# Balloon Carpal Tunnel-Plasty versus Endoscopic Carpal Tunnel Release: A Cadaveric Assessment of Median Nerve and Compartment Pressure Changes

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## Introduction

Carpal tunnel syndrome is the most common nerve entrapment disease of the upper extremity. Surgical decompression has been accomplished through release of the transverse carpal ligament (TCL), which has historically been achieved through an open approach. Minimally-invasive techniques have been implemented using an endoscope and smaller incisions to minimize morbidity. However, complications associated with transection of the TCL are still numerous, including ulnar nerve neuropraxia, paresthesias, reflex sympathetic dystrophy, superficial palmar arch injury, interdigital lesions, Guyon's canal release, scarring, infection, pillar pain, loss of grip strength, flexor tendon laceration, and hematoma.

Balloon carpal tunnel-plasty (BCTP) is an alternate technique to decompress the median nerve while sparing the TCL. It involves inserting a FDA-approved balloon catheter device (Inflatable Tissue Elevator/Expander, LB Medical, Franklin Lakes, NJ) into the carpal tunnel. This theoretically protects the median nerve by expanding the carpal canal and sparing the nerve. Moreover, it is speculated that wrist biomechanics are preserved by sparing the TCL. The goal of this study was to determine the changes of position of the median nerve within the carpal tunnel, and measure compartment pressures after BCTP alone, BCTP followed by endoscopic carpal tunnel release (ECTR), and ECTR alone.

## Methods

Ten fresh-frozen proximal forearms were prepared. Sonographic position of the median nerve within the carpal tunnel were taken at baseline. A transducer attached to a calibrated pressure gauge was inserted through a small incision 1 cm radial to the intersection of Kaplan's cardinal line and the radial border of the fourth ray. The incision was sealed with n-butyl cyanoacrylate. The transducer was calibrated until a baseline pressure was recorded (Fig. 1).

For five specimens, BCTP was performed followed by ECTR. A 1 centimeter incision was made at the level of the volar wrist crease in line with the fourth ray. The carpal tunnel was identified after dissection, the synovial tissue was cleared, and the balloon catheter was inserted into the canal. The balloon was inflated to 10 atmospheres of pressure and deflated for a total of three cycles. The position of the median nerve was visualized with video ultrasound and compartment pressures were recorded before and after each inflation. The balloon was then removed, and the compartment pressures were re-calibrated. Next, a two-portal ECTR was performed with the Chow technique. An exit portal was made 1 cm proximal to the intersection of Kaplan's cardinal line and the radial border of the fourth ray. The incision for the balloon was used as the entry portal for the endoscope. The slotted cannula was inserted through both portals, and the endoscope was used to visual the fibers of the TCL. A sequence of cuts in an anterograde and retrograde fashion was used to cut the TCL until release was complete. Ultrasound measurements and compartment pressure changes were recorded before, during, and after ECTR. For the remaining 5 specimens, ECTR was performed in isolation without BCTP using the two-portal ECTR Chow technique. An identical sequence of procedures was conducted excluding the BCTP.

Ultrasound images were analyzed using Kinovea software (Fig.2). Statistical analysis was performed with paired two-tailed Student's t -test for changes from baseline for ultrasound and pressure data within each cohort. Individual paired two-tailed Student's t-test was used for comparisons between each cohort as well.

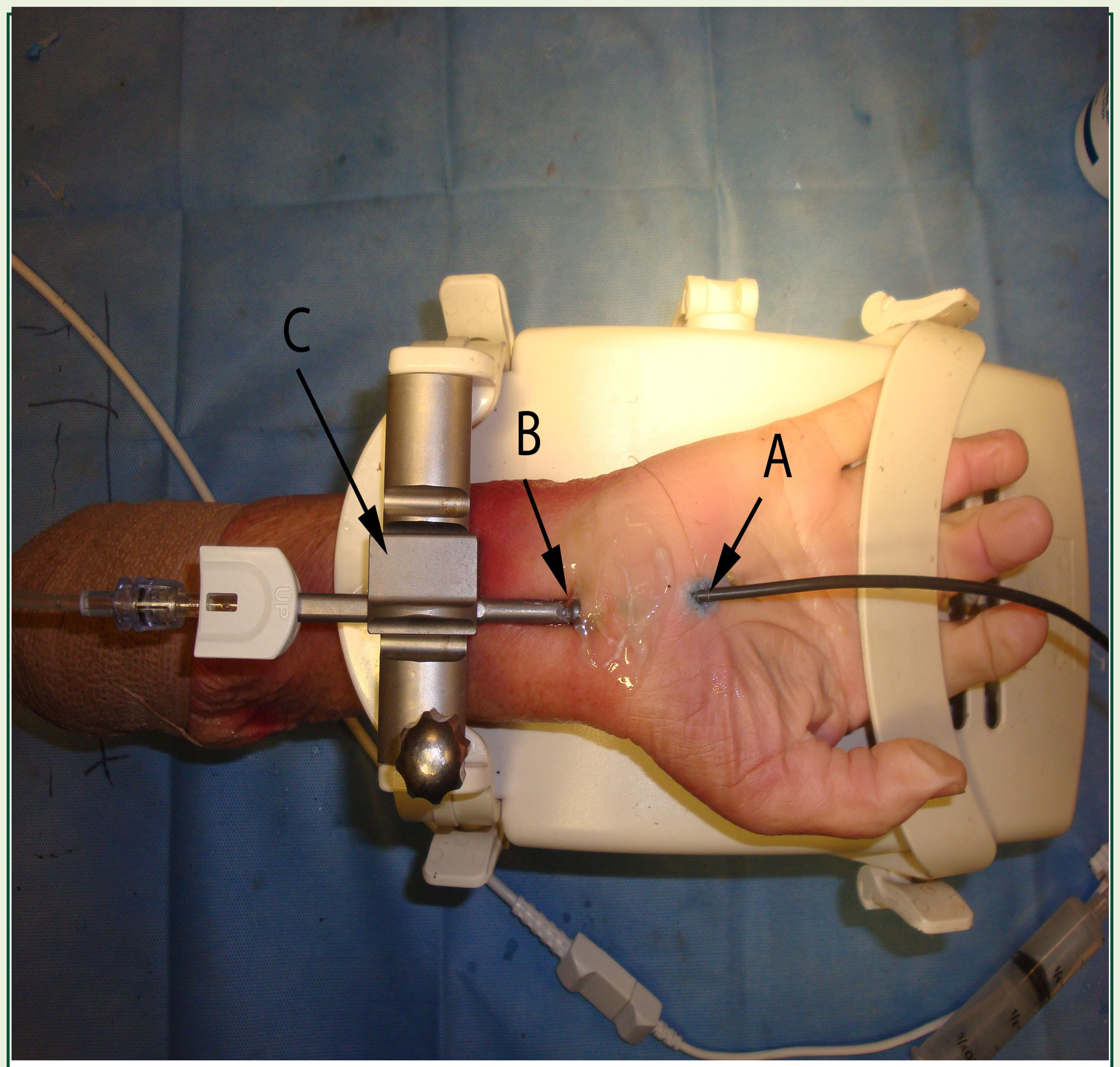


Figure 1: Calibration prior to BCT A. Transducer. B. Balloon cannula . C. Custom hand device to secure and guide the catheter.

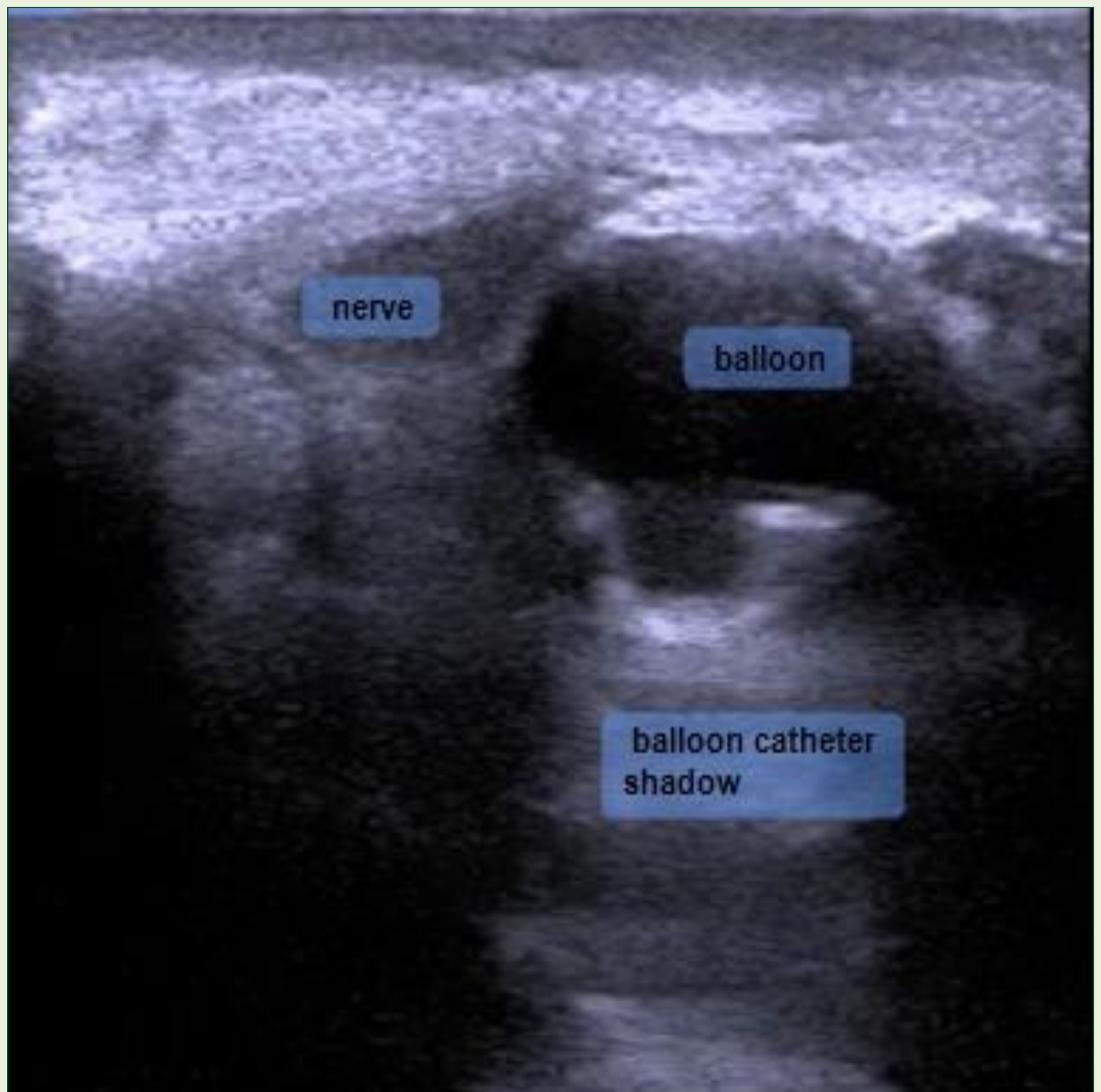


Figure 2: Ultrasound picture analysis of median nerve positioning relative to the balloon catheter.

## Results

All groups increased median nerve displacement (51.6% BCTP, 102.0% BCTP+ECTR, 31.9% ECTR). No one procedure was significantly more effective than any other. There was a mean 0.47 mm increase in distance from the cutting probe to the median nerve with BCTP compared to without BCTP ($p=0.67$). Compartment pressures dropped after each procedure (86.7% BCTP, additional 27.9% BCTP+ECTR, 32.1% ECTR). BCTP+ECTR was more effective at reducing pressure than ECTR in isolation ($p=0.024$). (Fig 3,4)

## Discussion

The results indicate that both BCTP and ECTR increase carpal tunnel dimensions and decrease compartment pressures. However, there is a more dramatic expansion and drop in pressure when both techniques are combined 102.0%. Balloon carpal tunnel-plasty creates an expansion of carpal canal volume, as indicated by a 51.6% increase in displacement (palmar and ulnar) of the median nerve from baseline in our study. Li et al developed a geometrical model of the TCL to elucidate this further. After gradual application of a palmar directed force to the TCL, arches formed with a subsequent increase in carpal canal cross-sectional area. This study's results are in concordance with this model, as the median nerve displacement increased with each iteration of the balloon expansion prior to ECTR.

## Significance

This cadaveric study provides data that validates BCTP as a technique to decompress the median nerve. Further studies will focus on clinically correlating the degree of decompression achieved with BCTP to symptomatic reduction in patients.

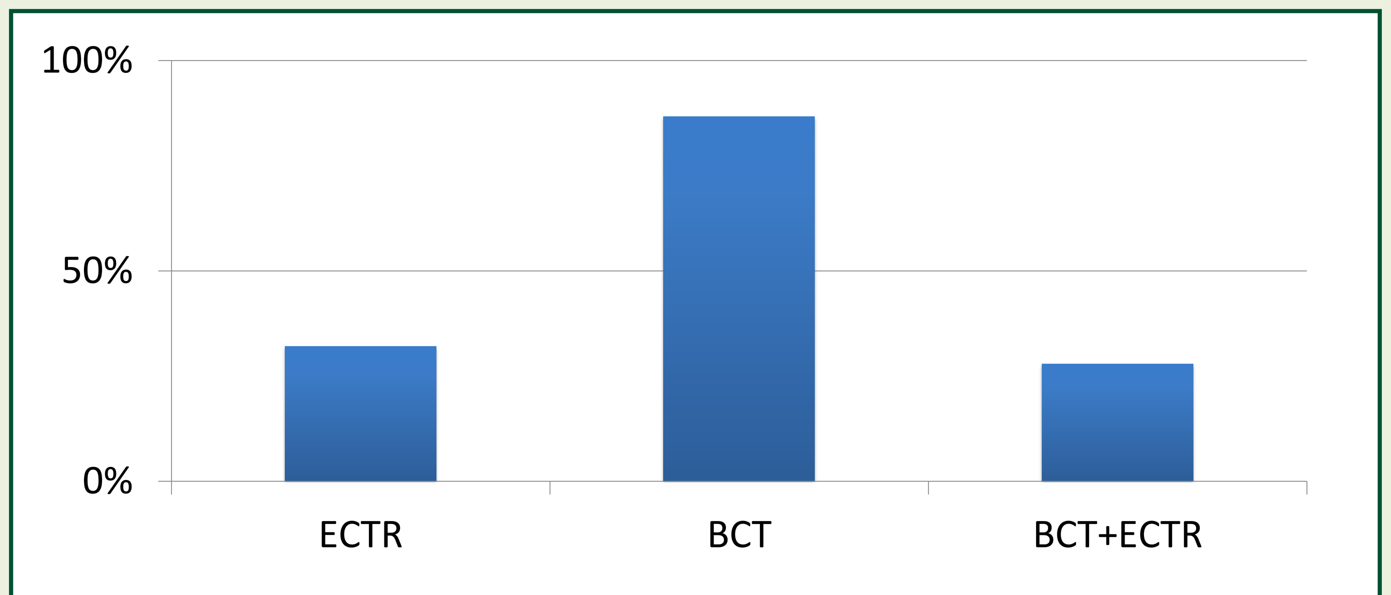


Figure.3: Percent Reduction in Compartment Pressures from Baseline

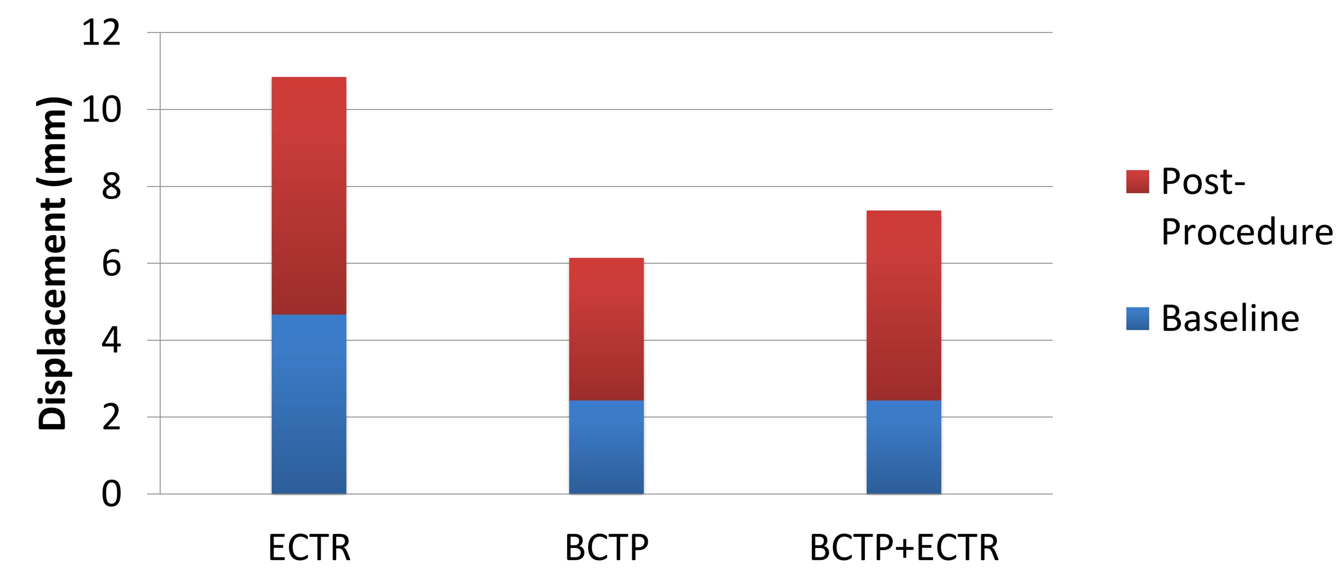


Figure 4: Changes in Median Nerve Displacement