard way of data acquisition by CT-scanning both the diseased wrist and the healthy contralateral wrist in the clenched fist position. The different surgical steps to obtain the optimal fusion position can be practiced on virtual 3D models based on these data using the Mimics® software:

1. correction of the position of the lunate and capitate bones;
2. osteotomy with removal of the opposing midcarpal joint surfaces of the lunate and capitates bones;
3. assembly of the arthrodesis respecting the capitolunar alignment and the restraint provided by the radio-scaphocapitate ligament;
4. positioning of the 2 HCS-screws and measuring of their required length;
5. design of patient-specific surgical tools to guide the bone cuts of the lunate and capitates bones, and to guide the drilling of the guide wire of the HCS-screws.



Each tool presents a registration element that allows it to engage on a chosen anatomic surface of either the lunate or the capitate. Both these computer designed patient specific tools and real 3D models of the lunate and capitate bones are then manufactured (Surgicase®) and sterilized for use during surgery. The CA-3CA can be executed in a straightforward and controlled way using the tools once adequate access to the bone surfaces has been provided for. Intra-operative fluoroscopy is needed merely to check the final screw position.

Methods: During a laboratory experiment we operated 4 cadaver wrists using computer designed tools according to the CA-3CA protocol (except for the clenched fist positioning during the preoperative CT-scanning). In a prospective pilot study 4 patients, who presented with a clear indication for midcarpal fusion, were operated using the CA-3CA technique. Postoperative CT-scans were done in these 8 wrists, in the patient group also to check bone healing. The capitolunar alignment in the virtually planned 3CA-models was compared to the capitolunar alignment of the operated wrists, after similar transcription (Mimics®) of the postop CT data to virtual 3D models. Specific anatomic landmarks (points), axes and planes where defined on the lunate and the 3rd metacarpal, which is firmly linked to the capitate, in order to describe the capitolunate alignment. Different parameters can thus be defined and measured using a perpendicular projection technique: carpal height, antero-posterior and radio-ulnar translation, sagital alignment (flexum or disi – recurvatum or visi), coronal alignment (varus-valgus) and axial rotation (prono-supination). The accuracy of the technique can thus be evaluated by comparing the postoperative situation with the intended fusion position in the virtual 3CA-models

Results: From the start it was clear that the computer assisted osteomies have a quite different position compared to those performed in a conventional non computerized technique. For instance the capitate computer assisted osteotomy plane has usually around 30° of palmar tilt compared to the conventional plane of osteotomy, which usually lies perpendicular to the capitate axis. When comparing the postoperative capitolunate alignment to that of the virtually planned 3CA-models, we made the following observations: apparently we tended to resect less bone and hence shorten the carpus less than planned. This is not necessarily bad. We also tended to move the capitate less than planned both in the volar and the ulnar direction in relation to the lunate. For any translation the margin of error appears to be around 1 mm or less. In the sagital plane we tended to overcorrect any disi-tendency with a margin of error below 10° in patients. This is probably less problematic than disi-undercorrection, which is often encountered in the conventional midcarpal fusion techniques. In the coronal plane we created more often a varus position compared to the planned position but also within a 10° limit in patients. Axial rotation appeared to be the most difficult parameter to control and deviations measured up to 23° in both directions. Malrotation of the capitates in pronation relative to the lunate was slightly more common than supination. The clinical importance of this amount of malrotation is unclear.

Conclusions: CA-3CA is clearly different from the conventional midcarpal fusion techniques. The results of this pilot study indicate that it is indeed a controlled and standardized technique which allows to reproduce the ‘optimal’ capitolunate fusion position in vivo with a high level of accuracy. Proof of possible clinical gains is the subject of ongoing clinical trials.

References

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