D48 The Quantification and Time Effects of Bruises Created Using a Drop Mass System

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The goal of this presentation is to educate attendees on the effects that mass and impact velocity have on the duration and color of bruises created on the forearms of volunteers.

The impact of this research to the forensic community lies in its ability to build a scientific basis for a bruise classification and a better understanding of bruising biomechanics. These findings will assist emergency room physicians in determining cases of possible physical abuse.

Existing literature contains conflicting information regarding the color changes in bruises with respect to time. There is general agreement that the first colors seen are usually deeper reds, black and blue. Yellow is generally not seen for the first 18-24 hours, but after that, any color may be present. It follows that deeper tissue bruises will remain darker, longer. It is hypothesized that a lighter, faster impactor will create a bruise that will begin to resolve more quickly and the colors will be lighter.

The relationship between mass, velocity and bruise characteristics has not been explored in any published literature. Specifically of interest is the affect that impact velocity has on bruise area and bruise color when the impact is controlled for constant impact energy. It is hypothesized that a faster lighter impactor will create a bruise with a larger surface area than a slower heavier impactor.

Preliminary data was collected using a drop mass system. Seven healthy adult volunteers age 23.3 +/- 3.2 years completed an initial questionnaire to screen for bleeding disorders and blood thinning medications. Informed consent was garnered and each subject had both forearms photographed (Canon EOS Digital Rebel XT, Lake Success, NY.). Prior to impact, tri-stimulus light reflectance was also measured using a commercially available colorimeter (model CR-400, Konica Minolta, Mahwah, NJ.) Tri-stimulus light reflectance was reported using the three dimensional CIE 1976 (L*, a*, b*) color space, where L* represents luminance (0 = black, 100 = white), a* represents the shift from magenta to green (green is indicated with negative values, red with positive values) and b* represents the shift from yellow to blue (blue is indicated with negative values, yellow with positive values).

The drop mass system was designed to deliver a constant 19.6 Joules of energy by dropping a steel mass down a PVC tube onto an impactor resting on the forearm of the subject. Two conditions were tested: low velocity, high mass and high velocity, and low mass. The low velocity, high mass consisted of a 2 kg mass being dropped from 1 meter resulting in a velocity of 4.4 m/s. The high velocity, low mass consisted of a 1 kg mass being dropped from a 2 meter height resulting in a velocity of 6.3 m/s. A load cell (model SPL 7187, Syscon Instruments Private Ltd., Bangalor, India) was placed under the volunteers' forearms to measure the amount of force transmitted through the forearm. Load data was collected at 10000 HZ using TDAS (Diversified Technical Systems, Seal Beach, Ca.) and displacement of the impactor was measured using high speed video at 1000 frames per second (model HG 100K, Redlake Inc., Tucson, AZ).

Volunteers were subjected to both impacts, one to each arm, based on randomization. Photographs were taken and light reflectance was measured immediately following the impacts and then every 24 hours for 96 hours. Each day, all three values of the tri-stimulus were recorded for both arms and compared to the pre-test values. Observation showed the forearms were visibly more red immediately following low velocity impact and this was confirmed by higher a* values for the low velocity impact between the pre-test and immediate post-test scans. Values at 72 and 96 hours for the a* values were significantly lower or more green (9.68 +/- 1.24, and 8.82 +/- 1.59 respectively) than the pre-test values (10.08 +/- 1.36) for the same arms ($p<0.05$). The initial increase in red comes from the inflammation response with the increase in green due to the metabolism of bilirubin, a metabolite of hemoglobin which is found when blood cells are lysed.

Table1 – a* values measured every 24 hours

Test Condition	Pre-test	0 hours 11.02+/-	24 hours
Low Velocity	10.08 +/- 1.36	1.05	10.04 +/-1.25
High Velocity	9.61+/-1.49	10.42+/-0.87	9.52+/-1.35
Test Condition	48 hours 9.85+/-	72 hours 9.68+/-	96 hours 8.82+/-
Low Velocity	1.28	1.24†	1.59†
High Velocity	9.61+/-1.14	9.33+/-1.57	9.01+/-1.15

† Statistically significant compared to pre-test values ($p<0.05$)

Bruising, Contusion, Impact Velocity

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