

Assessment of Forearm Rotational Control Using Four Upper Extremity Immobilization Constructs

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OBJECTIVES

- Forearm immobilization techniques are commonly used in the management of distal radius, scaphoid, and metacarpal fractures.
- The purpose of our study was to compare the degree of rotational immobilization provided by a sugartong splint (STS), short arm cast (SAC), Munster cast (MC), and long arm cast (LAC) at the level of the distal radioulnar joint (DRUJ), carpus, and metacarpals.

METHODS

- Seven cadaveric upper extremity specimens were mounted to a custom jig with the ulnohumeral joint fixated in 90° of flexion and the humerus and ulna rigidly fixed (Figure 1).
- Supination and pronation of the radius were unrestricted. K-wires were placed in the distal radius, scaphoid, and metacarpals under fluoroscopic guidance to measure the total arc of motion (supination to pronation) referenced to the ulnar fix pin.
- Baseline measurements followed by sequential immobilization with well-molded STS, SAC, MC, and LAC were obtained with 1.25 ft-lbs, 2.5 ft-lbs, and 3.75 ft-lbs of supination and pronation force directed through the metacarpal K-wire. Each immobilization technique was tested three times.
- Digital photographs taken perpendicular to the ulnar axis were used to analyze the total arc of motion.

RESULTS

- Significant differences in rotation among the four immobilization constructs were found at the level of the DRUJ ($P < 0.001$), carpus ($P < 0.001$), and metacarpals ($P < 0.001$) for all deforming torques (1.25 ft-lbs, 2.5 ft-lbs, and 3.75 ft-lbs).
- The most effective constructs in order of greatest to least rotational control were LAC, MC, SAC, and STS.
- Circumferential constructs (SAC, MC, LAC) were superior to the non-circumferential construct (STS).
- Above-elbow circumferential constructs (MC, LAC) demonstrated superior immobilization compared to below-elbow constructs (SAC).
- There were no significant differences in rotational control between the MC and LAC in any conditions tested.

CONCLUSIONS

- Both circumferential and proximally extended immobilization independently provide improved rotational control of the wrist.
- Extending immobilization proximal to the elbow does not confer additional stability.
- Munster cast provides similar rotational control as a long-arm cast, thus allowing the extremity some degree of flexion-extension motion.



Figure 1. En-face view of a cadaveric upper extremity specimen demonstrating external fixation construct with sugartong immobilization, K-wire pin fixation through the scaphoid (white flag), distal radius (blue flag) and metacarpals (unmarked).

Table 1. Total arc of motion allowed by immobilization constructs under 1.25 ft-lbs of deforming torque.

	Sugartong Splint	Short Arm Cast	Munster Cast	Long Arm Cast	P Value
DRUJ	21.2°	17°	4.3°	2.8°	<0.001
Intercarpal	30.6°	19.9°	7.7°	5°	<0.001
Metacarpal	43.9°	27.2°	17.8°	18.8°	<0.001

Table 2. Total arc of motion allowed by immobilization constructs under 2.5 ft-lbs of deforming torque.

	Sugartong Splint	Short Arm Cast	Munster Cast	Long Arm Cast	P Value
DRUJ	38°	27.9°	5.4°	3.8°	<0.001
Intercarpal	53.4°	32.2°	10.3°	8.5°	<0.001
Metacarpal	72.9°	45.3°	26.4°	25.6°	<0.001

Table 3. Total arc of motion allowed by immobilization constructs under 3.75 ft-lbs of deforming torque.

	Sugartong Splint	Short Arm Cast	Munster Cast	Long Arm Cast	P Value
DRUJ	54.2°	38.8°	6.2°	4.2°	<0.001
Intercarpal	74.8°	47.4°	14.3°	13.7°	<0.001
Metacarpal	100.3°	65.2°	32.4°	32°	<0.001

Abbreviations: DRUJ, distal radioulnar joint.