Crush Injuries to the Forefoot

John Y. Kwon, MD

Effect of a Steel Toe Cap

Crush injuries to the foot are a common workplace injury, causing significant morbidity, disability and lost wages. A report by the Bureau of Labor Statistics estimated that more than 60% of workplace injuries involve the musculoskeletal system, and 10% of these are foot and ankle injuries.\(^1\)

Regulatory bodies like the Occupational Safety and Health Administration (OSHA) were developed to protect the workforce and to establish guidelines to improve work conditions and safety standards. Since OSHA’s inception in 1971, occupational injury and illness rates have declined 40% while the American workforce has nearly doubled. However, while the total number of days lost from work due to occupational injuries has declined, the percentage of foot and ankle injuries has remained relatively constant.

Although steel toe capped boots are commonly accepted as a protective measure, there are no published data about the protection afforded by a steel toe. There is a common belief that a significant crush injury sustained while wearing steel toe capped boots results in amputations of the toes and that not wearing them may be safer. This belief is so pervasive that a popular television show, Myth Busters, investigated this.\(^2\) We studied the influence of the steel toe cap on injury pattern after a crush injury to the forefoot.\(^3\)

Methods

Five paired cadaver lower extremities were used for the study. The feet were measured and fitted into a corresponding size 9 work boot. Five pairs had a steel toe cap (ANSI Z-41 & ATSM 2315 compliant), while five corresponding pairs did not. One foot from each matched pair was fitted into a steel toe capped boot while the other foot was fitted into the regular work boot.

We constructed a custom jig to provide a reproducible crushing mechanism with a total weight of 150 lbs.

Each specimen was placed with the boom centered on the proximal edge of the steel toe cap. The boom was raised 3 feet and released to crush the cadaveric foot. X-rays were obtained to assess for fracture location and comminution. Stress fluoroscopy was performed to assess for any ligamentous Lisfranc injury.

Results

Overall, the feet in the regular work boots averaged 8.2 fractures per foot while those protected in the steel toe boot averaged 3.6 fractures per foot. The steel toe boot had fewer metatarsal and toe fractures and less comminution to the bone. There were no bony nor ligamentous Lisfranc injuries. There were no traumatic amputations nor open fractures produced.

OSHA has recommended the use of safety shoes in certain occupations, which must meet the American National Standards Institute (ANSI) minimum compression and impact performance standards. ANSI has established testing and performance criteria for footwear safety and has standardized the impact and compression resistance characteristics of steel toe capped boots. The ANSI test-
ing consists of a steel weight weighing 50 lbs (±0.5 lbs) dropped from a height of 3 feet.\textsuperscript{5,6}

Conclusions

In our study we tripled this weight to ensure the creation of fractures in our non-protected specimens and to elucidate the protective nature of the steel cap. Even when tripling the weight used by the ANSI protocol we found no toe amputations nor complete failures of the steel toe cap.

Although steel toe capped boots are commonly accepted as a protective measure, there are no published data about how protection afforded by a steel toe influences foot fracture epidemiology. This study demonstrated that the steel toe protects the foot from crush injuries, limiting the number and severity of forefoot fractures. However, the steel toe cap does not fully protect the forefoot from injury and in addition to the use of safety shoes, strict adherence to workplace safety standards may limit the severity of crush injuries to the foot.

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Bibliography

2. MythBusters, Episode 42, Discovery Channel: November 9, 2005

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In Memoriam

Edward "Teddy" Kim
September 3, 1984 - April 6, 2012
We are saddened to report the passing of our friend and former colleague, Teddy Kim, who recently passed away after a yearlong battle with leukemia. Teddy worked with us as a research assistant during his junior and senior years at Boston College. He will be missed.

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