



## The association between healed skeletal fractures indicative of interpersonal violence and alcoholic liver disease in a cadaver cohort from the Western Cape, South Africa



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### ABSTRACT

Interpersonal violence (IPV) and heavy alcohol consumption are major problems in the Western Cape Province of South Africa. Cranio-maxillofacial fractures, particularly nasal and zygomatic bone fractures, as well as isolated radial fractures (Colles fractures) and ulnar shaft fractures (parry fractures), are indicative of IPV, while alcoholic liver disease (ALD) is the consequence of chronic alcohol abuse. We therefore aim to investigate whether a significant association exists between the prevalence of cranio-maxillofacial fractures and parry fractures and ALD in a Western Cape population. Embalmed cadavers ( $n = 124$ ) used for medical students' anatomy training at the Division of Anatomy and Histology, Faculty of Medicine and Health Sciences, Stellenbosch University were studied. The cadavers were dissected according to departmental protocol. The liver of each cadaver was investigated for macroscopic pathology lesions. Tissue samples were removed, processed to wax, and sectioned and stained with hematoxylin and eosin (H&E). All soft tissue was removed from the skulls, radii, and ulnae, which were then investigated for healed skeletal trauma. The results showed 37/124 (29.8%) cadavers had healed cranio-maxillofacial fractures and 24/124 (19.4%) cadavers had morphologic features of ALD. A total of 12/124 (9.7%) cadavers showed signs of both ALD and healed cranio-maxillofacial trauma. More males were affected than females, and left-sided facial fractures were statistically more common compared to the right side. This study illustrated a significant trend between alcohol abuse and cranio-maxillofacial fractures in individuals from communities with a low socio-economic status (SES) where IPV is a major problem.

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### Introduction

Trauma is not only a major global health problem with significant morbidity, but also has a profound impact on the health systems and socio-economic cost to society (Alvi, Doherty, & Lewen, 2003; Lee, Snape, Steenberg, & Worthington, 2007). South Africa has a high burden of violent injury, with interpersonal violence (IPV) being the leading cause of premature death among the South African male population (Groenewald, Msemburi, Morden, & Zinyakatira et al., 2014). In the Western Cape Province of South Africa, IPV is ranked as the third leading cause of death after

retroviral disease (RVD) and tuberculosis (TB), with 8.3% of the total Western Cape population affected (Groenewald et al., 2014).

Because the head is the most exposed region of the human body, cranio-maxillofacial fractures are a common finding among trauma patients (Adeyemo, Ladeinde, Ogunlewe, & James, 2005; Lee et al., 2007; Oji, 1999). While several studies have shown that road traffic accidents (RTA) are mainly responsible for maxillofacial fractures in developing countries (Adeyemo et al. 2005; Lee et al., 2007; Oji, 1999), recent literature from developed countries has demonstrated a shift toward IPV (Alvi et al., 2003; Lee et al., 2007). This is particularly true for the South African population, as IPV has been shown to be the leading etiology of facial fractures (Bamjee, Lownie, Cleaton-Jones, & Lownie et al., 1996). Although the epidemiology of facial fractures is largely dependent on the population studied, IPV and RTA remain the leading causes of facial fractures (Lee et al., 2007). However, injury as a result of the high-speed impact observed during RTA tends to result in more complex

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fractures affecting multiple bones (Lee et al., 2007). Furthermore, Hussain and colleagues (Hussain, Wijetunge, Grubnic, & Jackson, 1994) demonstrated in 950 patients that in accidental falls soft tissue injuries were more commonly observed, while IPV more frequently resulted in craniofacial fractures.

Although the ribs, scapulae, and hands have been implicated as sites for violence-related injuries (Fibiger, Ahlström, Bennike, & Schulting, 2013), fractures to the lower arm, including Colles' and parry fractures, are mostly associated with violent interactions (Martin, Harrod, & Fields, 2010). Females tend to have more fractures on the forearms compared to males, and these fractures have been linked to fending a blow to the head; however, it is likely that not all of these fractures may be the outcome of fending an attack (Alvi et al., 2003). Parry fractures occur when the ulna, which is more exposed than the radius when the arms are raised in a defense position, receives the full force of the blunt force attack (Martin et al., 2010). The resultant injury occurs on the distal part of the ulnar shaft; however, a concomitant radial fracture may occur if the force is excessive (Martin et al., 2010).

Heavy alcohol consumption, particularly in the Western Cape Province of South Africa, is a major problem (Schneider, Norman, Parry, Bradshaw, & Plüddemann et al., 2007). Fetal alcohol syndrome (FAS) is not only one of the most commonly encountered pediatric disorders among the Western Cape population (Schneider et al., 2007), but heavy alcohol consumption also increases the prevalence of infectious diseases, including tuberculosis (TB) and bacterial pneumonia, due to increased host susceptibility to infections (Nelson & Kolls, 2002). Alcoholic liver disease (ALD), another outcome of chronic alcohol abuse, includes a wide spectrum of liver injury and may range from reversible steatosis (fatty liver disease) to irreversible cirrhosis (O'Shea, Dasarathy, & McCullough et al., 2010). Alcohol has also been shown to be a major contributing factor to the increased incidence of IPV (Butchart & Brown, 1991; Parry, 2005) and craniofacial fractures (Lee et al., 2007).

At the Faculty of Medicine and Health Sciences (FMHS) at Stellenbosch University (SU) in the Western Cape, formalin-embalmed cadavers are used for dissection by medical students. Approximately 90% of these cadavers are unclaimed individuals from communities with a low socio-economic status (SES) where overcrowding and alcohol abuse and violence is common.

The majority of research on skeletal fractures associated with IPV in the literature has focused on the epidemiology and etiology in the anthropological and clinical setting (Brink, Vesterby, & Jensen, 1998; Hussain et al., 1994; Judd, 2004; Lee, 2009; Lee et al., 2007; Martin et al., 2010). In South Africa, a variety of studies investigated the incidence and site of fractures (Bamjee, Lownie, Cleaton-Jones, & Lownie, 1996; Butchart & Brown, 1991; Steyn, İşcan, De Kock, Kranioti, Michalodimitrakis, et al., 2010). Little, however, is known about the prevalence of cranio-maxillofacial and upper limb fractures in association with morphological signs of ALD in a South African cohort. As cranial fractures, nasal trauma, and parry fractures are suggestive of interpersonal trauma (Butchart & Brown, 1991; De La Cova, 2010), we aim to find a link between the occurrence of cranio-maxillofacial and upper limb fractures and ALD in a cadaver population from potentially vulnerable communities with a low SES.

## Materials and methods

In South Africa, the National Health Act, No. 61 of 2003 (National Health Act), allows for the use of cadavers, both unclaimed and donated, for medical training and research purposes. Obtaining cadavers for the Division of Anatomy and Histology, Stellenbosch University was done according to departmental protocol, which has

been approved by the Inspector of Anatomy. These cadavers are mostly unclaimed individuals with no medical history and have therefore an unknown cause of death.

Embalmed cadavers ( $n = 124$ ) consisting of 85 (68.5%) males and 39 (31.5%) females, were dissected by medical students at the Division of Anatomy and Histology, Stellenbosch University (SU). The average age was 49.2 years. The anterior abdominal wall was reflected according to the dissection method described in Grant's Dissector (Tank, 2013) and the abdominal organs were photographed *in situ* using a Sony® Cyber Shot digital camera. After removal of the liver, transverse sections at approximately 2 cm intervals were made to inspect the hepatic parenchyma. The macroscopic findings were reported in a customized pathology report and then confirmed by a forensic pathologist. Tissue samples measuring approximately 15 mm × 15 mm were taken from all cadavers, specifically from areas showing macroscopically visible lesions. Samples were processed to wax, sectioned at 5 μm and stained with hematoxylin and eosin (H&E) for histopathological examination. The Zeiss Light Microscope system with the attached Zeiss Axioskop camera was used to observe and photograph the sections.

After the cadavers were fully dissected, soft tissue was removed by trained technical staff at the division. The skeletal remains were placed in a container with water for a minimum of 3 days at a constant temperature of approximately 80 °C for removal of excess soft tissue. An enzyme detergent was added to concomitantly degrease the skull during the heating process. Defatting of bones was achieved using either trichloroethylene or hydrogen peroxide, which are volatile organic compounds. After processing of the bones, the skulls as well as the long bones (radius and ulna) of the forearm of the 124 cadavers were meticulously investigated for any signs of healed trauma. Fractures of the long bones of the forearm were classified according to site and appearance. Scaled photographs were taken with a Nikon® P520 camera to illustrate the healed trauma.

Statistical tests included cross-tabulation analysis and Fisher's exact tests. The latter was used as an alternative to the chi-squared test due to the small sample size and was performed by a statistician using Statistica® Version 12.0 (StatSoft Inc., 2014, USA). Figures were created using Paint (Microsoft Corporation 2014, USA).

Ethical clearance for this project was obtained by the Health Research Ethics Committee (HREC) of Stellenbosch University, which conforms to the principles defined in the 2013 Declaration of Helsinki.

## Results

### Cranio-maxillofacial trauma

#### Craniofacial distribution

Healed cranio-maxillofacial fractures were observed in 37/124 (29.8%) cadavers (Table 1). The distribution of these lesions can be seen in Fig. 1. Cranial trauma was more commonly observed in males compared to females, although this disparity was not statistically significant (male to female ratio was 1.1:1). The average age at death of the cadavers with cranial lesions was 52.2 years. The temporal, parietal, and frontal bones were the most frequently injured bones, respectively. Three cadavers presented with more than one injury affecting a single bone, which elevated the number of traumatic lesions observed. Healed cranial trauma was seen in 14/124 (11.3%) cadavers. Two cadavers (1.6%) presented with small glass fragments, presumably from a glass bottle, in the right parietal bone lateral to the sagittal suture (Fig. 2A) and left lateral part of the coronal suture, respectively. Depressed fractures of the vault of the

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