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Optimising ballistic facial coverage from military fragmenting munitions: a consensus statement

J. Breeze^{a,b,*}, D.C. Tong^c, D. Powers^d, N.A. Martin^{a,e}, A.M. Monaghan^b, D. Evriviades^b,
J. Combes^f, G. Lawton^g, C. Taylor^h, A. Kay^b, J. Baden^b, B. Reedⁱ, N. MacKenzie^j,
A.J. Gibbons^k, S. Heppell^j, R.F. Rickard^{a,h}

^a Academic Department of Military Surgery and Trauma, Royal Centre for Defence Medicine, Birmingham, UK

^b Queen Elizabeth Hospital Birmingham, UK

^c University of Otago, Dunedin, New Zealand

^d Duke University Medical Center, Durham, USA

^e St Andrews Centre for Plastic Surgery and Burns, Chelmsford, UK

^f Royal Surrey County Hospital, Guildford, UK

^g Imperial College London, UK

^h Defence Medical Group (SW), Derriford Hospital, Plymouth, UK

ⁱ Australian Airforce Reserve, John Hunter Hospital, Newcastle, Australia

^j Queen Alexandra Hospital, Cosham, Portsmouth, UK

^k Peterborough District General Hospital, Peterborough, UK

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Abstract

VIRTUS is the first United Kingdom (UK) military personal armour system to provide components that are capable of protecting the whole face from low velocity ballistic projectiles. Protection is modular, using a helmet worn with ballistic eyewear, a visor, and a mandibular guard. When all four components are worn together the face is completely covered, but the heat, discomfort, and weight may not be optimal in all types of combat. We organized a Delphi consensus group analysis with 29 military consultant surgeons from the UK, United States, Canada, Australia, and New Zealand to identify a potential hierarchy of functional facial units in order of importance that require protection. We identified the causes of those facial injuries that are hardest to reconstruct, and the most effective combinations of facial protection. Protection is required from both penetrating projectiles and burns. There was strong consensus that blunt injury to the facial skeleton was currently not a military priority. Functional units that should be prioritised are eyes and eyelids, followed consecutively by the nose, lips, and ears. Twenty-nine respondents felt that the visor was more important than the mandibular guard if only one piece was to be worn. Essential cover of the brain and eyes is achieved from all directions using a combination of helmet and visor. Nasal cover currently requires the mandibular guard unless the visor can be modified to cover it as well. Any such prototype would need extensive ergonomics and assessment of integration, as any changes would have to be acceptable to the people who wear them in the long term.

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* Corresponding author.

E-mail address: johnno.breeze@gmail.com (J. Breeze).

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Introduction

Facial injuries in combat

Facial injuries sustained in combat were responsible for appreciable morbidity among United Kingdom (UK) forces between 2001 and 2014 during the conflicts in Iraq and Afghanistan.¹ During this period, most injuries were caused by energised fragments, with a smaller proportion (18% - 20%) from high velocity gunshot wounds.² The energised fragments usually originated from devices planted in the ground, with the pressure plate or command-operated Improvised Explosive Device becoming the signature weapon later in these conflicts.³ The vertical blast component drives projectiles upwards, with those structures of the face that project out the furthest (nose, chin, and lips) being at greatest risk.¹

Development of facial protection

Modern military personal ballistic protection began with the helmet and body armour vest; pieces of equipment that sought to prevent death.⁴ Helmets have always provided a degree of cover to the upper face, but their primary requirement is to protect the brain.^{5,6} It has long been recognised that cover of the remaining face is an important consideration for the prevention of long term morbidity in terms of function, aesthetics, and social interaction.⁷ The introduction of ballistic eyewear to British forces in 2006 was the first type of personal armour that was designed purely to prevent morbidity rather than mortality,⁸ and has been completed more recently by the anogenital cover provided by pelvic protection.⁹ The introduction of ballistic spectacles and goggles recognised that damage to one or both eyes would immediately incapacitate a soldier, but would also have a long-term adverse effect on quality of life. Ballistic eyewear has subsequently been issued to all those UK service personnel deployed on operations, and has resulted in a halving of the incidence of eye injuries sustained in Afghanistan.⁸ A considerably revised neck collar was introduced in 2013, with the primary aim to reduce mortality from neurovascular injury to the head and neck.¹⁰ However, the projection of the collar from the vest also provides a degree of protection of the face from projectiles that originate from the ground. Surface wound mapping at the end of these conflicts illustrated the need to cover the remaining face under certain tactical circumstances, with early trials of the visor and mandibular guard showing that they were acceptable to potential users.⁷

VIRTUS

Modern soldiers need to be adaptable to changing battlefields and ever-evolving contingency operations, so the VIRTUS personal armour system has been issued to the UK Armed Forces since September 2015 and will gradually replace the current OSPREY system.⁶ Facial protection is now modular,



Fig. 1. A British soldier taking “top cover” on the outside of an armoured vehicle wearing the helmet, visor, and mandibular guard of the VIRTUS armour system. The patrol neck collar has been temporarily rolled down at a time of low threat to improve dissipation of heat.



Fig. 2. The helmet in the VIRTUS system can be used with either a visor, mandibular guard, or both. Potential modifications include an additional component for the bottom of the visor to cover the nose when the mandibular guard is not worn.

and a new shape of helmet is worn in conjunction with ballistic eyewear (spectacles or goggles), a visor, and a mandibular guard (Fig. 1). This system enables different components of the face to be protected under certain circumstances. When all four components of the facial protection system used in VIRTUS are worn together, the face is completely covered. However the heat, discomfort, and weight of wearing all four components are likely to be unacceptable to soldiers in some combat roles. Potential modifications include covering the nose with the visor (Fig. 2), or extending the helmet inferiorly at the sides to cover more of the ears.

Facial subdivisions into functional units

One way to prioritise protection of the areas of the face in terms of morbidity is to divide it into aesthetic units (Fig. 3). Such an approach is internationally recognised by surgeons as a guide for reconstruction.¹¹ For example, crossing the boundaries between aesthetic units is known to produce less favourable outcomes than keeping both the resection, and the tissue used to reconstruct it, within the same aesthetic unit.¹² Tissue loss from some particular aesthetic units is harder to reconstruct than others, and this is most commonly seen when doing a reconstruction for a patient after a resection for cancer. The nose and ears are particularly difficult, and in some cases prostheses provide better cosmetic outcomes than reconstruction.¹³ Although this may be more acceptable

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