J Shoulder Elbow Surg (2015) 24, 1197-1205

ELSEVIER

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

A new autocentering hinged external fixator of the elbow: a device that stabilizes the elbow axis without use of the articular pin

Prospero Bigazzi, MD[a,*], Marco Biondi, MD[a], Andrea Corvi, MSc Eng[b], Sandra Pfanner, MD[a], Giuseppe Checcucci, MD[a], Massimo Ceruso, MD[a]

[a]*Department of Hand Surgery and Reconstructive Microsurgery, Azienda Ospedaliero Universitaria Careggi, Florence, Italy*
[b]*Department of Engineering, Università degli Studi di Firenze, Florence, Italy*

Background: Hinged external fixation of the elbow is an important tool for the orthopedic surgeon. It enables early postoperative mobilization that may result in better outcomes. All models require correct alignment with the elbow axis of rotation. There is a long learning curve to this procedure, it may be time-consuming, and it can be associated with a high dose of x-ray exposure. An axial pin can interfere with bone-ligament suture anchors and bone reconstruction plates.

Materials and methods: A new external fixator has been designed and mechanically tested. The hinge has a special gear able to freely align itself with the center of elbow rotation during passive flexion-extension movements. It has been clinically tested on 7 patients affected by traumatic and post-traumatic elbow disorders. The maintenance of the correct position has been tested clinically with computed tomography scans and radiographs.

Results: All patients had correct alignment of the axis of rotation of the external fixator with the axis of elbow rotation. No cases of misalignment, loss of fixation, pin loosening, or instability were found.

Conclusion: A new self-centering hinged external fixator correctly aligns itself with the axis of elbow rotation. It does not interfere with ligamentous reconstruction anchors, distal plates, or screw fixation. The surgical technique is easy to learn and relatively quick. It can also be positioned without performing an arthrotomy to maintain reduction of simple dislocations of the elbow.

Level of evidence: Level IV, Case Series, Treatment Study.

Keywords: External fixator of the elbow; elbow instability; elbow collateral ligament injury; elbow trauma; elbow fracture; elbow dislocation

Hinged external fixation of the elbow has been developed[8] to maintain congruency and stability of both the humeroulnar and humeroradial joints. In 1975, Volkov and Oganesian were the first authors to report, in an English-language journal, an elbow hinged distraction apparatus designed to eliminate "excessive friction between the surfaces, prevent abnormal joint kinematics and allow the newly formed joint surfaces to develop correctly."[20]

Hinged external fixation of the elbow allows active and passive range of motion, taking stress off the ligaments and maintaining articular stability. It enables early and secure postoperative rehabilitation that may reduce stiffness and result in a better final range of motion.[13,18]

*Reprint requests: Prospero Bigazzi, MD, Via del Palmerino n 11, I-50137 Florence, Italy.
E-mail address: pbigazzi@prosperius.it (P. Bigazzi).

1058-2746/$ - see front matter © 2015 Journal of Shoulder and Elbow Surgery Board of Trustees.
http://dx.doi.org/10.1016/j.jse.2015.05.036

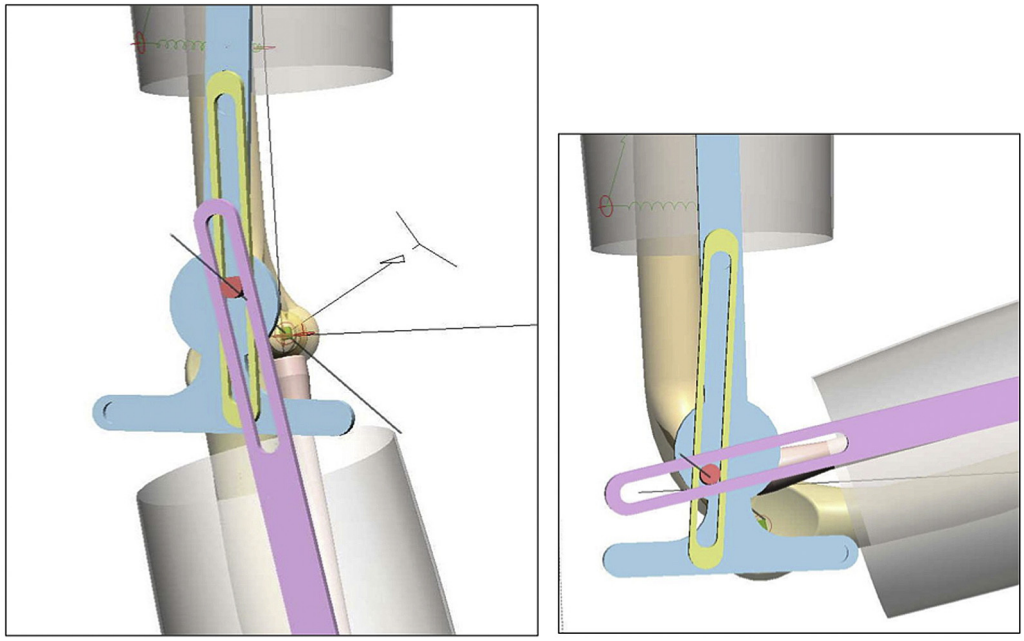

Figure 1 Elbow hinge configurations studied on a 3-dimensional anatomic model created with SolidWorks (Dassault Systèmes, Vélizy-Villacoublay, France) and tested with the physiologic kinematic with visualNastran 4D (MSC Software Corp., Newport Beach, CA, USA).

The clinical indications for elbow external fixation vary from acute instability of "simple" elbow dislocations to complex post-traumatic fracture-dislocations.[4,17] It may be used after complex arthrolysis and interposition arthroplasty of a stiff elbow, in which an extensive release of periarticular soft tissues or excision of heterotopic bone may cause instability.[22] For a distraction purpose, with or without soft tissue interposition, it neutralizes contact forces across the joint, preventing ligamentous contraction.[8] Furthermore, when it is applied in noncompliant patients, it protects ligamentous and bone reconstruction procedures with concentric reduction, allowing early postoperative physical therapy.[1]

Many devices are available with different features and a common surgical step: the positioning of a temporary pin in the center of elbow rotation. This surgical step is technically demanding,[9] as the hinge axis must coincide exactly with the flexion-extension axis of elbow rotation,[16] which passes through the center of the arcs formed by the trochlear sulcus and the capitellum. This axis is internally rotated 3° to 8° with regard to the plane of the epicondyles and forms an angle of 82° to 86° with the axis of the humerus. The axis pin should therefore pass parallel to the trochlea on the anteroposterior x-ray view and appear as a dot through the center of the trochlea from the lateral view. Madey et al[15] reported that a misalignment of 5° caused a 3.7-fold increase in energy expenditure, whereas a 10° mismatch yielded a 7.1-fold increase. Proper placement often requires multiple drilling attempts and fluoroscopic localization, which can be time-consuming and is associated with a steep surgical learning curve.

When an external fixator is first positioned, the hardware can impede ligament reconstruction, making it difficult to use suture anchors. However, the external fixator may also be difficult to apply after ligament reconstruction. In fact, the axial pin should pass exactly through the axis of elbow rotation where the suture anchor or transosseous sutures need to be placed. For these reasons, the application of an external fixator is a crucial step in the surgical treatment of the elbow and must be planned correctly.

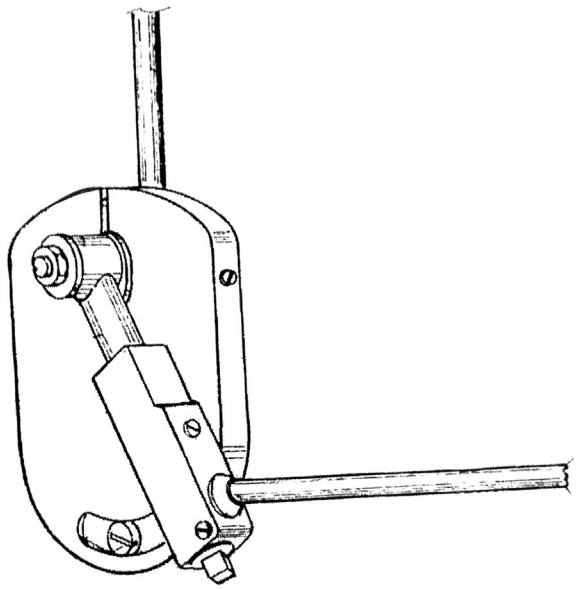

Figure 2 The final design of the hinged elbow external fixator.

We present a new external fixator design with a special hinge that autocenters the axis of elbow rotation, avoiding