# Investigation of Distal Radius Fracture due to Fall on Out-stretched Hand and Evaluation of Protection with Wrist Guards

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## Abstract

*Hypothesis: Wrist sprains and fractures are common in "extreme" sports such as snowboarding, skateboarding, and in-line skating. Wrist guards are effective at reducing incidence of fracture, with large epidemiologic studies showing up to 85% injury reduction in snowboarders. We hypothesized that a prototype wrist guard that relies on viscoelastic foam for energy absorption will compare favorably to commercially available volar and volar/dorsal rigid support wrist guards in cadaver impact testing.*

*Methods: Eight matched-pair fresh-frozen cadaver forearms were potted at the proximal radius and ulna and positioned vertically in a custom-made drop test apparatus with the wrist preloaded in extension. The arms were impacted by a 45 kg weight dropped from 0.8 – 2.5 cm height, based on a calculated non-destructive load of 30% of the anticipated fracture load. In alternating order, each arm was tested with a rigid volar, rigid dorsal and volar and viscoelastic prototype wrist guard. The prototype was constructed from a fingerless glove with 15mm thick viscoelastic pad (Poron XRDMA 15374-65) centered over the base of the palm and a 1/16" thick molded orthoplast cover. Impact force was measured using two load cells, one at either end of the forearm. The displacement and acceleration of the load transfer plate were measured with a string potentiometer and an accelerometer, respectively. Distal radius and ulna strains were measured with strain gage rosettes. After a battery of non-destructive tests, two matched pair arms with either prototype or rigid volar wrist guard were tested to failure using 15 cm drop height. Bone fracture in the wrist area was visualized using high speed x-ray photography at 1000 fps.*

*Results: Non-destructive axial force time histories revealed, for the prototype, near constant force over the first 50 ms during which the foam was being compressed, compared to a gradual and curved response for the rigid guards. This indicates the prototype reacts quicker and has higher, more controllable energy absorption capability compared to the rigid guards. Maximum axial force absorbed by the guard was higher in the prototype (1.24 kN) compared to the volar (1.05 kN) and volar/dorsal (1.02 kN) guards, though this was not statistically significant (p=0.64). Maximum principal strain in the distal radius metaphysis for the volar guard and the*

*volar/dorsal guard were 3.6 times ($p=0.09$) and 1.4 times ($p=0.09$) that of the prototype respectively, indicating greater deformation of the radius and more susceptibility to failure using the rigid guards. The destructive force for both wrist guards was approximately 2.5 kN ($p=0.35$). High speed video revealed that axial compression of the carpus and not hyperextension of the wrist is the main reason for failure. The volar splint tended to slip down the arm and appeared to distribute load to the forearm.*

*Summary Points: A prototype wrist guard incorporating a viscoelastic cushion was shown to be equally to more effective than commercially available rigid guards at absorbing load and reducing forearm strain in non-destructive tests.*
*This research provides the basis to optimize the prototype guard design to perform effectively in both non-destructive and destructive tests.*