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Original article

## Effect of four-corner fusion with locking plate without bone graft on functional recovery of the wrist: New treatment guidelines

*Bénéfice fonctionnel d'une arthrodèse des quatre os par plaque avec vis verrouillées, sans apport d'autogreffe sur la récupération fonctionnelle des patients. Essai d'une nouvelle ligne thérapeutique*

A. Tielemans<sup>a,b,\*</sup>, F. Van Innis<sup>a</sup>, S. Troussel<sup>a</sup>, C. Detrembleur<sup>c</sup>, X. Libouton<sup>b,c</sup>, T. Lequint<sup>a</sup>

<sup>a</sup> Grand hôpital de Charleroi, Department of Orthopedics, Grand-Rue 3, 6000 Charleroi, Belgium

<sup>b</sup> Cliniques universitaires Saint-Luc, Department of Orthopedics and Traumatology, Avenue Hippocrate 10, 1200 Brussels, Belgium

<sup>c</sup> Université catholique de Louvain, institut de recherche expérimentale et clinique (IREC), pôle Computer-Assisted Robotic Surgery (pole CARS), 53, avenue Mounier, B15307, 1200 Brussels, Belgium

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### ABSTRACT

We assessed the effect of four-corner intercarpal fusion with locking plate without bone graft on daily activities and pain in patients with stage II and III scapholunate advanced collapse and scaphoid nonunion. Twenty-one patients who underwent four-corner fusion with scaphoidectomy without bone graft were evaluated with the Disabilities of the Arm, Shoulder and Hand (QuickDASH) and Visual Analog Scale (VAS) pain scores before and 16 months after surgery. We also compared postoperative grip strength between the operated and the healthy side. A principal component analysis was used to establish the relationship between functional benefit, immobilization period and number of physiotherapy sessions. We compared our results with published data. VAS and QuickDASH scores improved significantly. Loss of strength was observed postoperatively. QuickDASH score improved the most with a short immobilization period. No significant difference was found relative to the literature for follow-up time, range of motion, grip strength and QuickDASH score. All patients had bone fusion after 1 year. Four-corner fusion with locking plate is a procedure that reduces pain and improves functional scores. Our results are equal to those reported in the literature with bone graft. The union rate seemed high despite the absence of bone graft but was only assessed by x rays. This study allowed us to establish a treatment guideline: a shorter immobilization leads to better recovery.

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### R É S U M É

Nous avons évalué le bénéfice fonctionnel d'une arthrodèse des quatre os médiaux du carpe par plaque avec vis verrouillées sans autogreffe sur les activités de la vie quotidienne et la douleur. Les patients présentaient des stades II et III de collapsus arthrosique sur instabilité scapholunaire ou pseudarthrose du scaphoïde. Vingt et un patients ont été évalués en utilisant le questionnaire Disabilities of the Arm, Shoulder and Hand (QuickDASH) et la douleur par l'échelle visuelle analogique (EVA) avant l'opération et à 16 mois postopératoires. Nous avons évalué la force du côté opéré. Une analyse en composante principale mettait en évidence la relation entre les résultats fonctionnels, la période d'immobilisation, le nombre de séances de kinésithérapie et le délai postopératoire. Nous avons comparé nos résultats à ceux de la littérature avec autogreffe. Les scores EVA et QuickDASH étaient améliorés malgré une perte de force du côté opéré. Une relation inverse a été observée entre la période d'immobilisation et les résultats fonctionnels. Nous n'avons pas observé de différence entre nos résultats et ceux rapportés dans la

\* Corresponding author at: Cliniques Universitaires Saint-Luc, Department of Orthopedics and Traumatology, Avenue Hippocrate 10, 1200 Brussels, Belgium.

E-mail addresses: alexandre.tielemans@student.uclouvain.be, alexandre.tielemans@hotmail.com (A. Tielemans), fernand.van.innis@skynet.be (F. Van Innis), serge-troussel@gmail.com (S. Troussel), christine.detrembleur@uclouvain.be (C. Detrembleur), Xavier.Libouton@uclouvain.be (X. Libouton), Tleq@hotmail.com (T. Lequint).

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littérature. L'arthrodèse des quatre os avec plaque à vis verrouillées est une intervention qui réduit la douleur des patients et les améliore fonctionnellement. Nos résultats ne diffèrent pas de la littérature. Le taux de consolidation est important mais évalué seulement à l'aide de la radiographie standard. Cette étude établit une ligne de conduite thérapeutique : diminuer la période d'immobilisation pour améliorer les résultats fonctionnels des patients.

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## 1. Introduction

Scaphoid nonunion and scapholunate lesions remain common despite improved diagnostic techniques. Neglecting to treat these lesions inevitably leads to degenerative complications in the wrist bones. Often resulting in arthritis, these lesions are painful and gradually lead to a loss of upper limb function [1,2]. Such lesions tend to occur among the working age population. One surgical solution to this problem is scaphoidectomy associated with four-corner fusion (4CF). Various techniques have been described for this procedure, namely arthrodesis with staples, screws, pins or even plate fixation. Plates with non-locking screws have high nonunion rates [3–6]. Scaphoidectomy associated with 4CF and locking screws has good functional results and low non-union rates [7–10]. This same technique, without bone grafting, has not yet been evaluated in the literature.

Our main objective was to assess whether 4CF with locking plate, but no bone graft, can significantly improve patient daily activities and decrease pain. We evaluated the daily activities through the QuickDASH (Disabilities of the Arm, Shoulder and Hand) score and used the VAS (visual analog scale) for pain in 21 patients pre- and postoperatively. The main question in the study was whether the fusion rate was the same as with autograft. We hypothesized that if fusion is achieved in a good position, the presence of a graft does not influence function.

## 2. Patients and methods

### 2.1. Patients

We performed a retrospective study on patients suffering from stage II or III scapholunate advanced collapse (SLAC) and scaphoid nonunion advanced collapse (SNAC), who benefited from scaphoidectomy with 4CF. This procedure was chosen based preoperatively on CT-scan to exclude some unexpected findings during surgery. Diagnosis was based on clinical, radiographic and CT arthrography evaluations [11]. We used the radiological classifications for SLAC and SLAC wrists [12,13]. The study was approved by the Local Ethics Committee and the protocol conformed to the ethical guidelines of the 1975 Declaration of Helsinki. Our study was registered in the clinical trial.gov database (PRS number NCT02355301).

Between 2010 and 2014, two experienced senior surgeons (TL and FV) performed 25 scaphoidectomy with 4CF procedures. We excluded four patients who consulted for revision surgery. Twenty-one patients were included in our study, and all were re-seen by an independent observer (AT, a junior orthopedic surgeon). The analyzed population consisted of nine SNAC-wrist patients, of which five were stage II and four were stage III, and twelve SLAC-wrist patients, of which three were stage II and nine were stage III. Median follow-up was 16 months (range: 12–27 months). The median age of patients was 53 years (range: 28–78 years). The study sample consisted of 15 men and 6 women. The dominant side was operated in 15 of 21 patients.

### 2.2. Surgical technique

Surgical procedures were performed under regional anesthesia with a tourniquet at the base of the limb. The surgical approach

was dorsal, passing between the third and fourth extensor compartments before exposing the joint capsule. A Z-incision was made for capsulotomy according to Herzberg's technique. The area was examined to ensure that the radiolunate joint was in good condition. Scaphoidectomy was done either en bloc or through fragmentation. Joint surfaces between the lunate and capitate, as well as between the triquetrum and hamate, were stripped of cartilage with a lock-off chisel (Luer Classic®). No bone grafting was performed. Dorsal intercalated segment instability (DISI) of the lunate was reduced by a joystick pin and maintained with a temporary pin between the lunate and capitate. The implant used in our study was the 4CF plate with locking screws (Synthes 2.4 mm Variable Angle Locking Intercarpal Fusion System®). It is a circular titanium implant available in different sizes. The size of the plate was chosen as a function of wrist size and the size of the indentation seen under fluoroscopy. Variable angle was locking for stable fixation within 15° in all directions. The low profile circular plate had a smooth surface and rounded edges allowing additional compression of the carpus with the reaming guide if the carpal bones had to be reduced. A detailed description of features and benefits of this implant is given in Table 1.

Locking screws were then placed. Two locking screws were placed in the capitate and lunate; one was placed in the triquetrum and another in the hamate. The surgeon took care to bury the plate to prevent any impingement with the dorsal edge of the radius. The reaming guide received four pins at the extremity, each in a bone, which provides compression before screwing. The carpal height was reduced 2 or 3 mm, corresponding to the cartilage removed. Finally, a last fluoroscopy ensured correct plate positioning and screw length (Fig. 1). The joint was then thoroughly rinsed. The capsule was not sutured to the dorsal edge of the radius so as to prevent a flexion deficit postoperatively. The extensor retinaculum was sutured. The skin was closed with an absorbable suture. A subcutaneous Redon drain was placed, followed by a volar plaster splint.

### 2.3. Postoperative care

Patients received prophylactic antibiotics at 8 and 16 hours postoperatively, the standard treatment at our hand clinic. Analgesia was administered by a catheter for 36 hours; conventional analgesics and anti-inflammatory agents were also administered. Hospital length of stay was 48 hours to manage pain. Before 2015, this protocol was the standard at our hand clinic to

**Table 1**

Features and benefits of the implant used for 4CF with locking plate (2.4 mm Variable Angle Locking Intercarpal Fusion System®, Synthes Implants Belgium).

Features	Benefits
Variable angle locking	Holes allow up to 15° off-axis screw angulation in all directions to adapt to the specific anatomy
Different plate sizes	Address different anatomies
K-wire holes	Allow temporary plate fixation
Low profile circular plate with smooth surface and rounded edges	Reduce the risk of soft tissue irritation
Reduction reaming guide	Allow additional compression of the carpus
Plate holder	For precise plate positioning

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