An Analysis of Grip Design for Manual Hammer Stapling Tool

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Abstract:

Three commercial hammer stapling tools with comparable length and magazine size, but with progressively improved design of grip, were evaluated in this study. The grips of Tools#1&2 were made from plastic and had a rectangular cross section. While Tool#1 had serrated grooves to prevent sliding within the grip, Tool#2 grip was more rounded, smooth, and had raised sections at the two ends to prevent sliding. The grip of Tool#2 also had shields to preventing accidental pinching of fingers during tool strike. Tool#3 grip was formed with compressible rubber and had an oval cross-section. The thickness of grip increased along its length that conformed to the human grip shape. This shape restricted the tool sliding within the grip. Unlike Tool #1 & 2, the grip axis of Tool#3 had a 10 degree bend from the tool axis, which was intended to reduce the wrist deviation during impact, and provided a clearance to prevent accidental pinching during tool strike.

A 6x4-feet platform, fabricated with roofing grade plywood, was adjustable to two slopes commonly found in residential roof pitches. Sixteen male participants stood on this platform and stapled roofing paper at a rate of 1Hz for two minutes. Six experimental trials were completed by each participant, involving three tools and two roof pitches, in a randomized order. An electrogoniometer recorded the wrist deviation angles at a rate of 50 Hz. Surface electromyographic activities (EMG) of the Biceps Brachii, Extensor Radialis Longus, and Flexor Carpi Ulnaris muscles were recorded at 1000 Hz. Participants rated their body discomforts, and rated each tool in terms of ease of use, grip comfort, and safety quality in protecting from accidental injury in a 0-10 subjective scale.

A 2-factor repeated measure analysis of variance model was employed, and the significant differences ($p<0.05$) of the means were as following. Tool#3 produced less ulnar deviation than the other two tools, and the smaller roof pitch produced less radial deviation. Tool#3 produced less EMG from Flexor Carpi Ulnaris as compared to that of the other two tools. Tool#2 produced less EMG from Extensor Radialis

Longus compared to that of the other two tools. The mean discomfort scores of Tool#3 were less than Tool#1 in fingers and upper back. The rating of ease of use for Tool#3 was better than Tool#2 and Tool#1. The grip comfort rating and safety quality rating of Tool #2 & #3 were rated better than Tool#1.

In stapling operation, the ulnar deviation and the Flexor Carpi Ulinaris activity maximize at the instant of tool strike, when the wrist is subjected to the impact load. The Tool#3, with bent handle and with most favorable ergonomic grip design, reduced both the above parameters, which should synergistically reduce tendon inflammation potential in the carpal tunnel. The ratings of body discomfort, grip comfort, ease of use and safety quality, largely showed positive correlations with the implementation of ergonomic measures for improving the grip efficiency. The results of this study demonstrated that ergonomic grip design enhanced comfort and usability and reduced the risk of musculoskeletal injury of wrist.