Chinese Indentured Mine Labour and the Dangers Associated with Early 20th Century Deep-level Mining on the Witwatersrand Gold Mines, South Africa

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Abstract

Trauma analysis in archaeological human remains can aid our understanding of cultural practices, socio-economic status, environmental and social conditions, and even aspects of a person's occupation. For this reason, fracture patterns and frequencies can be useful in making inferences about the environment people lived and worked in. This is especially true for the 20th century mining industry where unskilled migrant labourers were often subjected to harsh working and living conditions. In this study, the skeletal remains of 36 Chinese indentured mine labourers, who worked and died on the Witwatersrand mines, South Africa, during the period ad 1904–1910, were assessed for evidence of trauma. Historical information suggests that these indentured Chinese labourers were unfamiliar with the workings of deep-level mines and as a result sustained many work-related injuries. Analyses suggest low frequencies of ante-mortem trauma. In the few instances where they occurred, these healed fractures most probably reflect injuries already sustained in China, some time before Chinese indentured employment on the Witwatersrand mines. A high frequency of traumatic lesions, specifically peri-mortem fractures, however, suggests a drastic shift in their working environment attesting to the hazardous working conditions associated with deep-level mining in the early 20th century.

Keywords: ante-mortem trauma; Chinese indentured mine labour; deep-level mining; peri-mortem trauma; Witwatersrand mines

Introduction

Much of South African history had been shaped and influenced by the discovery of diamonds in Kimberley in 1871 and gold in 1886 in the Witwatersrand area (e.g. Richardson, 1982; Turrell, 1987). This period saw the implementation of migrant labour and the compound system, resulting in the displacement of countless Africans. The compound system was implemented to provide on-site accommodation to migrant African labourers. However, this process was mainly aimed at restricting labourer movement in an attempt to minimise theft and to increase work productivity (Turrell, 1987). Even though mining provided a very important boost needed for the economic and technological advancement of South

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Africa, this was performed at the cost of many lives, including those of the Chinese who were imported as unskilled contract labourers to work on the Witwatersrand mines from 1904 to 1910. The aim of this study was to gain insight into the working conditions experienced by the Chinese indentured mine labourers by assessing the incidence of trauma in the skeletal remains of 36 Chinese miners recovered from the Witwatersrand Deep Mine premises. These skeletons represent the only known Chinese indentured labourer sample in South Africa and are representative of a very short, but important, period in the history of the Transvaal gold mines. Several studies have already been conducted on the skeletal remains from diamond miners (L'Abbe *et al.*, 2003; Van der Merwe *et al.*, 2010a, 2010b, 2010c, 2010d, 2010e), but much less is known about the health status of people working on the gold mines.

Historical overview

After the discovery of gold in 1886 in the area of the Witwatersrand, large numbers of prospectors and mining companies flocked to the area, seeing to the eventual founding of Johannesburg (Richardson, 1982; Beavon, 2004). Because of the low-grade nature of the ore found at the Witwatersrand, deep-level mining techniques had to be employed, which created a need for a large unskilled labour force. This labour force was almost exclusively made up of African migrant labourers (Richardson, 1982; Beavon, 2004). After the second Anglo-Boer War (1899–1902), however, the Witwatersrand mines became less profitable because of the large-scale desertion of many of the unskilled workers as a result of the prevailing effects of the war, low wages, and dangerous and harsh working conditions on the mines. Unable to find a satisfactory alternative local workforce, the Chamber of Mines (the controlling mine body in the Witwatersrand) focused on China, known for its large, hardworking and dedicated unskilled working forces (Richardson, 1982; Harris, 1998). After agreements between Britain and China were reached in May 1904, 63 695 Chinese indentured labourers were imported to work as unskilled labourers on the Witwatersrand from 1904 to 1910 (Richardson, 1982; Yap & Man, 1996).

The recruitment and importation of unskilled Chinese labour began in July 1904 (Richardson, 1982; Yap & Man, 1996). Initially, the Chamber of Mines focused their attention towards southern China as it was believed that the Southern Chinese were already accustomed to the idea of working abroad (Richardson, 1982; Yap & Man, 1996; Harris, 1998). It was, however, soon realised that the Southern Chinese did not represent as a feasible labouring group to recruit from, mainly as a result of their extremely poor health (Richardson, 1982; Yap & Man, 1996). Recruitment therefore commenced from the northern regions of China from 1905 onwards (Bright, 2013). The majority of the labourers came from northern areas of Chihli (also known as Zihli, modern-day Hebei Province), Shantung and Honan (also known as Shandong and Henan Provinces; Richardson, 1982; Yap & Man, 1996; Harris, 1998; Bright, 2013). Recruitment from these areas, even though more expensive, was more successful owing to the fact that the northern regions were suffering the effects of the 1900 Boxer rebellion; the more immediate Russo-Japanese War (1904–1905); and economic instability brought on by the collapse of the silk-spinning industry and continued episodes of droughts, floods and famines (Yap & Man, 1996; Bright, 2013). A previous study assessing the health of the 36 Chinese miner skeletons in question revealed signs of continued episodes of disease and malnutrition (Meyer *et al.*, 2013), attesting to the harsh conditions experienced in early 20th century

northern China. This seems to suggest that these individuals were already put at a disadvantage as they were clearly from the poorer echelons of society, making them an easy prey for the large mining companies seeking cheap alternative labour.

Only Chinese men were employed, and even though some provisions were made for accompanying wives, only six women were reported to have come to South Africa between 1904 and 19071 (Richardson, 1982; Harris, 1998). The age distribution of recruits ranged from 20 to 55 years, with a marked concentration in the age group 20–35 years (Richardson, 1982). Very few recruits were younger than 20 years; however, with parental consent, those younger than 20 years could still legally be employed (Richardson, 1982). Each Chinese labourer had to work for a minimum contract period of 3 years after which an application for an additional 2-year contract could be made to the Chamber of Mines (Richardson, 1982; Yap & Man, 1996).

After recruits had passed medical screening, they were fingerprinted and issued with a unique number (engraved on a metal disc), a passport, some clothes and a salary advance of about £2–£10 (Yap & Man, 1996; Bright, 2013). Once in South Africa, they were placed with different mines, each providing its own on-site accommodation in the form of compounds (Richardson, 1982; Harris, 1998). The compound system was already in place prior to Chinese employment and was used as a means to enforce control and restrictions on unskilled, almost exclusively African, migrant labourers. It was a system referred to by Worger as '*the most controlled form of labour short of slavery*' (Worger, 2004: 63). The compound system was first used on the Kimberley diamond mines from the late 1870s onwards, initially to house convicts who had to serve out part of their sentencing as unpaid menial labourers (Turrell, 1984; Worger, 2004). This system proved to be so successful that mining companies decided to implement it for migrant labourers as well. The compound system and the restriction of labour movement within the country were not just useful in further implementing the racial policies of the Transvaal government, but also became crucial in the eventual approval of Chinese labour importation. This was especially important considering the widespread anti-Chinese sentiments already felt across the US and British colonies of Australia and New Zealand, all of whom had already implemented the Chinese indentured labour system (Harris, 2006; Bright, 2013). Following Britain's victory over South Africa, many Europeans in the country felt threatened by the prospects of large numbers of Chinese moving in. In an attempt to calm the public, labour unions and anti-Asian leagues protesting against the importation of Chinese labourers, the Labour Importation Ordinance was drawn up by the British government in 1904 (Harris, 2006; Bright, 2013). This Ordinance largely restricted Chinese labourers' movement as well as their rights within South Africa. Some of the key restrictions mentioned in the Ordinance were that all Chinese labourers were to be employed on the Witwatersrand mines only, exclusively as unskilled labour, meaning that they did not have access to any of the higher paying jobs, except for the few employed as Chinese 'police boys' (Richardson, 1982; Harris, 2006). They could not own any landed property or engage in any form of trade. Their movements were restricted to the premises of the mining company employing them and could only leave should they obtain a permit (Harris, 2006; Bright, 2013). A red permit allowed absence until sundown on the day of issue, whereas a white permit allowed overnight leave or for a period not exceeding 48-h (Figure 1; Richardson, 1982; Yap & Man, 1996). However, even with

a permit, Chinese workers were not permitted to leave the Witwatersrand magisterial district (Kynoch, 2003).
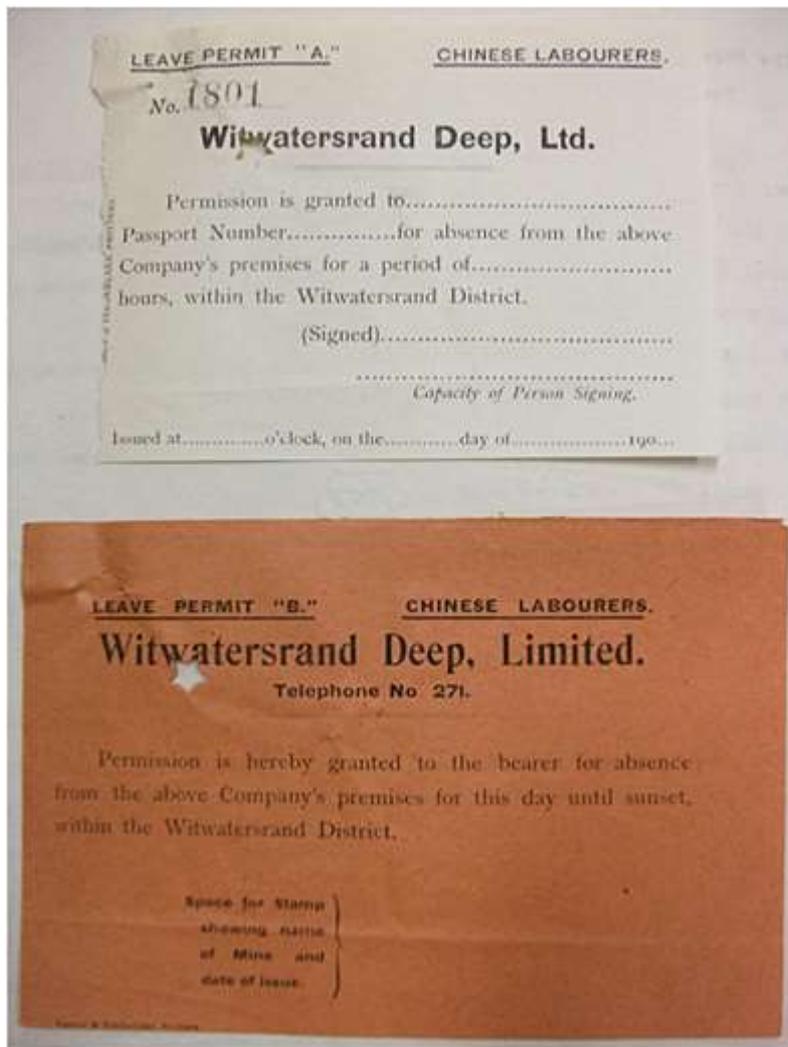
Figure 1. Leave permits for Chinese miners (FLD 214, 55/7).

These restrictions meant that the Chinese were in effect a 'captive workforce' as Kynoch (2003) puts it, forced to complete their 3-year contract unless they could get the money to reimburse their employer for all of their travelling expenses; something very few could afford. Furthermore, it has been argued by Harris (2006), that the very nature of the racialised systems implemented by the countries importing Chinese as cheap unskilled labour actually created a situation where-in Chinese labourers could be subjected to severe abuse. Large-scale abuse came from the mining companies who felt that they had to maximise their returns for what they perceived as a costly endeavour. This meant long and hard working hours with minimum pay. Each Chinese miner had to complete a 10-h work day for 6 days of the week (Kynoch, 2003). For the first 6 months, workers were paid 1 shilling per 10-h day worked, with the notion that once they had gained more experience their salary would increase to 50 shillings a month (Kynoch, 2003). Unfortunately, many of the mines failed to keep to this understanding and instead used a piece work system, enforcing an incentive and penalty system for the amount of work

performed. It was expected of each miner to drill an average of 24 in. per 10-h shift. Should a miner hand drill more than 24 in. per 10-h shift, he would be granted an incentive; however, should he drill less than 12 in. per shift, his pay would be decreased by half a penny (Kynoch, 2003). Some mines resorted to not paying their labourers at all should they drill less than 30 in. per shift and even enforced punishment and ration restrictions should labourers not perform adequately (Kynoch, 2003).

Physical abuse and ill treatment of Chinese labourers by mine management was also a frequent occurrence. One of the most contentious issues surrounding the treatment of labourers was 'floggings'. This form of corporal punishment was used to circumvent legal proceedings as these were time-consuming and expensive (Yap & Man, 1996; Kynoch, 2003). A public outcry, however, eventually led to the abolishment of floggings in June of 1905 (Yap & Man, 1996; Kynoch, 2003). Additionally, Chinese police, or 'police boys' as they were often referred to, were also notorious for their beatings (Yap & Man, 1996; Kynoch, 2003). For every hundred Chinese workers, one Chinese policeman was assigned, but unfortunately often abused their power and severely mistreated the labourers they were responsible for (Kynoch, 2003). Part of their responsibilities was to deal with complaints and grievances on the labourers' behalf, therefore acting as a middleman between labourers and white officials (Richardson, 1982; Harris, 1998). Bribes were commonly accepted to keep illicit activities quiet, and as a result, many labourers had little hope of gaining justice through appeals to white officials (Kynoch, 2005). Some of the hostilities between Chinese police and Chinese labourers may have derived from previous antagonisms in their home areas (Kynoch, 2005). The most successful recruiting grounds were those areas affected by the Boxer Rebellion (1900), and as a result, some of these tensions may have made their way into the mines and compounds (Richardson, 1982; Kynoch, 2005).

However, Chinese police most probably fell under extreme pressure from white mine managers to exercise excessive and sometimes unnecessary control over the Chinese miners. As Chinese police obtained better wages, had access to larger living quarters and engaged in work that was much less demanding than mining, they would not have wanted to fall into disfavour, which may have resulted in the loss of their jobs and social rankings (Kynoch, 2003).

These types of abuse were often met by protests from Chinese labourers (Yap & Man, 1996; Kynoch, 2003, 2005). Prior to 1906, there had already been 25 riots, serious enough to require outside police intervention before rioters were arrested and incarcerated (Kynoch, 2003). These riots were often violent and resulted in injury and sometimes death (Kynoch, 2003, 2005). Violent altercations did not just happened between Chinese miners and the mine managers and Chinese police, but often also between fellow workers. Opium trading and gambling became an increasing problem in the compounds, something the Foreign Labour Department (FLD)2 mostly turned a blind eye to. Powerful syndicates, controlling the gambling activities and to some extent the opium supplies, came into place and were often directed or at least sanctioned by the Chinese police force (Kynoch, 2005). This led to violence within the compounds and often resulted in murder and/or suicide of fellow workers (Yap & Man, 1996; Harris, 1998; Kynoch, 2005). '*Tied to their workplace by three-year contracts, and with virtually no access to legal protection,*

Chinese mineworkers found it difficult to escape persecution without resort to violence—including suicide'. (Kynoch, 2005: 533)

Abuse and violence were not the only difficulties Chinese labourers had to face on the mines as the more immediate danger posed to them was their dangerous working conditions. Not only did underground work present with obvious hazards, but many of the Chinese labourers employed had no prior experience in mining underground and had never dealt with explosives before, causing many work-related accidents (Richardson, 1982). Chinese miners often drilled into unexploded or misfired holes from previous blasting shifts, killing and injuring many in the process (Richardson, 1982).

'*It was estimated that 3192 Chinese labourers died on the Rand between 1904 and 1910, a mortality rate of nearly one in twenty. Of these, 986 died as a result of causes directly attributable to their conditions of work.*' (Yap & Man, 1996: 117)

A further 611 Chinese labourers sustained injuries that left them partially or totally disabled resulting in the repatriation of 523 disabled Chinese labourers (Richardson, 1982; Yap & Man, 1996).

It also seems as though Chinese recruits were not fully aware of the circumstances surrounding their employment, especially considering the language barrier between Chinese and immigration officers, the latter of whom were not familiar with the Northern Chinese dialects (Yap & Man, 1996). This can be corroborated by the fact that so many complaints were lodged by Chinese miners once they were employed, stating that they had not been made aware of the fact that they had to work underground (especially very deep underground) as mining in China was mainly performed above ground or at very shallow depths (FLD 240, 76/7).

Even though the identity of the 36 Chinese miners studied here are still unknown, the area in which their graves were found is known to have belonged to the Witwatersrand Deep Ltd. gold mine (Dart, 1952). This mine was owned by S. Neumann & Co. and was first registered in 1899 (Richardson, 1982). Records indicate that they had employed Chinese labourers from 1904 to 1908 (Transvaal Mines Department, 1906; Richardson, 1982). In October of 1906, it was recorded that 2942 Chinese were employed by Witwatersrand Deep Ltd. (Transvaal Mines Department, 1906; Richardson, 1982). Medical records for the year 1905 to 1906 reflect the causes of death for Chinese employees (Table 1; FLD 90, 13/7; FLD 91, 13/7; FLD 127, 18/7; FLD 166, 32/7).

Table 1. Causes of death recorded for the Chinese employees from Witwatersrand Deep Ltd. for 1905 to 1906

Cause of death	Total number	Cause of death	Total number
Septicaemia	17	Chronic diarrhoea	4
Dysentery	10	Malaria	1
Acute gastritis	2	Electric shock	1
Enteric fever	9	Inhalation of gas	1
Opium poisoning	14	Beriberi	11
Peritonitis	3	Syphilis	4
Abscess of brain	5	Necrosis of skull	1
Chronic bronchitis	2	Shock[a]	58
Wounds	2	Fracture (skull/neck)	21
Haemorrhage	2	Murder	4
Insanity	1	Execution	3
Phthisis	3	Shot by South African Corps	1
Cardiac disease	2	Suicide	5
Erysipelas	2		

[a]Shock: fractures obtained through rock falls, explosions, falls from skip and down mine shafts, and mine accidents in general.

It is clear from these numbers that by far the most deaths could be attributed to injuries sustained as a result of trauma referred to as either 'shock' or 'fractures to the skull and neck'. This high number of trauma-related deaths clearly reflects the dangers associated with mining, in terms of not only the hazardous working conditions, but also the complex social interactions and altercations brought on by the compound system.

The deceased ended up being buried in mine cemeteries, sometimes alongside African mine workers or in separate areas specifically allocated for Chinese mine labourers (Dart, 1952). With the commencement of the repatriation of Chinese indentured labourers from 1907 to 1910, some of the graves were exhumed, and the remains cremated to be taken back to China (Richardson, 1982; Yap & Man, 1996). Graves were dug up under municipal supervision, and funeral pyres were made out of stone and flammable material, with the coffin placed on top (Yap & Man, 1996). Afterwards, the ashes were collected into 2-foot square bags and taken back to

China (Yap & Man, 1996). For safety reasons, this was only allowed for graves that were older than 1 year (Yap & Man, 1996), and as a result, many of the graves were left in place. These graveyards, although classified as official mine cemeteries, were unmarked and presented what can be termed as paupers' graves. Today, these mining cemeteries remain scattered throughout the Witwatersrand area, most no longer visible on the surface.

Materials and methods

In 1951, the skeletonized remains of 36 Chinese individuals were exhumed during rescue excavations following their accidental discovery during construction activities in the Boksburg area, South Africa (Dart, 1952). The remains were buried in a formal, but unmarked, paupers' cemetery. Raymond A. Dart, who was responsible for the excavation and retrieval of the remains, concluded that they belonged to Chinese indentured miners employed and buried on the Witwatersrand Deep Ltd. mine grounds. These individuals came to South Africa during the period of Chinese indentured employment (1904–1910) on the Witwatersrand (Dart, 1952). The remains were transferred for permanent custody to the Raymond A. Dart Collection housed at the Department of Anatomy, University of the Witwatersrand, where they are still housed today (Dayal *et al.*, 2009).

The skeletal remains of these 36 Chinese individuals were analysed for the purposes of this study. Each skeleton was assessed using standard physical anthropological techniques to determine osteobiological profiles (Krogman & Işcan, 1986; Buikstra & Ubelaker, 1994) and to assess aspects of health (Aufderheide & Rodríguez-Martin, 1998; Ortner, 2003; Brickley & Ives, 2008). Analyses suggested that all 36 individuals were men between the ages of 16 and 45 years, with the majority being of young adult age (n = 21; 20–34 years; Meyer *et al.*, 2013).

Each skeleton was visually assessed for macroscopic signs of trauma. Trauma may be defined as injury to living tissue as a result of an external mechanical force (Lovell, 1997). Such forces include tension, compression, flexion and shearing (Lovell, 1997; Ortner, 2003). Continued stress in the same area (e.g. spondylolysis and Schmorl's nodes), as well as additional underlying medical conditions may also result in trauma (Merbs, 1989, 1996; Lovell, 1997; Ortner, 2003; Brickley & Ives, 2008). Fracture timing is described as being ante-mortem, peri-mortem or post-mortem. Ante-mortem fractures are those that have had time to heal (partially or completely) prior to death, whereas peri-mortem fractures refer to fractures obtained prior to or around the time of death (when bone is still fresh enough to react as live bone) and that do not present with healing. Post-mortem refers to the period well after death when bone no longer reacts as live tissue. These changes are associated with taphonomic alterations during the depositional phase.

For recognition of ante-mortem and peri-mortem trauma, criteria from Lovell (1997), Galloway (1999), Galloway & Zephro (2005) and Porta (2005) were used. Trauma was identified as being ante-mortem or peri-mortem based on the degree of healing present. Fractures were regarded as ante-mortem in cases where macroscopic signs of healing could be observed and peri-mortem when there were no macroscopic signs of healing. Peri-mortem fractures were classified according to the type of fracture (oblique, transverse, butterfly, spiral and/or compression) as well as whether

the fractures were partial or complete. Finally, the incidence of trauma observed in the Chinese miners was determined in relation to the number of individuals in the sample as well as the number of skeletal elements investigated.

Results

Ante-mortem fractures

Ante-mortem healed fractures were observed in four individuals (13.3%; Table 2): one presenting with a well-healed fracture of the right tibia (proximal third); another with a partially healed fracture of the right fibula, involving the shaft and distal epiphysis; one presenting with a possible healed crush fracture of the left foot, involving the first metatarsal and associated tarsal; and the fourth with a partially healed depressed fracture of the left parietal bone (Table 3).

Table 2. Frequency of traumatic lesions observed in the 36 Chinese miners

Trauma	*N* affected	*N* inspected
Ante-mortem	4 (13.3%)	30
Spondylolysis*	2 (12.5%)	16
Schmorl's nodes*	3 (18.8%)	16
Peri-mortem	9 (30%)	30
Multiple peri-mortem	7 (23.3%)	30

N = number of individuals.

*= inspected if at least 80% of vertebral column was present.

Table 3. Prevalence of ante-mortem trauma in the Chinese miners

Skeleton #	Age (years)	S	Vba	Vbb	Ti	Fi	Mt/T	Total fractures
A997	20–34			1				1
A1003	35–45					1		1
A1007	35–45		1					1
A1019	20–34				1			1
A1023	20–34		1	1				2
A1030	20–34	1						1
A1031	20–34			1			1	2
Total inspected		30	16c	16c	30	26	6c	
Total affected		1 (3.3%)	2 (12.5%)	3 (18.8%)	1 (3.3%)	1 (3.8%)	1 (16.6%)	9

S, skull; Vb, vertebrae; Ti, tibia; Fi, fibula; Mt/T, metatarsals and tarsal.

[a]Vb: vertebrae affected by spondylolysis.

[b]Vb: vertebrae affected by Schmorl's nodes.

[c]At least 80% present.

Spondylolysis and Schmorl's nodes

Spondylolysis of the lumbar vertebrae was found in two individuals. One individual presented with bilateral spondylolysis of L5 (Figure 2), whereas the other presented with unilateral spondylolysis of L5. Schmorl's nodes were identified in three individuals on T11, T8–T10 and on L1–L4, respectively.

Figure 2. Bilateral spondylolysis (Chinese A1007

Peri-mortem fractures

Thirty percent of the Chinese miners presented with peri-mortem fractures, with most affecting the long bones (Table 4). Two individuals presented with peri-mortem fractures of the humerus; one complete transverse fracture of the right humerus (Figure 3) and one spiral fracture of the right humeral shaft. One individual presented with a radial butterfly fracture (Figure 4).

Figure 3. Transverse fracture of right humerus (Chinese A997). This figure is available in colour online at wileyonlinelibrary.com/journal/oa

Table 4. Prevalence of peri-mortem trauma in the Chinese miners

Skeleton #	Age (year)	Vb	Hu	Ra	Oc	Fe	Ti	Fi	Total fractures
A997	20–34	1	1			1			3
A1003	35–45	1			1				2
A1004	>20			1		1	1		3
A1009	20–34					1	1	1	3
A1011	20–34	1				1			2
A1013	20–34	1							1
A1015	20–34		1			1	1		3
A1023	20–34					1			1
A1030	20–34	1					1		2
Total inspected		16a	20	23	28	33	30	26	
Total affected		5 (31.3%)	2 (10%)	1 (4.3%)	1 (3.6%)	6 (18.2%)	4 (13.3%)	1 (3.8%)	20

Vb, vertebrae; Hu, humerus; Ra, radius; Oc, os coxa; Fe, femur; Ti, tibia; Fi, fibula.

[a]At least 80% present.

Figure 4. Butterfly fracture of the left radius (Chinese A1004).

Five individuals presented with vertebral fractures, two presented with possible wedge fractures of T12 (presented by a collapse of the anterior part of the vertebral body), and three with compression or burst fractures in the spinous process of T2, T4 and L3–L5, respectively. The latter three cases presented with fracture lines throughout the vertebral body extending into the spinous processes (Figure 5).

Figure 5. Burst fractures of the lumbar vertebrae (Chinese A1013).

Six femoral fractures were observed. Three of these fractures presented as spiral fractures (Figure 6), whereas the other three presented as butterfly fractures (Figure 7). One possible compression fracture of a right os coxa was observed and presented with a medially compressed ilium causing fracturing of the iliac wing. Four individuals presented with fractures of the tibia. All of these fractures presented as butterfly fractures except for the two individuals presenting with spiral fractures. One fibular spiral fracture was also observed.

Figure 6. Spiral fracture of the right femur (Chinese A997).

Figure 7. Butterfly fracture of the right femur (Chinese A1004).

Seven out of the nine individuals presenting with peri-mortem fractures presented with more than one fracture throughout the body. This represented 23.3% of the total number of individuals assessed for trauma.

Discussion

Low frequencies of ante-mortem trauma were observed in the Chinese miners with most lesions presenting with a significant degree of healing. This seems to suggest that these injuries were already sustained before their arrival and employment on the Witwatersrand mines. The reasoning behind this stems from the fact that the Chinese miners were only employed for a relatively short period (contract of 3–5 years between 1904 and 1910) minimising the time necessary for significant bone healing. The fact that the Chinese were hired on a contract basis also meant that once they got injured to such an extent that they could no longer fulfil their contract agreement they would have been sent home. Historical records indicate that many Chinese were repatriated because of injuries sustained which made them unable to continue work. They were paid a once-off compensation salary and then put on the first ship going back to China (FLD 240, 76/3; Richardson, 1982; Yap & Man, 1996).

One individual presented with a partially healed depressed fracture to the left parietal bone. This specific injury could have been sustained in China already; however, considering that this was the only ante-mortem fracture that did not present with significant healing, it must also be considered that this injury could have been sustained during this individual's time on the mines. Cranial trauma is often associated with a blow to the head. Such an injury could easily have been sustained during a rock fall or cave-in whilst working underground. However, cranial trauma is also often times interpreted as evidence of interpersonal violence (Walker, 2001). Archival and historical accounts indicate that tension rose in the confined spaces created by compounds and was worsened by abuse from mine managers and the Chinese police employed to exercise control over the Chinese miners (FLD 51, 6/7; FLD 224, 62/7; GOV 79, GEN 56A/05; Yap & Man, 1996; Kynoch, 2005). Mine management's exploitation and abuse of Chinese labourers were often countered with violent riots causing serious injury and even death (Kynoch, 2005). Gambling was also a major contributing factor in creating tension amongst fellow Chinese, often leading to physical violence and even homicide (LTG 157, 140/35; LD 1323, AG 4040/06; LTG 157, 140/41; Yap & Man, 1996).

Additionally, the presence of spondylolysis (12.5%) and Schmorl's nodes (18.8%) were observed in the thoracic and lumbar vertebrae. The aetiology of spondylolysis is twofold, and it is argued that this condition can either be caused by a congenital anomaly (Aufderheide & Rodríguez-Martin, 1998; Haun & Kettner, 2005; Ward & Latimer, 2005; Ward et al., 2007) or as a result of stress (fatigue) fractures caused by hyperflexion of the lumbar vertebrae (Merbs, 1996; Aufderheide & Rodríguez-Martin, 1998; Ortner, 2003; Waldron, 2009). Any one of these aetiologies may be considered when looking at the presence of spondylolysis in the Chinese miners. The first, suggesting that this type of pathology is associated with stress or fatigue fractures of the spine, may be a very plausible cause for the spondylolysis seen in the Chinese individuals. It is known that these people engaged in very strenuous labour during their time on the mines, which could potentially have contributed to the appearance of these lesions. In order for mines to maximise on their profits, they placed Chinese labourers in areas which they deemed to be most financially strategic (Yap & Man, 1996). This effectively meant that Chinese labourers were almost exclusively employed for underground work, which was much more labour-intensive than working above ground. This was made worse when mechanised

means of mining were substituted for hand drilling, extraction and sorting, so as to ensure that mining costs were kept at a minimum (Yap & Man, 1996). The piece work system employed by many mining companies also meant that labourers had to work exceptionally hard to keep up with the standard drilling of 25 in. a day. Factors like these would have placed additional strain on their bodies, which may in turn have resulted in typical fatigue fractures like spondylolysis.

Additionally, it should also be considered that the spondylolysis observed in the Chinese is the result of an underlying genetic predisposition (Ward & Latimer, 2005; Ward et al., 2007). Spondylolysis is often associated with developmental defects such as spina bifida and notochord defects, which in turn may be related to prenatal deficiencies of folic acid, zinc and B vitamins (Aufderheide & Rodríguez-Martin, 1998; Sairyo et al., 2006). A previous study has shown that the Chinese miners also presented with metabolic and nutritional diseases that may additionally have contributed to the appearance of vertebral developmental defects (Meyer et al., 2013). These lesions may therefore also be reflective of these people's socio-economic status back in China. Coming from very poor peasant societies, their health was already compromised before being further exposed to harsh working and living conditions on the mines.

Schmorl's nodes are also sometimes associated with stress-related trauma, however, alternative causes, such as metabolic diseases, genetic developmental defects and/or a genetic predisposition towards developing the condition, may also be considered as possible aetiologies (Barnes, 1994; Aufderheide & Rodríguez-Martin, 1998; Ortner, 2003; Haun & Kettner, 2005; Ward & Latimer, 2005; Ward et al., 2007; Williams et al., 2007; Brickley & Ives, 2008; Waldron, 2009). When taking the presence of Schmorl's nodes in the Chinese miners into account, both genetic and traumatic factors should be considered as possible causes. The presence of Schmorl's nodes in the lower thoracic and upper lumbar vertebrae of the Chinese, as well as their relative young ages at death (all three individuals were estimated to have been between 20 and 34 years), suggests that they most probably suffered from endplate-driven disc degeneration (Williams et al., 2007; Adams & Dolan, 2012). This condition can be attributed to a genetic predisposition for developing the condition, which may be worsened in cases where there is an insufficient intake of calcium (for example, juvenile osteoporosis and osteopenia; Adams & Dolan, 2012). The Chinese may therefore have been genetically inclined to developing the condition. Their traditional diet is known to have contained very little animal-derived products, which meant that calcium intake would have been limited (Chen & Xu, 1996; Du et al., 2002). This in turn may have slightly increased the incidence of Schmorl's nodes. Alternatively, this condition may also have been caused by stress-related trauma (Jurmain et al., 2012), possibly due to the strenuous work associated with menial farm labour in China and/or mining on the Witwatersrand mines.

Peri-mortem trauma was present in nearly a third of the Chinese skeletons. These lesions showed no macroscopic signs of healing, suggesting that injuries were sustained around the time of death, and most probably contributed to their death. Peri-mortem fractures observed in the thoracic and lumbar vertebrae, and the pelvis, were mainly due to compression/crush forces as defined by Lovell (1997) and Ortner (2003). Compression fractures are usually the result of a sudden excessive (axial) impaction and result in a variety of fracture patterns. The most common injuries

associated with thoracic and lumbar fractures are caused by excessive flexion. Flexion usually occurs when a person falls from a height into a sitting or hunched position, when a weight falls onto the hunched back of a person, or when a person is struck from behind by a moving object (Galloway, 1999; Waldron, 2009). Pelvic fractures are also often associated with falls from heights, especially in cases where the person lands on the buttocks or on his or her side (Galloway, 1999). These types of fractures are generally associated with a high mortality rate, especially in cases where the internal soft tissue structures and organs have been perforated causing, haemorrhage and excessive blood loss (Galloway, 1999).

Peri-mortem fractures were most often observed in the lower limbs.3 The majority of these fractures were classified as butterfly fractures, followed by several spiral fractures. Butterfly fractures are comminuted fractures that form as a result of a combination of compression and tension forces (Lovell, 1997). This type of fracture can be characterised by the separation of a triangular fragment of bone (Lovell, 1997). Spiral fractures, on the other hand, are linear fractures occurring as a result of rotational and downward loading stress on the longitudinal axis (Lovell, 1997). Lower limb injuries are also often associated with falls from heights, especially in the cases where landing is primarily focussed on the lower limbs (Galloway, 1999). Shaft fractures constitute major trauma and may result in death, often as a result of excessive blood loss (Galloway, 1999; Waldron, 2009).

The relatively high incidence of peri-mortem trauma in this sample may be related to the extremely hazardous working conditions presented by deep-level mining. Even though interpersonal violence cannot be ruled out completely, especially considering the historical and archival evidence of violent altercations between Chinese labourers and exploitive mine managers, corrupt Chinese police and even fellow workers, the peri-mortem fracture pattern observed in the Chinese miners seems to follow injuries more commonly associated with work-related accidents. In most cases of interpersonal violence, the craniofacial bones would be affected, and where postcranial trauma occurs as a result of interpersonal violence, it would most often co-occur with cranial fractures (Larsen, 1997). As the majority of the fractures were observed in the lower extremities, with the absence of craniofacial trauma, these injuries are more likely to have been sustained during work-related accidents associated with deep-level mining. Historical records indicate that the majority of the work-related deaths were caused by falls from heights (down mine shafts and falls from skips transporting miners up and down the shafts) as well as cave-ins and rock falls (mainly due to accidental detonation of explosives; FLD 90, 13/7; FLD 91. 13/7; FLD 127, 18/7; FLD 166, 32/7). Indentured Chinese labourers were often unfamiliar with the workings of underground mines and as a result sustained many injuries either due to falls or cave-ins. This was especially the case with blasting and drilling activities as many of the Chinese labourers were not properly trained in the use of explosives (Richardson, 1982; Yap & Man, 1996; Harris, 1998). It also seems that many of the Chinese who were employed to do the underground mining were not fully aware of the circumstances surrounding their employment. Because of language constraints experienced during the initial recruitment phase, many Chinese had not been made aware of the fact that they would have to work in shafts deep underground. Mining in China was almost exclusively performed above ground or at very shallow depths (FLD 240, 76/7). This meant that they had no prior experience in deep-level mining, which most probably increased the likelihood of them sustaining

work-related injuries. Furthermore, because deep-level mining was a relatively new method of mining, many of the safety measures associated with modern-day underground mining were not yet in place.

All of these accidents could therefore have contributed to the types of peri-mortem fractures seen here. Injuries sustained through such accidents would have caused multiple injuries resulting in major trauma. This is evident in the large proportion of Chinese miners presenting with multiple fractures. Of the 30% of Chinese presenting with peri-mortem trauma, 23.3% presented with multiple fractures.

Conclusion

A low frequency of ante-mortem trauma was observed and most probably reflects injuries already sustained in China, some time before Chinese indentured employment on the Witwatersrand mines. The presence of spondylolysis and Schmorl's nodes may be associated with a genetic predisposition and had most probably been worsened by poverty and poor health experienced back in China. However, these lesions may also be associated with continuous strenuous physical labour, something these people would have been subjected to on a daily basis. The Chinese miners presented with a high incidence of peri-mortem trauma. These lesions were mainly observed in the extremities and, to a lesser extent, in the vertebrae suggesting that these were most likely work-related. Lesions showed no signs of healing suggesting that they occurred around the time of death and probably contributed to the cause of death. A high frequency of traumatic lesions, specifically peri-mortem fractures, suggests a drastic shift in their working environment attesting to the hazardous working conditions associated with deep-level mining in the early 20th century. Deep-level mining, especially during this early phase of operation, created a much more hazardous working environment. '*Deep-level mining, particularly in the early days when miners were literally feeling their way, was (and remains) highly dangerous*'. (Beavon, 2004:35)

1. 1907 being the last year new recruits were allowed into South Africa.

2. The FLD was created specifically to oversee the Chinese labour force. Acting independently from the Chamber of Mines, their main role was not only to inspect housing, food and sanitary conditions but also to handle all grievances lodged by Chinese miners. Unfortunately, as Chinese police were often mediators in this

whole process, many Chinese workers could never receive the justice they deserved.

3. Poor preservation and incomplete skeletal elements of more fragile skeletal remains such as the ribs, hand and foot bones, and to some extent of vertebrae, meant that a complete assessment of injuries sustained due to traumatic events could not be performed. The trauma observed here may therefore only be representative of the minimum amount of the total trauma sustained.

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