Short Commentary

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# Clothing Increases the Risk of Indirect Ballistic Fractures: A Short Commentary

**Kieser DC***

Orthopaedic Registrar Surgical Sciences, Orthopaedic Surgery, Health Sciences, Dunedin School of Medicine, University of Otago, New Zealand

***Corresponding author:** Dr. David C Kieser, Orthopaedic Registrar Surgical Sciences, Orthopaedic Surgery, Health Sciences, Dunedin School of Medicine, University of Otago, New Zealand, E-mail: kieserdavid@gmail.com

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## Commentary

Gunshot injuries are common with over 500,000 people being killed and 1.5 million injured annually [1]. Around 45% of gunshot injuries present with a fracture [2,3].

Most ballistic fractures occur from direct contact of the projectile with the bone. However, indirect ballistic fractures occur when the projectile does not directly contact the bone [4,5]. In this injury the fracture occurs because of distortion of the bone beyond its fracture limit by the enlargement of the temporary cavity [5].

Because these fractures are caused by the temporary cavity, the closer the cavity to the bone, the more likely indirect fractures will occur [4,5]. Similarly, the larger and more aggressive the temporary cavity expansion, the more likely an indirect fracture is to occur [4,5].

Clothing acts as an interface to deform and deflect a bullet, making it yaw or fragment, both of which result in a larger and more superficial temporary cavity [6]. While no statistics are available, one may presume that a significant proportion of victims are shot through clothing.

The purpose of this study was therefore to assess the effects of clothing on the development of indirect fractures.

In this study, the authors used 23 adult female red deer rear femora embedded in 20% 250B ballistic gelatine. Red deer femora have been validated as comparable to human femora for the purposes of biomechanical testing [7]. The samples were shot in an anterior to posterior direction in relation to the bone with varying distances off the bone utilising a 5.56 x 45 mm (NATO SS109) bullet fired from 10 m. While the authors also assessed the effects of mould size, the emphasis was on clothing with 13 moulds unclothed, 6 with a single layer of denim and 2 with a double layer of denim.

The results showed that clothing resulted in a significantly larger temporary cavity (average maximal diameter of 150 mm (130-200 mm) and an average volume of 3710 $cm^3$ (2790-6600 $cm^3$) for a single layer and an average maximal diameter of 160 mm (150-170 mm) and an average volume of 3720 $cm^3$ (3220-4220 $cm^3$) in contrast to an average maximal diameter of 140 mm (110-200 mm) and an average volume of 1,640 $cm^3$ (900-4390 $cm^3$) for unclothed samples [6]. Furthermore, clothing resulted in a more superficial temporary cavity, commencing at 20 mm in contrast to 100 mm for the unclothed samples [6].

This corresponded to fracture occurring with bullet passage up to 20 mm off the bone in the clothed samples in contrast to 10 mm in the unclothed samples. In addition, at bullet passage of 10 mm off the bone, the clothed samples had significantly more bone comminution than the unclothed samples [6].

The authors conclude that clothing increases the risk of indirect fracture and results in larger, more superficial temporary cavities, than are seen in unclothed specimens [6]. They also comment on the size of the mould and recognise that a thinner mould prevented a larger temporary cavity to form and thus did not cause indirect fracture within these samples [6]. They hypothesise, that this is the reason why the humerus is seemingly spared from indirect ballistic fractures [6,8]. While small numbers and a simplistic model limit this study, it offers an excellent understanding of this complex injury and clearly demonstrates that clothing increases the risk of indirect ballistic fractures with this specific bullet type shot at 10 m.

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