Long bone fractures in impala (*Aepyceros melampus*): a classification system and review of 55 cases

by

Frans G. van Heerden

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DISSERTATION

Long bone fractures in impala (*Aepyceros melampus*): a classification system and review of 55 cases

Frans G. van Heerden
04372638

Supervisor: Professor Marthinus J Hartman
BVSc (Hons) MSc MMedVet PhD
Associate Professor
Department Companion Animal Clinical Studies
Onderstepoort Veterinary Academic Hospital
Faculty of Veterinary Science
University of Pretoria

Co-supervisor: Professor Robert M Kirberger
BVSc DVSc MMedVet Dip ECVDI
Extraordinary lecturer
Department Companion Animal Clinical Studies
Faculty of Veterinary Science
University of Pretoria

Department: Companion Animal Clinical Studies
Faculty of Veterinary Science

University: University of Pretoria

DECLARATION

I, Frans G van Heerden, do hereby declare that the research presented in this dissertation, "*Long bone fractures in impala (Aepyceros melampus): a classification system and review of 55 cases",* is submitted in accordance with the requirements of the Master in Veterinary Medicine degree at the University of Pretoria. This work was conceived and executed by myself, and apart from the normal guidance from my supervisors, I have received no assistance. Neither the substance, nor any part of this dissertation has been submitted in the past, or is to be submitted for another degree at this University or any other University. All sources cited and quoted in this research paper are indicated and acknowledged with a comprehensive list of references.

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Signed: …………………………………………………….
Frans G van Heerden

Date: ……………………………………………………..

DEDICATION

I dedicate this reseach to my wife Ezit for her unconditional love and support, and to my parents Carl and Mona and my brother Casper, who have carried me through the difficult times in my career.

Quote

“A classification is useful only if it considers the severity of the bone lesion, serves as a basis for treatment and for evaluation of the results.”

Maurice E. Müller, 1988

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SUMMARY

Aim and objective

To introduce and apply a modified-Unger fracture classification in impala, determine the long bone fracture distribution based on 58 long bone fractures, and report the fracture fixation methods used to treat some of the fractures studied.

Study design

Retrospective descriptive radiographic study.

Sample population

Fifty eight long bone fractures in 55 impala.

Materials and methods

This radiographic study evaluated 122 radiographs of 58 long bone fractures in 55 impala. The Unger fracture classification was modified and fracture illustrations for the metacarpal and metatarsal bones added. Each fracture was classified and assigned a four symbol alpha-numeric code using this classification. The long bone fracture distribution, patient signalment, skeletal maturity, fracture associated soft tissue changes, presence of fissure lines, periosteal reaction, fracture displacement, cause of the fracture and treatment were recorded.

Results

The overall fracture distribution based on location, found tibial (n=17) fractures to be the most common. Seventy eight percent of the cases had fractures in the diaphysis. The fracture distribution based on complexity was 46% simple, 28% wedge and 26% multi-fragmentary fractures and based on severity was 36% severity 1, 36% severity 2 and 28% severity 3. Fifty seven percent of the fractures affected rams and 43% ewes, with 68% of all cases being skeletally immature. Fifty three percent of cases had open fractures and fissure lines were detected in 34% of fractures. Eighty two percent of all cases had no periosteal reaction associated with the fracture. The average displacement in a cranio-caudal direction was 18 mm, medio-lateral 16 mm and proximo-distal 32 mm. The cause in the majority of fractures was unknown, with some fractures caused by an immobilization

dart (n=6). Most patients were treated with external fixation (n=18) only, followed by internal fixation (n=6) or a combination of internal and external fixation methods (n=4).

Conclusion

The modified-Unger fracture classification was applicable in classifying 58 long bone fractures in impala, and facilitated determining the long bone fracture distribution. This classification, the determined fracture distribution and the reported fracture fixation methods, should provide a foundation for further advances in veterinary and comparative ungulate, and particularly antelope, orthopaedics and traumatology.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

DICOM	Digital imaging and communication in medicine
IM	Intra-medullary
OVAH	Onderstepoort Veterinary Academic Hospital

1 INTRODUCTION

In the 1960s wildlife ranching was a very small part of the agricultural sector in Southern Africa, with only a handful of landowners using wildlife commercially. In the 1980s game farm owners realized that the sustainable use of wildlife could be financially viable. Furthermore, the Game Theft Act of 1991, provided certain ownership rights to land owners over wild animals, which lead to a major incentive for wildlife farming activities. This has since resulted in huge growth of wildlife ranching in South Africa.[1] In 2015 the median revenue generated from live sales on wildlife ranches across South Africa was estimated to be R4.3 billion.[1] During this period, it was estimated that 52% of all wildlife ranches bred colour variants. Among the colour variants, black impala was the most common. Impala comprise the largest number of species hunted for trophies on wildlife ranches.[1] For venison production, impala comprised 23% of all species hunted for venison, second only to springbuck at 28%.[1] Currently in the wildlife industry developing trends are moving away from colour variants and more towards breeding trophy animals. The importance of antelope, specifically impala, for conservation and their value in zoological and private wildlife collections, has led to an increase in the need for sophisticated veterinary care.[2]

The diagnosis and treatment of long bone fractures have consequently become more common in valuable antelope species, more specifically certain colour variations of impala (*Aepyceros malampus)*. The breeding potential and value of any antelope is obviously dependent on a sound and intact musculoskeletal system, which highlights the importance of uncomplicated bone healing after a fracture has occurred. Due to their fractious nature and extensive confinement, fracture treatment in antelope is inevitably challenging.

Unfortunately scientific literature has lagged behind the rise in popularity and commercial value of these small antelope species. To date no case reports or review articles have been published under the broader theme of fracture classification or fracture management in these species. The foundation of any investigation into fracture management of a species, is the development of a fracture classification that guides treatment, prognosis, comparative and retrospective studies. The purpose of this research is to develop a fracture classification system that is applicable to long bone fractures in impala. The long bone fracture distribution of 58 fractures in impala, classified with this system, is also reported. The findings of this study will guide further anatomical, biomechanical and clinical studies, to ultimately develop an effective fracture treatment methodology applicable to impala, and possibly other small antelope species.

2 JUSTIFICATION

2.1 Literature review

2.1.1 Fracture description and classification

The earliest recorded description of fractures were that they were either simple or compound.[3] These terms stemmed from the period prior to antibiotic therapy when compound fractures carried a high risk of infection and potential loss of the limb or life.[3] These terms have since been replaced with open or closed.[3] Fracture descriptions serve to standardize language and improve communication amongst medical professionals.[4] A fracture description gives the name of the affected bone and the location of the fracture within the bone, followed by fracture severity and displacement of fracture fragments relative to each other.[5] Additional descriptive terms can be used to detail a specific type of fracture, for example, pathological, avulsion, compression, condylar or supracondylar.[4] Formal classification of fractures systematically codes the descriptive process. It replaces words with symbols, according to categories, which convey the same information. In this way fracture classification allows for descriptive information to be more easily processed to facilitate research.[6]

Fracture morphology, and subsequent classification of fractures, has gained greater importance since the introduction of internal fixation in veterinary orthopaedics.[7] Some classifications are developed to organize fractures in clinically useful groups, while others are organised according to different coding systems, to conduct research.[4] When collecting fracture data the complexity of the coding systems can render these systems difficult to implement, allowing opportunity for variation and subsequent reduction in the value of the data. For this reason, no single long bone fracture classification has yet been adopted internationally in veterinary orthopaedics, including small animals.[3]

Ideally any fracture classification should be simple, precise, repeatable and applicable to the species in question.[7] Classifications developed for long bone fractures in humans, dogs and cats, meet this demand and still form the basis of the fracture classifications used by the Arbeitsgemeinschaft für Osteosynthesefragen/Association for the Study of Internal Fixation foundation today.[7-9] The Unger classification has been extensively utilized in dogs and cats, and was historically found easy to apply and useful in processing and quick retrieval of data.[10-12] For dogs and cats, additional detailed fracture classifications exist for the central tarsal bone, accessory carpal bone, long bones, open fractures, sacrum, scapula and recently the pelvis.[13-19] In addition, growth plate fractures in dogs, cats, equines and production animals are classified based on the Salter and Harris classification developed for humans.[20,21,22,23]

Despite attempts to document fracture types in horses, no detailed fracture classification for long bones has been published, however a fracture type description of the third carpal bone, the olecranon and the distal phalanx is available.[24,25,26,27] Furthermore, dog and cat fracture classifications were found to be inapplicable to long bone fractures in horses.[28] No long bone fracture classification is available for even-toed ungulates.

In this study, the Unger classification for small animals, was modified and the unique skeletal anatomy of the impala incorporated, to ensure a simple and precise classification. Most importantly, the metacarpal and metatarsal bones were added to the classification to make it applicable to impala.

2.1.2 Fracture distribution

The earliest survey studies done on fractures in dogs and cats were carried out in the 1970s.[29-31] Most studies determined the distribution of fractures based on the breed and sex of the patient, type of fracture, bone or limb involved, age and weight of the patient, fracture cause and treatment carried out. Some studies have also compared the incidence of long bone fractures with the incidence of other musculoskeletal diseases like cranial cruciate ligament disease, elbow and hip dysplasia, traumatic sub-luxation and luxation, patella luxation, etc. in dogs.[32] Fractures have been shown to be more common than any other musculoskeletal condition in canine and feline patients.[32-33]

Different results have been published for long bone fracture distribution in dogs and cats. The tibia and fibula have previously been reported as the most commonly fractured long bones.[32] However some authors have found the femur and some the radius and ulna to be the most commonly fractured in dogs.[31,33,34] The type of study, sample size, topography, as well as the different historic timelines of the studies could possibly have resulted in the different outcomes. In felines the results from published studies were similar, with the femur constantly reported as the most commonly fractured long bone in this species.[29,31,32]

Metacarpal and metatarsal fractures (50%) have been reported to be the most commonly fractured long bone in cattle, followed by fractures of the tibia (12%), radius and ulna (7%), and humerus (<5%).[35] Studies done on fracture distribution in goats had conflicting results. Fractures of the metacarpal (36%) and metatarsal (25%) bones were described as most common in one study.[36] The femur was found to be the most commonly fractured long bone in goats in another study.[37] These conflicting results can be explained by the different environments in which the studies were performed and consequently the type of trauma causing the fracture. The tibia is the single most commonly fractured long bone in llamas, alpacas and camels.[38-40] Studies investigating fracture distribution in wildlife species are lacking, where only one study in koalas found fractures of the skull were most commonly associated with motor vehicle trauma and a poor prognosis.[41]

The long bone fracture distribution in impala is unknown. In this study the application of the modified-Unger fracture classification helped determine the fracture distribution is this species. Together the classification and fracture distribution will form the foundation of future anatomical, biomechanical and clinical studies, to ultimately develop an effective fracture treatment methodology in impala and possibly other small antelope species.

2.2 Problem statement

- No long bone fracture classification for ungulate species exists.

- The long bone fracture distribution in impala is unknown.

- Fixation methods used to treat long bone fractures in impala has not been reported.

2.3 Hypothesis

- H_0 - The modified-Unger fracture classification is applicable to classify long bone fractures in impala.
- H_1 - The modified-Unger fracture classification is not applicable to classify long bone fractures in impala.

2.4 Aims and objectives

The purpose of this study was to:

- Confirm and apply the modified-Unger fracture classification system to long bone fractures in impala.

- To determine the fracture distribution based on fracture location and morphology, skeletal maturity, sex, open or closed status and cause of fracture in impala long bones.

- To report the fixation methods used to treat some of the fractures studied.

3 METHODS AND MATERIALS

3.1 Study design

Descriptive retrospective radiographic study.

3.2 Sample size

Radiographic images of 58 long bone fractures in 55 impala.

3.3 Ethical clearance

This study was approved by the Animal Ethics Committee of the University of Pretoria (Project number V141-16) (**Annexure A**).

3.4 Classification development

Modified-Unger fracture classification

Due to the lack of a long bone fracture classification system available for ungulates, and the fact that the Unger fracture classification is currently still the most accepted long bone fracture classification in dogs and cats, it was decided to modify the Unger fracture classification to be applicable to long bone fractures in impala. The fracture illustrations were imprinted and drawn from an impala skeleton, depicting the species' specific skeletal anatomical detail for the humerus, radius and ulna, femur, tibia, metacarpus and metatarsus (**Figures 1** to **6**). Besides the incorporated unique anatomy of the impala, the most notable change to the Unger classification was the addition of a fracture illustration for the metacarpal and metatarsal bones. Because no metacarpal or metatarsal illustrations were available in the Unger classification, the same long bone fracture methodology was applied to the metacarpal and metatarsal fracture illustrations, as for the other long bone fracture illustrations. The anatomical similarity of the impala metacarpus and metatarsus allowed for one illustration to incorporate both long bones (**Figures 7** and **8**). In order to facilitate comparative studies, wherever possible the Unger classification was retained, while incorporating some minor changes and additions based on the most recent human fracture and dislocation compendium, which are more in line with current fracture fixation principles.[42]

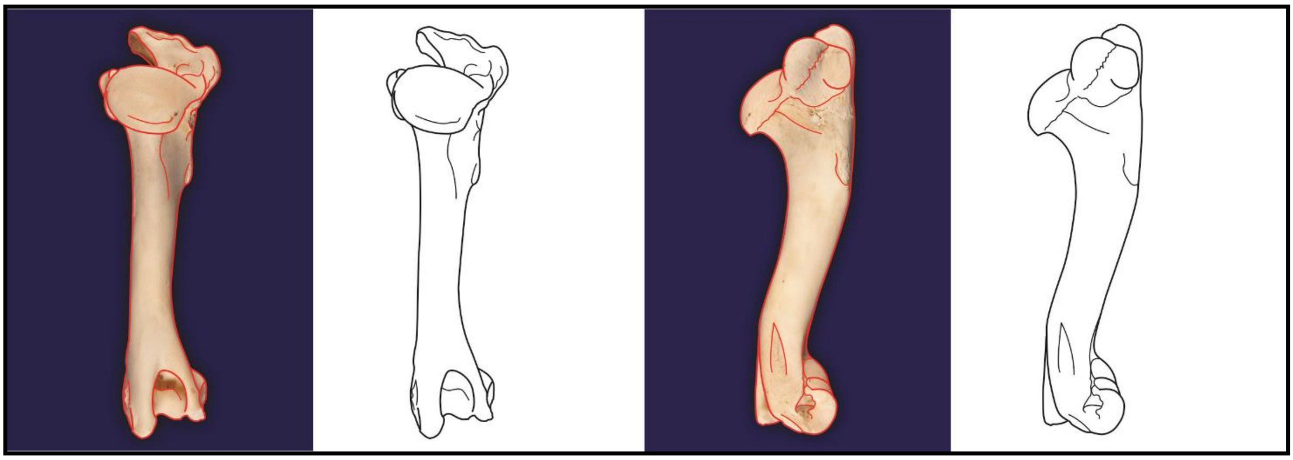

Figure 1 Digital photos and schematics of the cranio-caudal and medio-lateral views of a right impala humerus, used to draw the fracture illustrations.

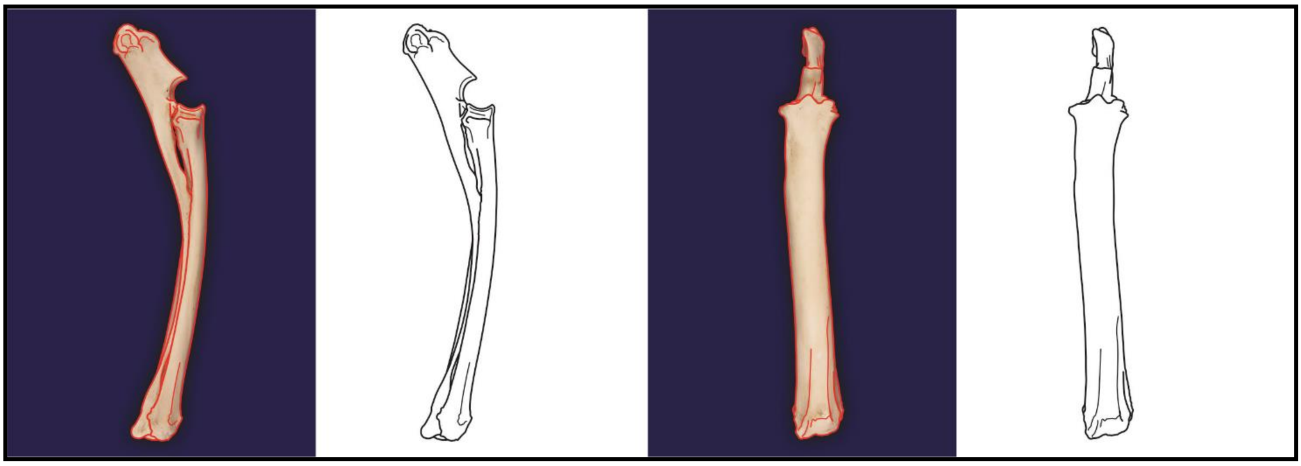

Figure 2 Digital photos and schematics of the medio-lateral and cranio-caudal views of a right impala radius and ulna.

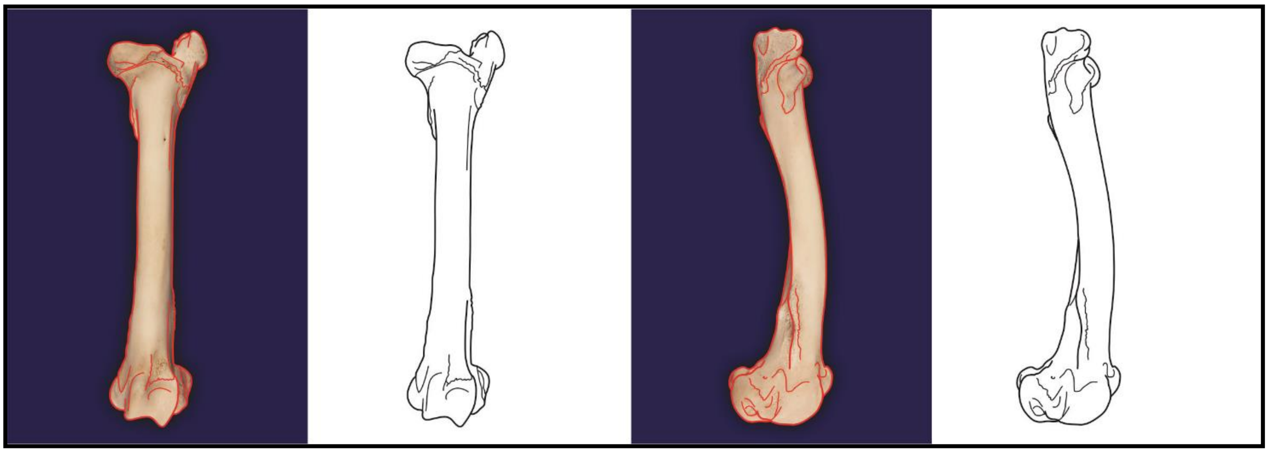

Figure 3 Digital photos and schematics of the cranio-caudal and medio-lateral views of a left impala femur.

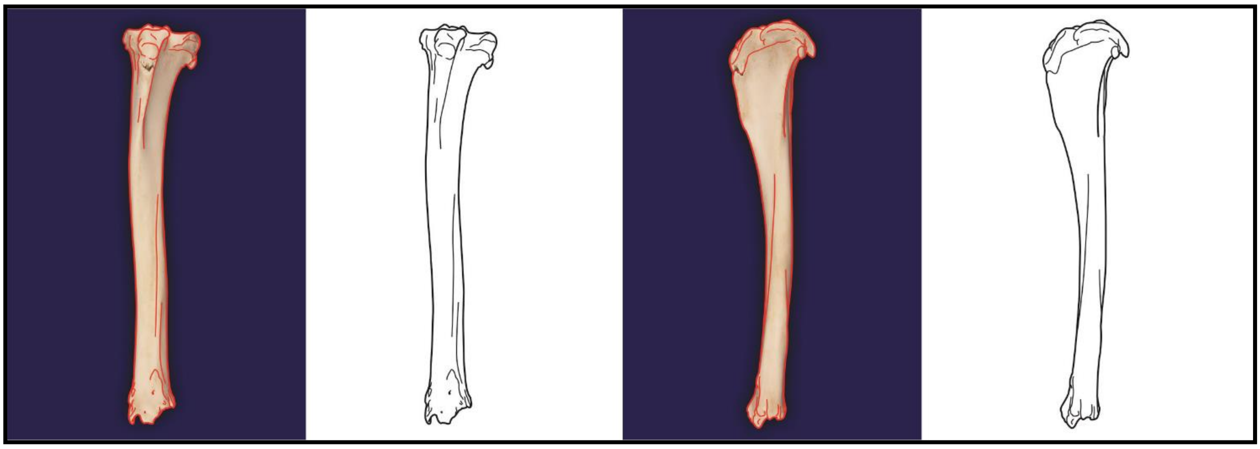

Figure 4 Digital photos and schematics of the cranio-caudal and medio-lateral views of a left impala tibia.

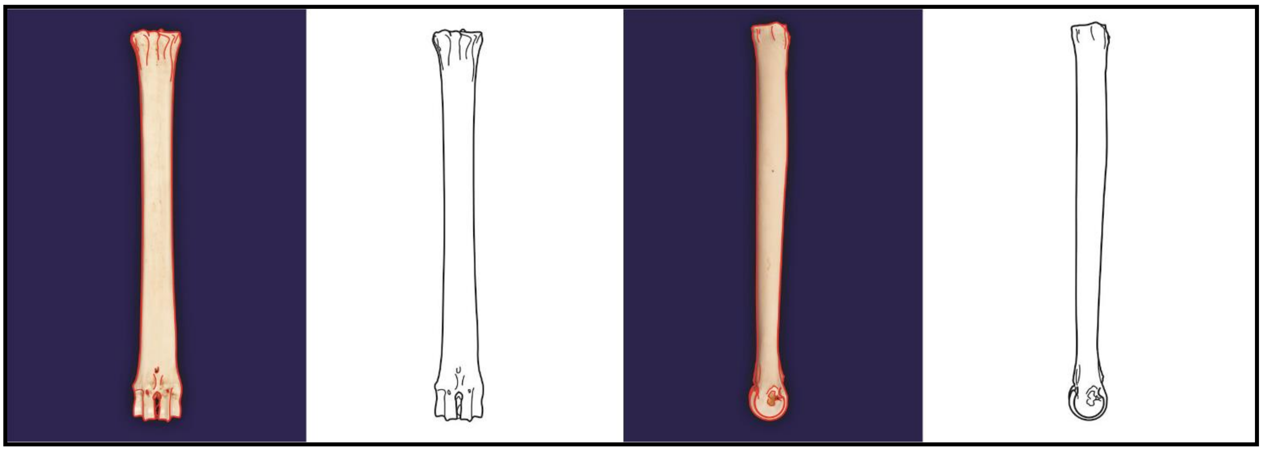

Figure 5 Digital photos and schematics of the cranio-caudal and medio-lateral views a right impala metacarpus.

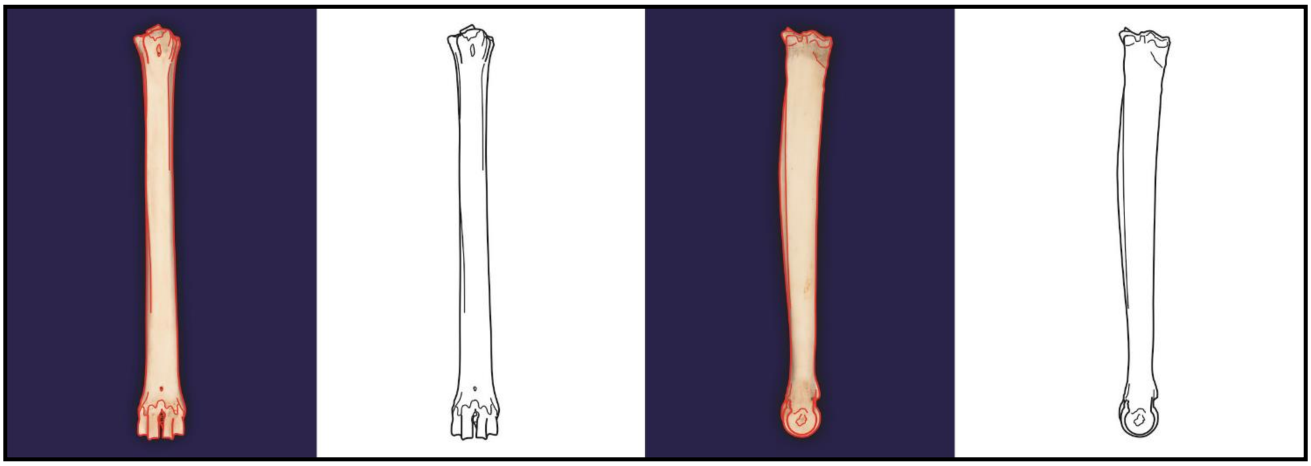

Figure 6 Digital photos and schematics of the cranio-caudal and medio-lateral views of a left impala metatarsus.

Figure 7 Digital photos of the cranio-caudal and medio-lateral views of a right impala metacarpus.

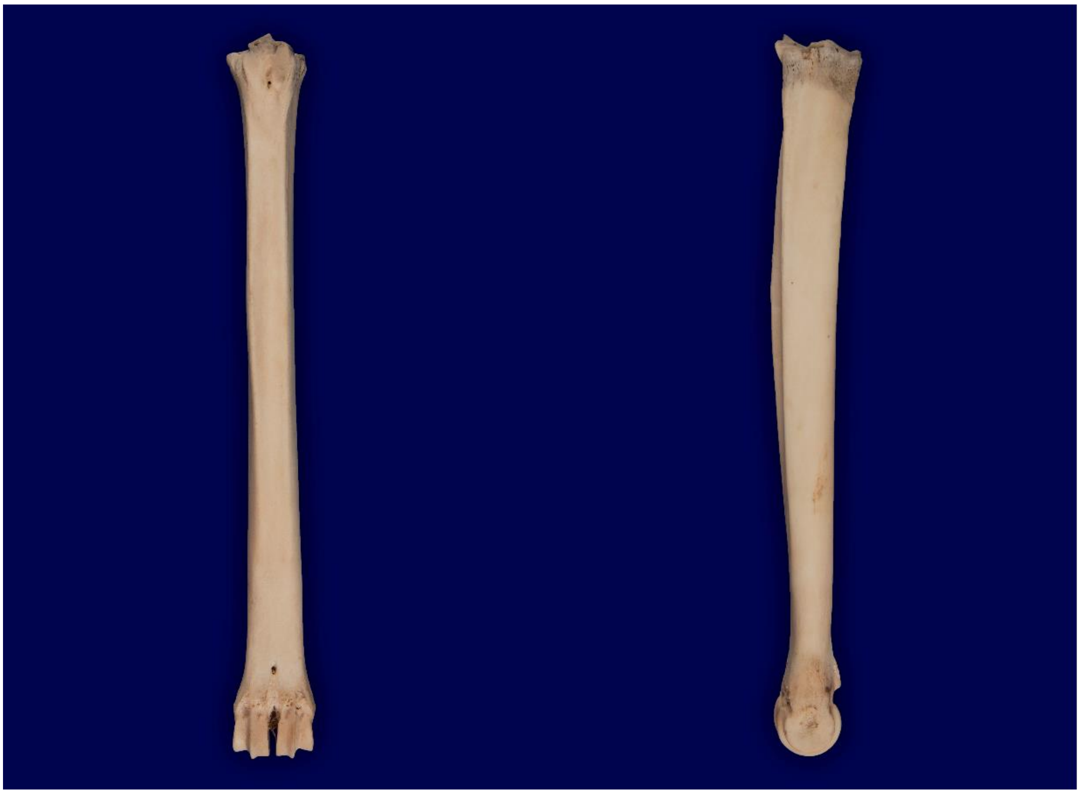

Figure 8 Digital photos of the cranio-caudal and medio-lateral views of a left impala metatarsus. Note the anatomical similarity with the metacarpus.

3.4.1 Fracture location

The first symbol of the alpha-numeric code represented the fractured bone involved; 1 – humerus, 2 – radius and ulna, 3 – femur, 4 – tibia, 5/6 – metacarpus or metatarsus (**Figures 9** and **10**). This was followed by the second symbol which represented the segment of bone over which the fracture was centred; 1 – distal, 2 – diaphyseal, 3 - proximal (**Figures 9** and **10**).[7] The proximal and distal segments were demarcated by using the Heim square rule, by drawing a numerical square over the epiphysis on a cranio-caudal radiographic projection.[43] The only exception was the proximal radius and ulna, where a rectangle incorporated the olecranon to demarcate the proximal segment of these two bones. The diaphyseal segment was located between the proximal and distal segments. In cases where fractures crossed the segmental borders, the location was determined based on the segment that included the larger portion of the fracture element.[15]

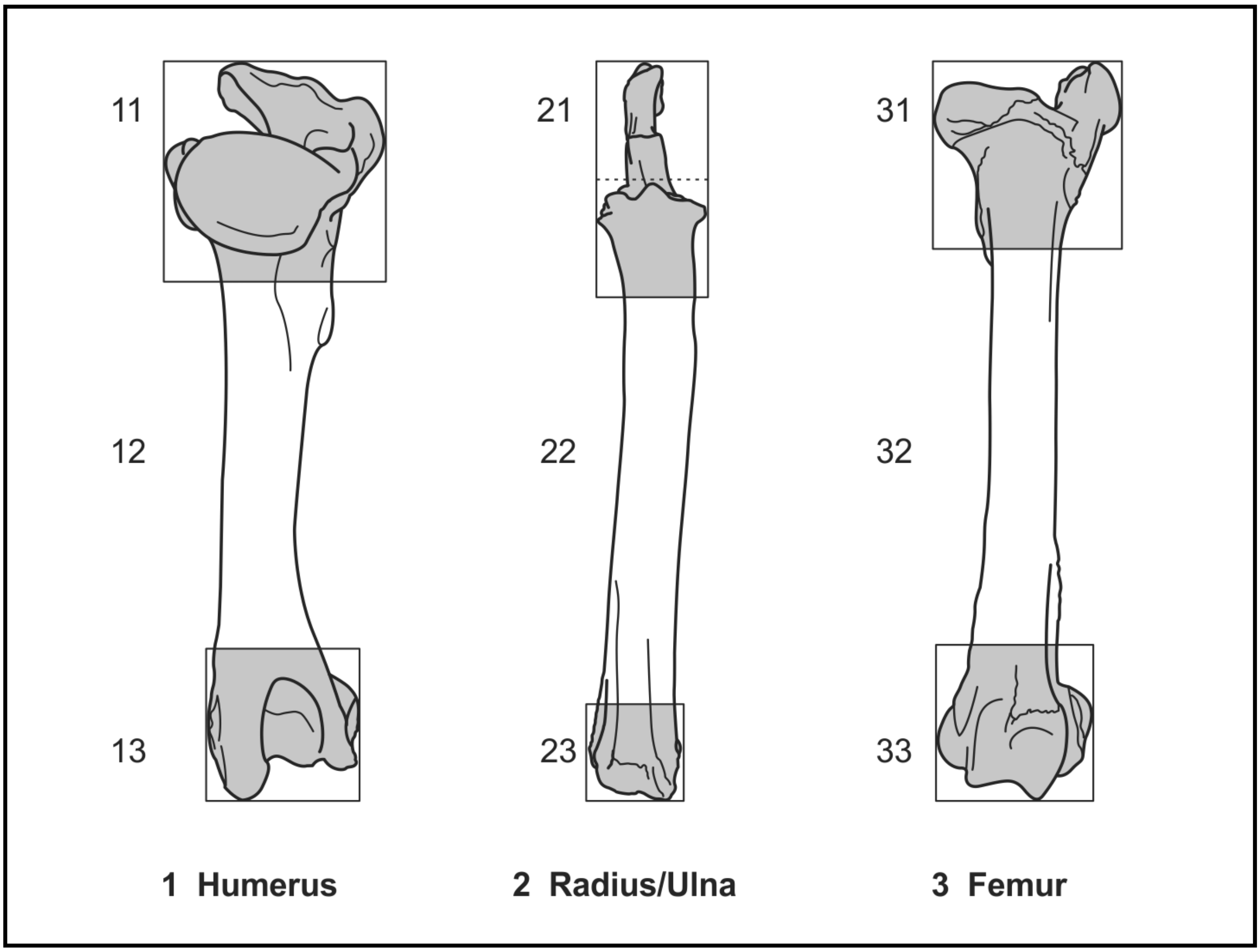

Figure 9 A cranio-caudal schematic illustration of numerical fracture location for a right humerus, right radius/ulna and left femur. First digit refers to the affected bone, second digit to the affected bone segment.

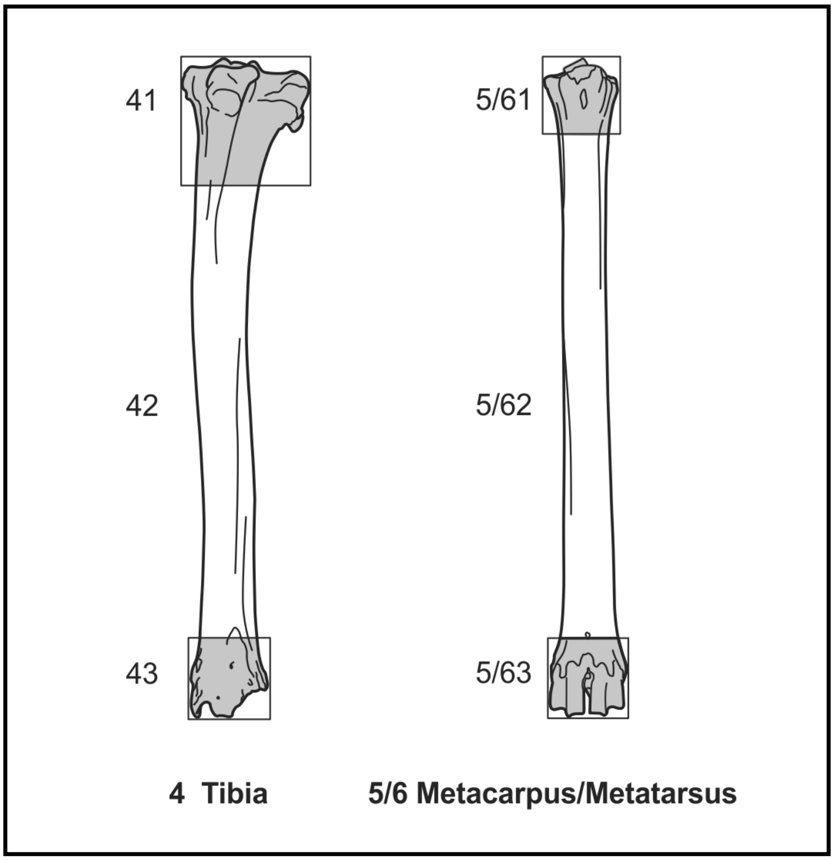

Figure 10 A cranio-caudal schematic illustration of numerical fracture location for a left tibia and a right metacarpus/metatarsus.

3.4.2 Fracture morphology

The third symbol of the alpha-numeric code represented fracture complexity, which in the diaphyseal bone segment, was based on the amount of cortical contact between the two main fracture fragments after envisaged reduction. Complete cortical contact in simple fractures was classified as (A), partial cortical contact in wedge fractures as (B) and no cortical contact in multi-fragmentary fractures as (C) (including segmental fractures) (**Figure 11**). Fracture complexity in the proximal and distal bone segments was based on the amount of articular involvement: Extra-articular (A) involved the metaphysis only, partial articular (B) involved either the lateral or medial aspect of a joint surface and complete articular (C) involved the metaphysis and the joint surface.

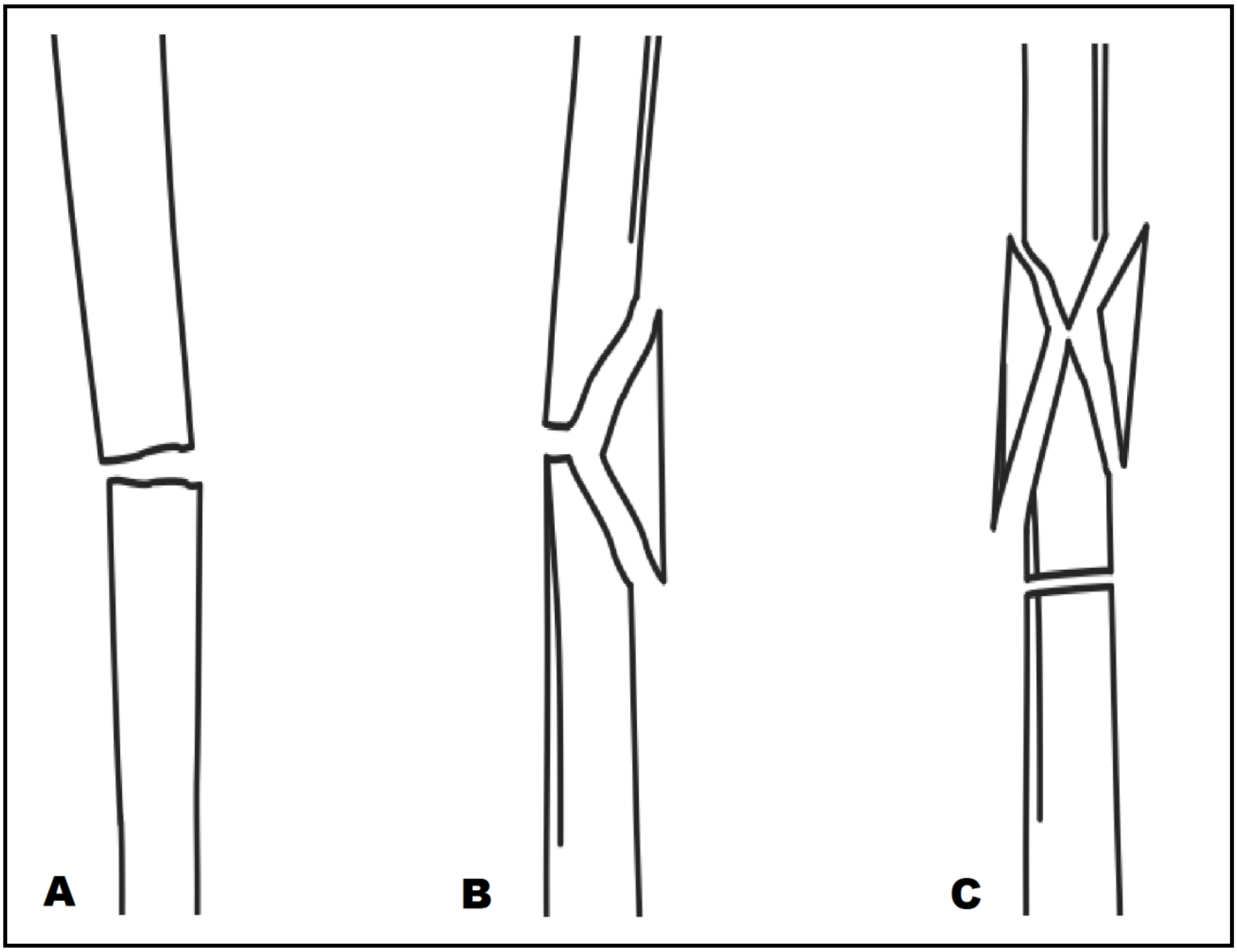

Figure 11 Illustration of simple (A), wedge (B) and multi-fragmentary (C) fractures.

The fourth symbol represented the fracture severity ranging from 1 to 3, with 3 being the most severe. This was based on the morphological complexity, difficulty of treatment and prognosis of the fracture.[7] For simple fractures in the diaphyseal bone segment the following definitions for fracture severity, as described by Unger, were used.[7]

Incomplete: A fracture line with only partial cortical disruption (mono-cortical or “greenstick” fracture) (**Figure 12A**).

Oblique: A fracture line with circumferential cortical disruption. The fracture line is more than 30º to the transverse plane of the bone (**Figure 12B**).

Transverse: A fracture line with circumferential cortical disruption. The fracture line is less than 30º to the transverse plane of the bone (**Figure 12C**).

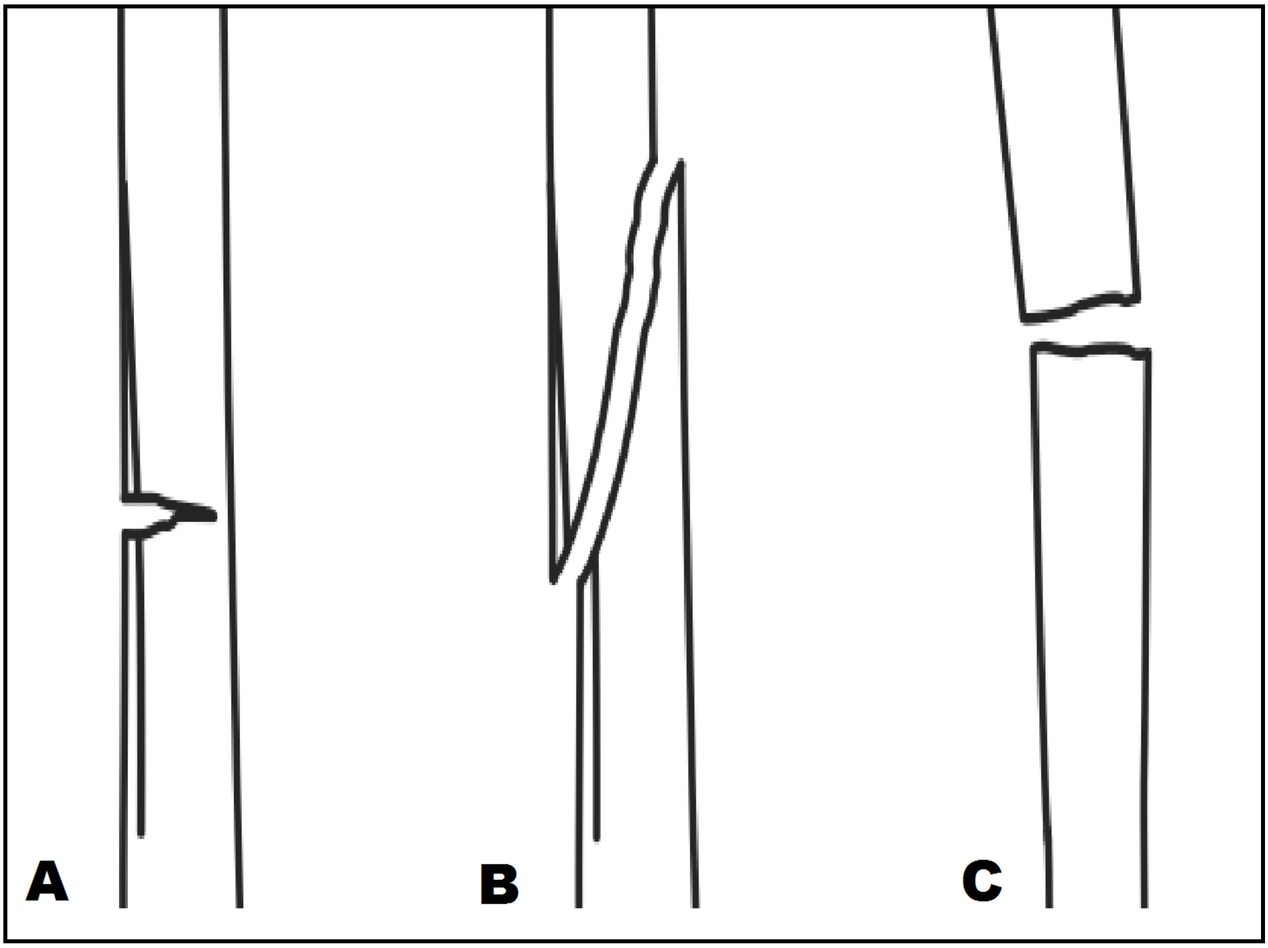

Figure 12 Illustration of incomplete (A), oblique (B) and transverse (C) fractures.

For wedge and multi-fragmentary fractures in the diaphyseal bone segment the following definitions for fracture severity, as described by Unger, are given below.[7]

Reducible wedge/s: An intermediate fragment (separate from the two main fracture fragments), with a length (y) and width (z) greater than one third of the mid-diaphyseal bone diameter (x), which amounts to $y + z > 1/3\ x$ (**Figures 13A, B** and **14**).

Non-reducible wedge/s: An intermediate fragment, with a length (y) and width (z) less than one third of the mid-diaphyseal bone diameter (x); $y + z < 1/3\ x$ (**Figures 13C** and **14**).

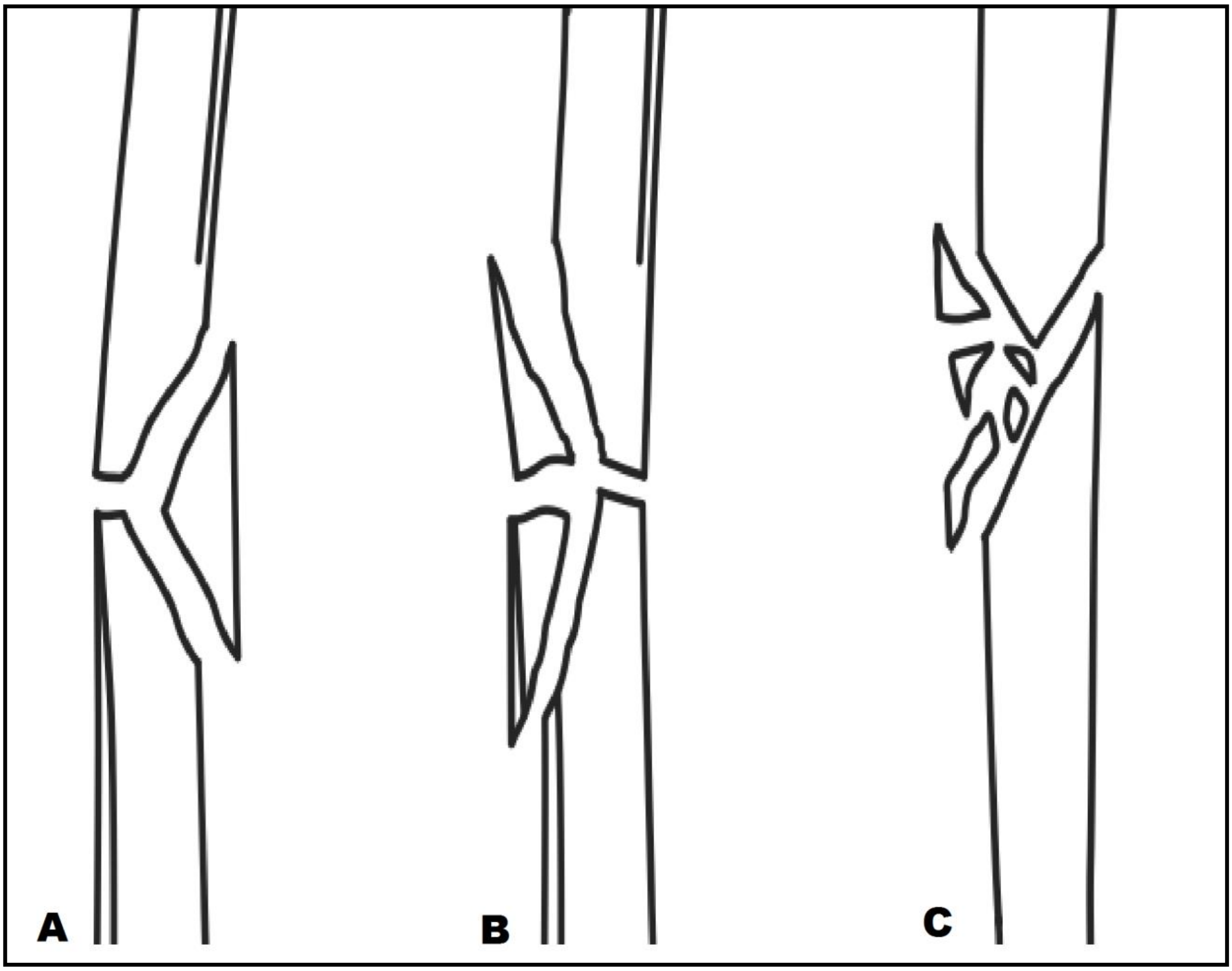

Figure 13 Illustration of reducible (A, B) and non-reducible (C) wedge/s.

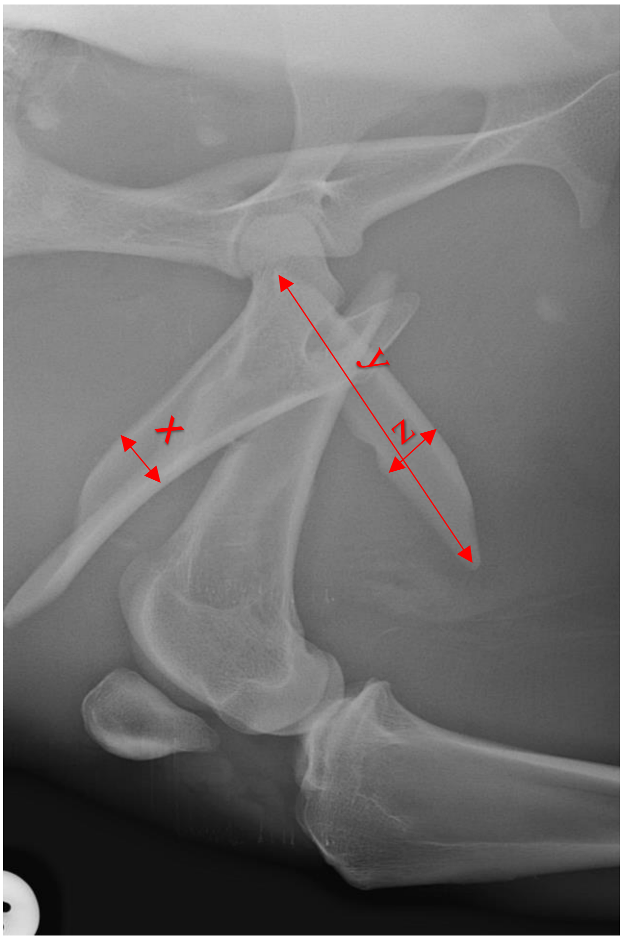

Figure 14 Medio-lateral radiographic view of a skeletally mature, impala ram with a 32B1 right femur fracture, caused by an immobilization dart. This figure illustrates measurement of an intermediate fracture fragment. The diaphyseal diameter (**x**), fragment width (**z**) and length (**y**).

Fracture severity for simple, wedge and multi-fragmentary fractures, in the proximal and distal bone segments, were based on the anatomy of the bone segments (e.g. lateral condyle, basicervical, medial malleolar), as well as some previously defined terms (including incomplete, simple, multi-fragmentary).[7]

Figures 15 to 19 illustrate typical individual long bone fractures with different locations, morphologies and severities which confirm the modified-Unger classification system in impala.

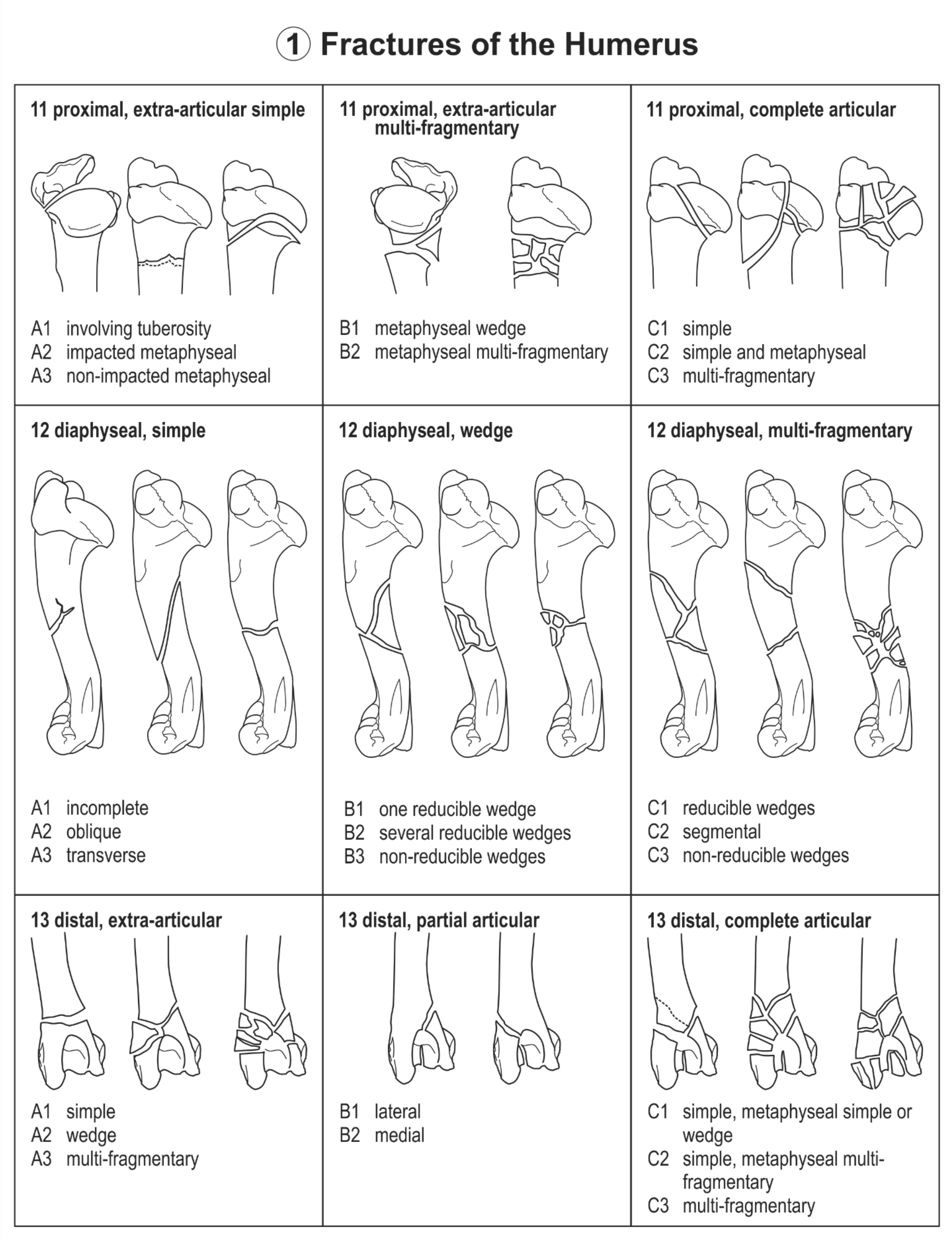

Figure 15 Cranio-caudal and medio-lateral illustrations of the different groups of right humerus fractures in impala.

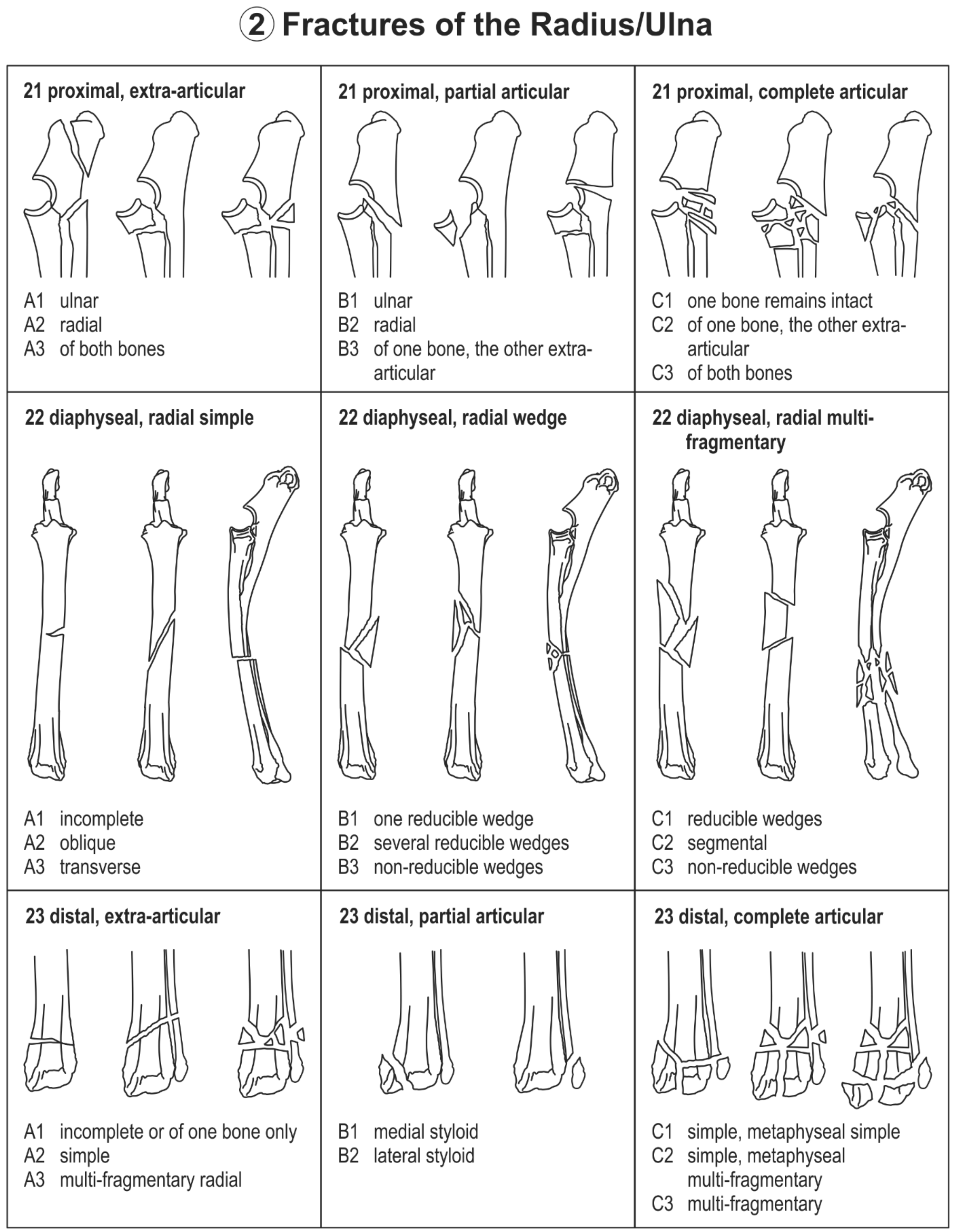

Figure 16 Medio-lateral and cranio-caudal illustrations of the different groups of right radius and ulna fractures in impala.

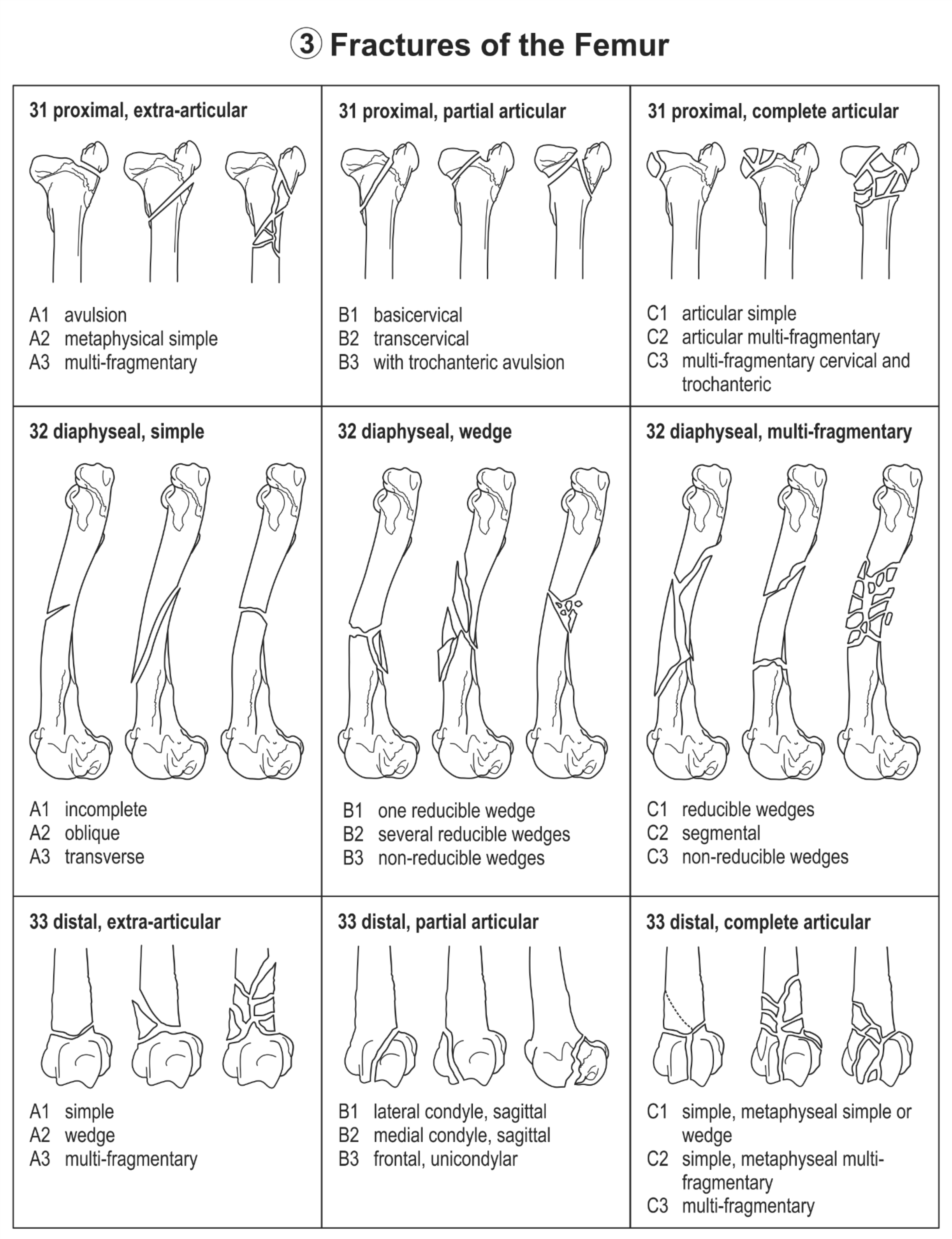

Figure 17 Cranio-caudal and medio-lateral illustrations of the different groups of left femur fractures in impala.

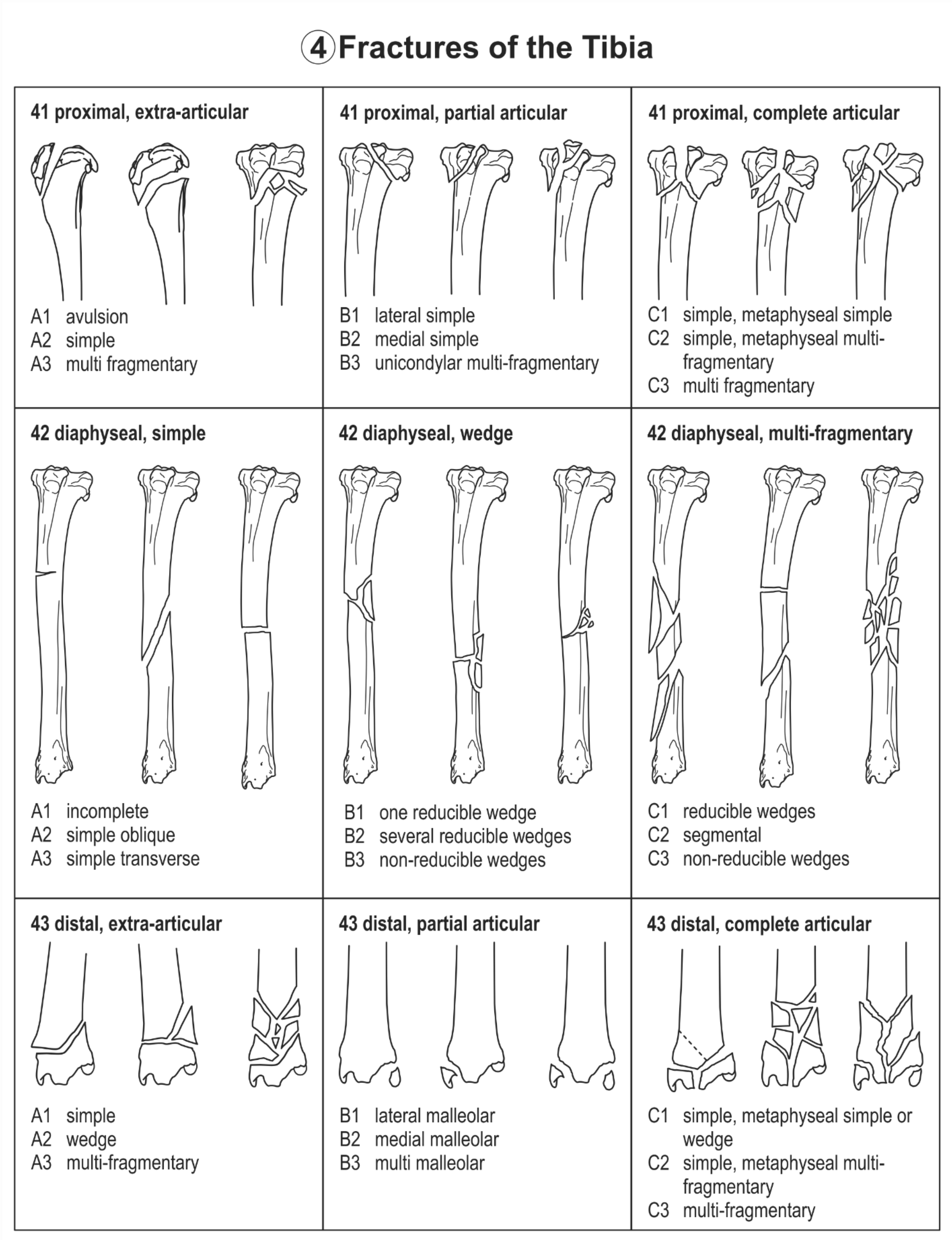

Figure 18 Medio-lateral and cranio-caudal illustrations of the different groups of left tibia fractures in impala.

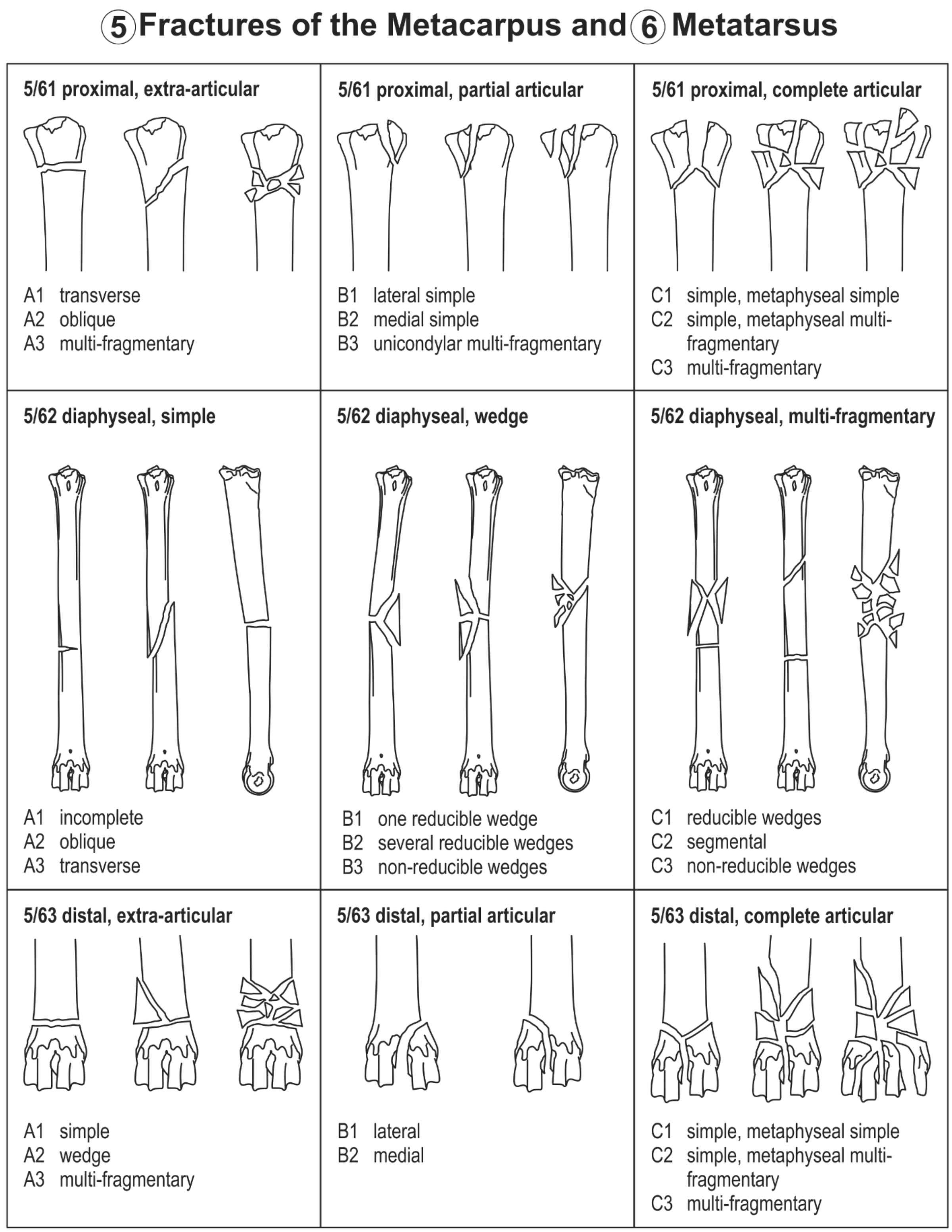

Figure 19 Cranio-caudal and medio-lateral illustrations of the different groups of right metacarpal and metatarsal fractures in impala.

3.5 Data collection

All veterinarians dealing with wildlife regularly in South Africa were invited to participate in this study by emailing them an invitation letter (**Annexure B**). Each responding veterinarian's practice was visited where digital images of long bone fractures of impala, were positively identified and copied onto an external hard drive as digital imaging and communication in medicine (DICOM) images. Any available radiographic images of contra-lateral limbs, intra-operative, post-operative or follow-up examinations were also collected. The treating veterinarian was required to complete an individual patient information consent form (**Annexure C**) which allowed the primary investigator to access to the patient details, history and other relevant data. An individual patient data capture sheet (**Annexure D**) was used to record the following data: patient identification number or name, signalment, body condition and reproductive status, information relating to husbandry, information relating to the fracture and treatment thereof, any follow-up information and the participating practice contact details. Additionally, radiographic images of long bone fractures in impala presented to and treated at the Onderstepoort Veterinary Academic Hospital (OVAH) from 2006-2018 were collected, together with any available radiographic images of contra-lateral limbs, intra-operative, post-operative or follow-up examinations. A back-up of each patient's data capture sheet and radiographic images were made on another external hard drive for safe keeping.

3.6 Data processing

All DICOM images were examined on a medical-grade, black-and-white two megapixel monitor (LG Electronics, Germiston, South Africa). The digital images were magnified and windowed, with brightness and contrast adjusted, to get the required optimal image quality. Radiographic images of non-diagnostic quality due to either incorrect exposure factors or radiographic artefacts, were omitted from the study. The amount of radiographic images of fractured long bones and normal long bones were recorded. Image blackening, peripheral blackening, gross image detail, orthogonal views and inclusion of joint surfaces were evaluated and recorded on a scale of 1 to 10 for diagnostic quality (**Annexure E**).

The diagnostic quality of 90% of the radiographic images studied, were rated six or more, out of 10.

Each fracture was classified and assigned a four symbol alpha-numeric code. The first symbol represented the fractured bone, the second symbol the segment of bone over which the fracture was centred, the third symbol the fracture complexity and the fourth symbol the fracture severity. Each fracture was classified using the modified-Unger fracture illustrations and the glossary of terms described above (**Annexure E**).

The sex of the patient was recorded from the patient data capture sheet. The skeletal maturity of each patient was recorded (**Annexure F**). This was determined by radiologically evaluating percentage physeal closure, apophyseal fusion or ossification of certain sesamoid or rudimentary bones (**Table 1**). Physeal closure was quantified as either 0% with the physis completely radiolucent, 50% with the physis partially radiolucent and 100% with the physis completely mineralised and a physeal scar visible. The same principle was applied to the amount of apophyseal fusion. For the sesamoid or rudimentary bone the percentage ossification was estimated at 0, 50 or 100% based on the normal size of the bone in question. A patient was considered skeletally mature once there was 100% closure, fusion or ossification on the radiographic image being studied.

Table 1 Anatomical landmarks used to determine skeletal maturity in impala.

Long Bone	Physis (%closure)	Apophysis (%fusion)	Other (%ossification)
Humerus	Proximal physis	Greater tubercle	
	Distal physis	Medial epicondyle	
		Lateral and medial trochlea	
Radius	Proximal physis		
	Distal physis		
Ulna		Olecranon tuber	
	Distal physis		
Carpus			Accessory carpal bone
Metacarpus 3+4	Distal physis		Rudimentary Mc 2+5
Femur	Head	Greater trochanter	Patella
	Distal physis	Lesser trochanter	
Tibia	Proximal physis	Tuberosity	
	Distal physis	Lateral malleolus	
Tarsus		Calcaneal tuber	
Metatarsus 3+4	Distal physis		Metatarsal sesamoid
			Rudimentary Mt 2+5

Any Salter-Harris fractures were recorded according to the Salter-Harris classification.[20,21] Fractures and fissure lines extending to articular surfaces were also recorded. Unlike articular fractures where the fracture is isolated to the proximal or distal segments of long bones, fissure lines extending to articular surfaces originated from a main fracture in the diaphyseal or metaphyseal segment, extending proximally or distally to the articular surface. Joint luxations, defined as the separation of articular surfaces, or a joint that has lost all contact between the articular surfaces, were recorded. Sub-luxation was classified as a joint that still had a degree of contact between the articular surfaces, which was also recorded (**Annexure G**).[44]

The open or closed status of the fracture, fracture associated soft tissue defects, amount and area of gas opacities and amount of soft tissue swelling were recorded. Open fractures were defined when gas opacities were visible within soft tissue planes or where the ends of the fracture fragments extended beyond the soft tissue plane of the skin, indicating exposure of the fracture fragments. Fractures with dart needles present or a dart gas tract were also classified as open fractures. A subjective grading system for soft tissue swelling was developed. The amount of soft tissue swelling was graded based on the increased diameter and opacity of the soft tissues associated with the fracture. The positioning of the limb and possible effect of superimposition and magnification was taken into account with this grading. The grading ranged from 1 to 4 for slight, mild, moderate and severe soft tissue swelling, respectively (**Annexure G**).

The presence, amount, direction and length of any fissure lines associated with the fracture were recorded. All fractures were assessed for the presence of a periosteal reaction. The periosteal reactions were classified as follows; 0, no periosteal reaction; 1, non-aggressive periosteal reaction; 2, aggressive periosteal reaction. A non-aggressive periosteal reaction was defined as a periosteum with either a regular, uninterrupted, smooth or rough, solid, lamellar, thick brush border or palisading margin. An aggressive periosteal reaction was defined as a periosteum with either an interrupted, irregular, spicular, sunburst or amorphous margin (**Annexure H**).[44]

The amount and direction of fracture displacement and fracture fragment rotation was recorded for each radiographic view. The amount of fracture displacement was determined by measuring, in the centre of the fracture element, the distance between longitudinal axes of the main fracture fragments, on each radiographic view (**Figure 20**). The possible cause of each fracture was also recorded (**Annexure H**).

Figure 20 Medio-lateral radiographic view of a skeletally immature, impala ewe with a 32B2 right femur fracture, caused by an immobilization dart. Fracture displacement was determined by measuring, in the centre of the fracture area, the distance between longitudinal axes of the main fracture fragments.

All fracture treatments were recorded on the treatment datasheet (**Annexure I**). The date when the post-operative radiograph was taken, the amount of radiographic images and the diagnostic quality was also recorded in this annexure. Where pin casts were used, the type of transfixation pins and the number of pins proximal and distal to the main fracture line were recorded separately. For external skeletal fixators the configuration type, type of transfixation pins as well as the amount of pins in the proximal and distal fracture fragments were recorded. For internal fixation methods, where cerclage wires were used, the type of knot and the amount of wires used were recorded. When plates and screws were used for internal fixation the type of plate, the length of the plate as well as the type and number of screws in the proximal and distal fracture fragments were recorded separately.

3.7 Statistical analysis

This was a descriptive study and no statistical data analysis was performed. The fracture distribution data was recorded and percentages for each component calculated and reported.

4 RESULTS

One hundred and twenty two radiographic images of long bone fractures were studied. Seven radiographic images of normal long bones were also studied. The modified-Unger classification was found to be applicable to 58 long bone fractures in 55 impala. Most patients (52 impala) had isolated fractures involving a single bone while three patients had multiple fractures. Of these three patients, one patient had bilateral humerus fractures, one patient had a metacarpal and an ipsilateral metatarsal fracture and one patient a radius/ulna fracture and a contralateral metatarsal fracture.

The fracture distribution based on location found that tibial (n=17, 29%), metacarpal (n=13, 22%) and metatarsal (n=11, 19%) fractures were most common. The anatomically similar metacarpal and metatarsal fractures combined, made up 41% of all fractures. Seventy eight percent of the cases had diaphyseal fractures. The overall fracture distribution based on location is shown below (**Figure 21**).

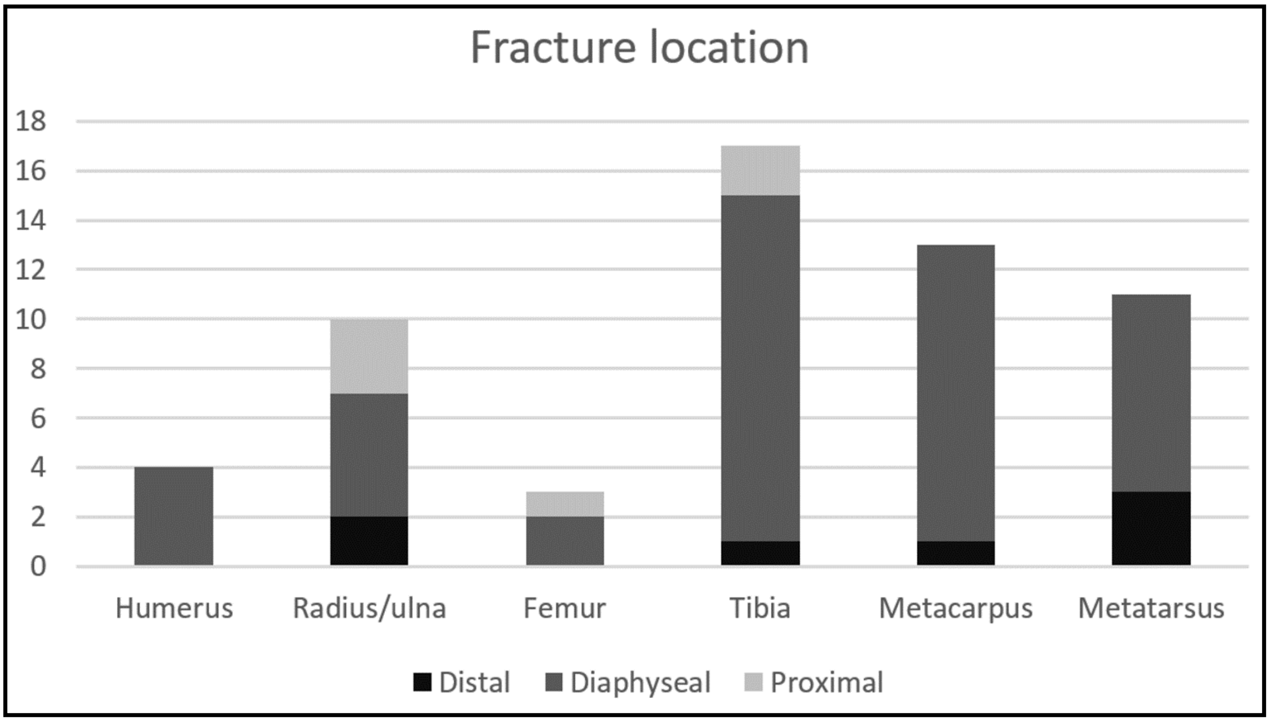

Figure 21 Fracture distribution in impala long bones based on location.

Aside from the 58 long bones fractures, one multi-fragmentary calcaneus fracture (caused by an immobilization dart) (**Figure 22)**, three fractures of the first phalanx; simple (n=1), wedge (n=1) and multi-fragmentary (n=1) and one metacarpo-phalangeal joint luxation were separately recorded.

Figure 22 Medio-lateral radiographic view of a skeletally immature impala ram with a multi-fragmentary left calcaneus fracture, caused by an immobilization dart.

The fracture distribution based on morphology was 46% simple (**Figure 23**), 28% wedge (**Figure 24**) and 26% multi-fragmentary fractures (**Figures 25** and **26**). Ten out of the 11 metatarsal fractures were simple type fractures, with the rest of the individual long bones, including the metacarpal fractures, having a near equal distribution of simple, wedge and multi-fragmentary fractures. Thirty six percent of fractures were classified severity 1, 36% severity 2 and 28% severity 3.

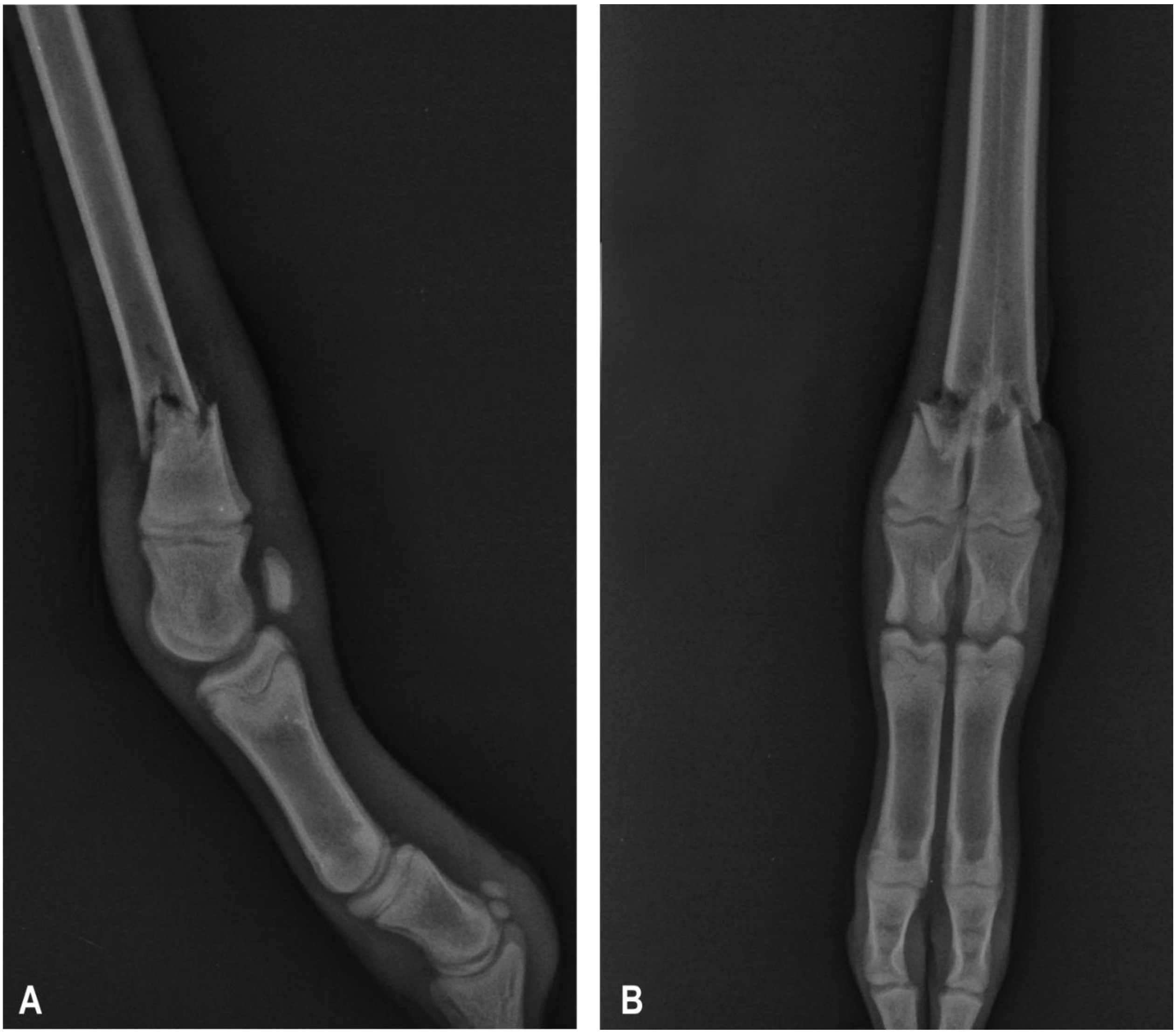

Figure 23 Medio-lateral (A) and cranio-caudal (B) radiographic views of a skeletally immature, impala ewe with a 63A2 left metatarsus fracture, cause unknown.

Figure 24 Medio-lateral (A) and cranio-caudal (B) radiographic views of a skeletally immature, impala ewe with a 32B2 left femur fracture, caused by an immobilization dart. Note the metallic dart needle in A and dart gas tract in B (arrow).

Figure 25 Medio-lateral (A) and cranio-caudal (B) radiographic views of a skeletally mature, impala ram with a 42C3 left open tibia fracture, caused by an immobilization dart.

Figure 26 Medio-lateral (A) and cranio-caudal (B) radiographic views of a skeletally immature, impala ram with a 52C3 right metacarpal fracture, cause unknown.

The sex of 35 cases were recorded of which 57% were rams and 43% ewes. Fifty seven percent of the affected patients were colour variations of impala. Based on growth plate closure and apohyseal fusion, 68% of cases were skeletally immature and 32% mature. Fifty percent of the fractures in immature patients were simple type fractures, compared to 43% in mature patients.

Two Salter-Harris Type 1 fractures were recorded, one distal metatarsal and one femur head fracture. Four intra-articular fractures were recorded which affected the proximal radius/ulna (n=3) and proximal tibia (n=1). Forty eight percent of fractures were open based on the assessment of fracture associated soft tissues, skin defects and gas opacities. Eighty two percent of the tibial fractures were open (**Figure 25**). Forty one percent of the open fractures were simple type fractures. Thirty nine percent of cases had slight, and 50% mild soft tissue swelling associated with the fracture.

Fissure lines were detected in 34% of cases. Fissure lines extending proximally (n=10) and distally (n=12) or in both directions (n=4) were recorded. The average length of the fissure lines extending proximally was 40 mm and distally was 24 mm. Forty five percent of the fractures with fissure lines were simple fractures. Fissure lines extending into the proximal (n=1) and distal (n=1) articular surfaces were recorded in two fractures, both were associated with multi-fragmentary fractures.

Eighty two percent of all cases had no periosteal reaction associated with the fracture. Fracture displacement in a cranio-caudal (n=32), medio-lateral (n=23) and proximo-distal direction (n=26) was recorded. The average displacement in a cranio-caudal direction was 18 mm, medio-lateral 16 mm and proximo-distal 32 mm.

The cause of the fractures varied from iatrogenic fracture due to an immobilization dart (n=6, 10% of fractures), fighting (n=1) and stuck in fence (n=1) with the cause in the majority of fractures unknown (n=50, 86% of fractures). Fractures caused by an immobilization dart could be identified based on history, the presence of an immobilization dart, dart needle or a dart gas tract, associated with the fracture (**Figures 24** and **27**). Of the six fractures caused by an immobilization dart, five affected the hind limb, with femur (n=2) and tibia (n=3) fractures recorded. Of these fractures four were wedge and two multi-fragmentary. Four of the six patients were skeletally immature. Three ewes and two rams were recorded, of which the sex of one patient not available in patient records.

Figure 27 Medio-lateral (A) and cranio-caudal (B) radiographic views of a skeletally immature, impala ram of a 42B2 left tibia fracture, caused by an immobilization dart.

Fracture treatments comprising of a range of internal and external fixation methods, or combinations thereof, were recorded in 28 cases (48% of all fractures) of which only 11 had follow-up radiographs. Most patients were treated with external fixation (n=18) only, followed by internal fixation (n=6) or internal and external fixation combined (n=4). Of all the fractures treated 48% were simple, 24% wedge and 28% multi-fragmentary. The following fixation methods were recorded for external fixation: Modified Robert Jones bandage (n=3), casting (n=2), pin casting (n=2), Type 1 (n=6), Type 2 (n=1), circular (n=1) and Illizarov external skeletal fixation (n=9) (**Figures 28** to **30**). For internal fixation, dynamic (n=1) and locking plate and screws (n=4), intra-medullary (IM) (n=6) and positional pins (n=1), cerclage wires (n=8) and lag screws (n=1) were recorded (**Figures 31** and **32**). Twelve patients were treated with combinations of fixation methods (**Figures 33** and **34)**. Clinical outcome based on the different fracture treatments was erratic and could not be standardized.

Figure 28 Medio-lateral (A) and cranio-caudal (B) radiographic views of a skeletally immature, impala ewe with a 52C3 left metacarpal fracture, treated with pin casting.

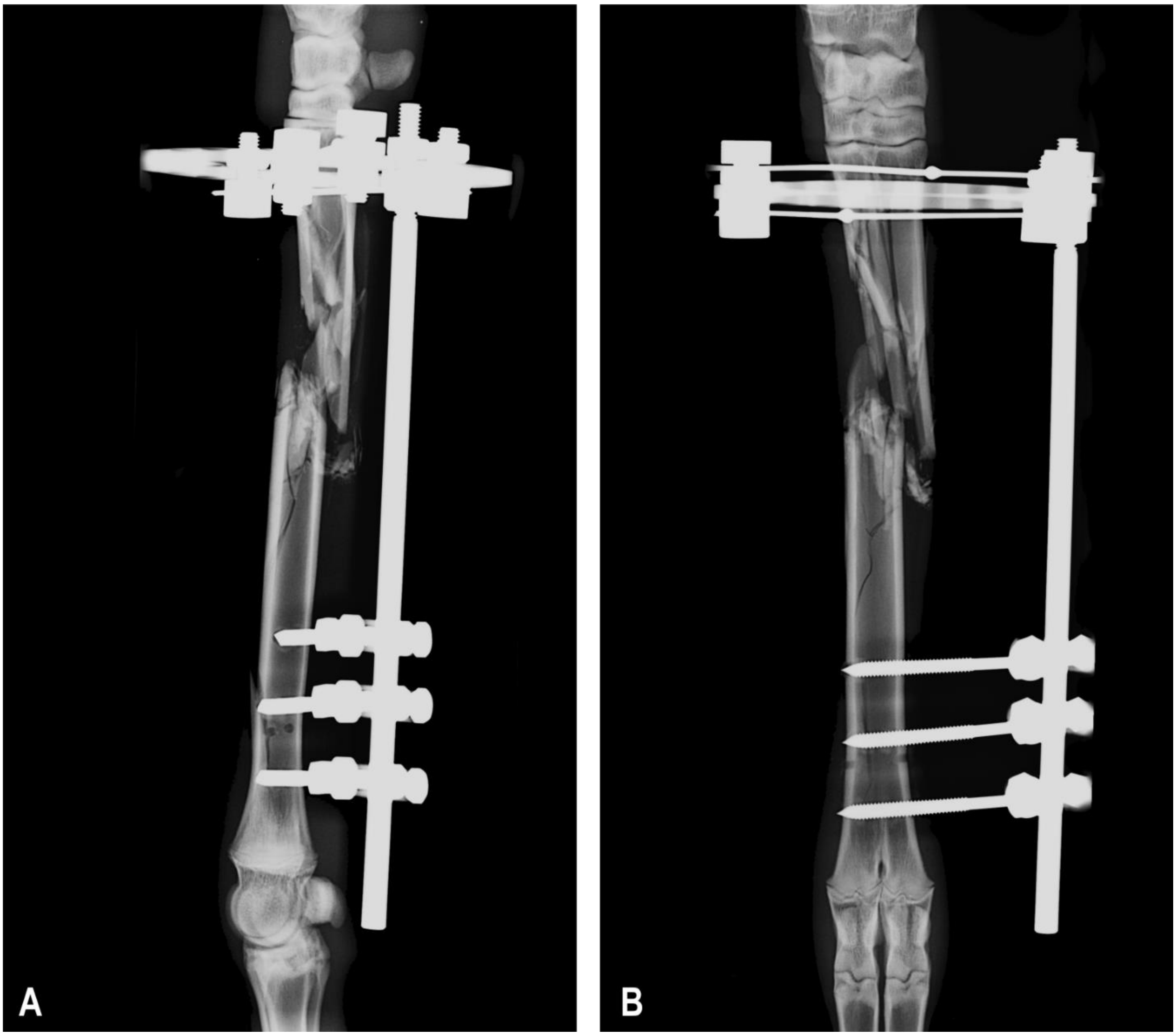

Figure 29 Medio-lateral (A) and cranio-caudal (B) radiographic views of a skeletally immature, impala ram with a 52C3 right metacarpal fracture, treated with a hybrid Type 1, circular external skeletal fixator.

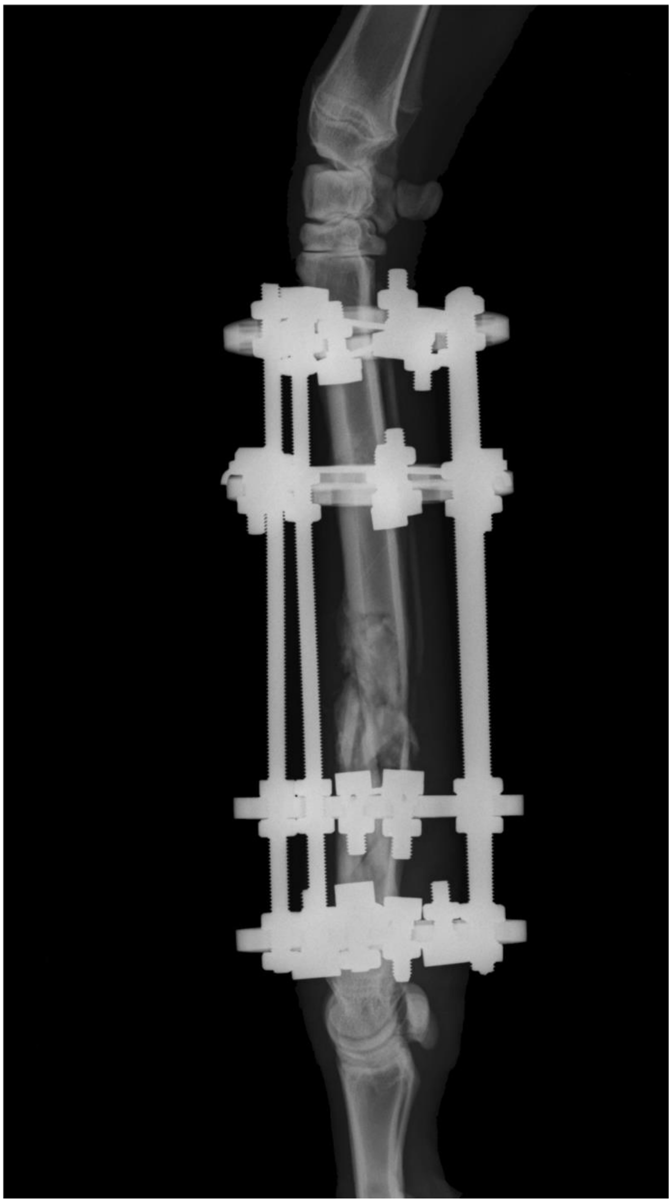

Figure 30 Medio-lateral radiographic view of a skeletally immature, impala ewe with a 52C3 right metacarpal fracture, treated with an Illizarov external skeletal fixator.

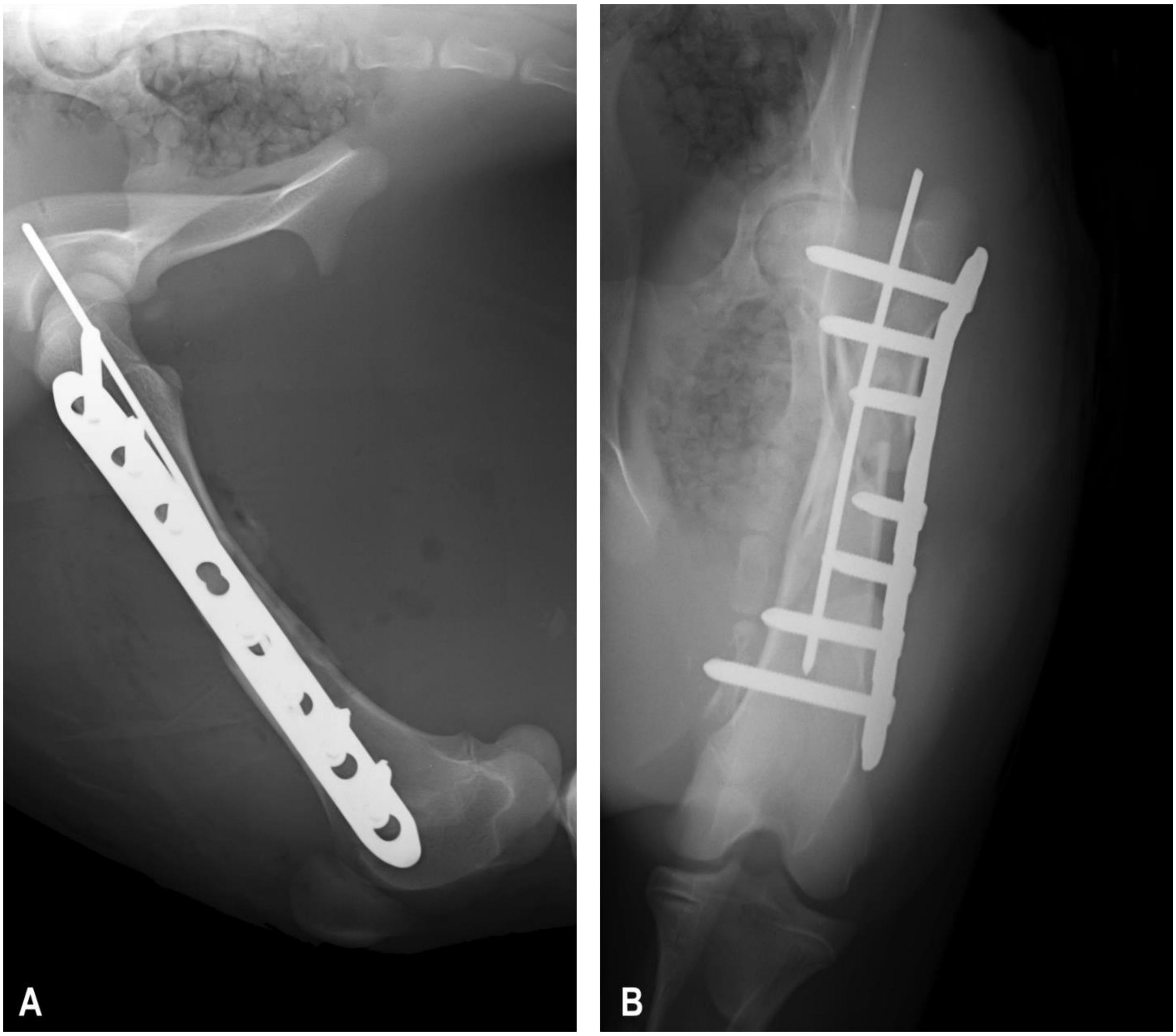

Figure 31 Medio-lateral (A) and cranio-caudal (B) radiographic views of a skeletally immature, impala ewe with a 32B2 left femur fracture, treated with a locking plate and screws and an intra-medullary pin.

Figure 32 Medio-lateral radiographic view of a skeletally immature, impala ram with a 42A2 right tibia fracture, treated with an intra-medullary pin and cerclage wires.

Figure 33 Medio-lateral (A) and cranio-caudal (B) radiographic views of a skeletally mature, impala ewe with a 12C1 left humerus fracture, treated with a combination of internal and external fixation. A metallic swab marker is present unrelated to the fixation.

Figure 34 Six weeks post-operative, medio-lateral radiographic view of a skeletally mature, impala ram with a 42A2 right tibia fracture, treated with an intra-medullary pin and cerclage wires, combined with a Type 1 external skeletal fixator.

5 DISCUSSION

The Arbeitsgemeinschaft für Osteosynthesefragen/Association for the Study of Internal Fixation foundation together with the Orthopaedic Trauma Association published a fracture classification for humans which was based on the principles of the Comprehensive Classification of Fractures of the Long Bones developed by Müller.[8,45,46] This compendium brought order to the state of fracture classification in human orthopaedics, which due to its multiple systems, made standardized language and accumulation of uniform data nearly impossible. It ensures an updated and standardized, rational methodology of describing fractures and dislocations in humans, as well as a mechanism to code data for analysis and research.[42] Since its publication, it has been regularly used in human trauma databases, scientific journals and textbooks.[42] Veterinary science will greatly benefit from a similar intervention, which can unify and update fracture classifications to be more aligned with current treatment principles.

Fracture classification systems aim at improving clinical record keeping.[24] Long term benefits accrue when the clinician wishes to obtain complete and statistically relevant data for publication, which could serve as foundation for further anatomical, biomechanical and clinical studies based specific fracture locations or morphologies.[24] In order to enable wider participation, it is necessary to use a common language when studying fractures.[24]

In this study an existing fracture classification was modified to ensure that standardized terminology was used when classifying fractures based on location and morphology. In our study the removal of the hyphen in the fracture code facilitated data entry and reduced error rate.[42] Care was taken not to drastically deviate from the Unger classification, with only minor changes allowing for a more uniform classification.

The skeletal anatomy of the impala was incorporated into the fracture illustrations, resulting in an anatomically all-inclusive classification. This allowed easy identification of fracture types and locations, as well as facilitated interpretation of the fracture glossary.

For fracture location, the Heim square rule was applied to the unique skeletal anatomy of the impala.[43] In our study the demarcation of zones for the radius and femur were simplified, removing the special demarcation based on the radial tuberosity or the minor trochanter as described by Unger.[7] In impala, the radius and ulna are fused and the fibula is vestigial. The radius and tibia were consequently classified as individual weight bearing bones.

In fracture morphology descriptions, the terms complex or comminuted are confusing and were replaced with multi-fragmentary which is more suited for fractures with no cortical contact after envisaged reduction.[42] In our study the classification of intermediate fragments was based on their size and possible incorporation in surgical reduction, resulting in the classification of either reducible or non-reducible wedges. Current principles on fixation of multi-fragmentary fractures however, have evolved towards bridging fixation and secondary bone healing, decreasing the inter-fragmentary strain by not anatomically reducing wedge/s.[47] Consequently, in human fracture classifications, intermediate fragments are classified as either intact (single) or fragmentary (multiple) wedges, which is more aligned with current treatment principles.[42,48] The incorporation of this concept into prospective veterinary fracture classifications is justified.

Fracture severity is based on its inferred relationship between difficulty of repair and worsening prognosis.[24] Because of the effect that fissure lines and open fractures have on repair and prognosis, a recommendation can be made to include open or closed status and presence of fissure lines as additional criteria under fracture severity for future studies.[16]

As with impala in South Africa, the increasing popularity of camelids in North America has increased their need for veterinary care, with camelid fractures becoming part of the normal caseload.[49] Due to anatomical similarities, the classification developed in this study can potentially be applied to long bone fractures in other ungulate species. Similar to our findings, the tibia is the single most commonly fractured long bone in llamas, alpacas and camels.[38-40] However, in a study of goats the metacarpus was reported the most commonly fractured long bone.[36] When the two anatomically similar bones were combined, the metacarpus and metacarpus were the most commonly fractured long bones in goats, llamas and alpacas, as well as in our impala.[36,38] The diaphysis was reported to be the most commonly affected bone segment in llamas, alpacas and camels as in our impala.[38-40]

The fracture morphology reported for llamas and alpacas were mostly comminuted fractures, which differs from our results where only 28% of fractures were multi-fragmentary.[38] Similar to our study, the most common fracture morphology in camels however, were simple fractures.[39,40] Apart from long bones, these two studies also included fractures of the head, neck and mandible, which could have biased the fracture morphology results.

A higher percentage of fractures were found in impala rams, probably because of their breeding potential and associated monetary value, leading to more capture related injuries. However our study recorded more ewes affected by immobilization darts, likely as a result of reduced muscle mass protecting the long bones in ewes. Rams are frequently involved in seasonal territorial fighting, which might further increase the risk of trauma and consequent long bone fractures.

A higher incidence of fractures in goats under 6 months of age has been reported.[36] In another study they found 53% of long bone fractures in llamas and alpacas affected skeletally immature patients.[38] One study performed on young camels found more fractures in camels under 6 months of age, where another study found only 28% of fractures occurred in camels under one year of age.[39,40] Our study reported 68% of long bone fractures occurred in skeletally immature patients. None of the above mentioned studies reported the amount of Salter-Harris type fractures encountered. In our study only two Salter-Harris type fractures were recorded (0.03%), which is low when compared to 30% of fractures involving the physis in small animals (135 cases) and 21% in equines (70 cases). [21,22]

The mechanical behaviour of bone is dependent on the type and density of bone, the amount, rate and direction of the applied load and the age and health status of the patient.[50] Because of the viscoelastic properties of bone, the more rapidly a bone is loaded, the stiffer it becomes and the more energy it stores. Once rapidly loaded bone reaches the failure point, more multi-fragmentary fractures, fissure lines and greater soft tissue compromise occur.[47] Biomechanical and bone ash determination studies based on equine cannon bones revealed that the degree of mineralization relates to the mechanical properties of the bone.[51] Studies analyzing the ash and collagen content as well as high density bone particles from samples in different species found that sheep have denser bone when compared to humans, dogs and pigs due to higher mineral and lower collagen content, as well as higher proportion of high density bone particles.[52,53] Similarly it is possible that antelope species may also have denser bones when compared to other species, which could explain a high percentage multi-fragmentary fractures and open fractures recorded in this study.

Various clinical classifications have been developed for open fractures which are designed to correlate with treatment guidelines and prognosis, and alert the surgeon to the complexity and magnitude of the soft tissue disruption.[16] In our study fractures were classified as open, based on radiographic signs only. Insufficient data were available to clinically classify open fractures, which precluded comparison with treatment and prognosis. Our study reported 53% of cases having open fractures, whereas 32% open fractures in llamas and alpacas, and 66%-45% compound fractures in camels have been reported.[38-40] The treatment of open fractures in camelids is wrought with complications, including delayed or non-union, sequestrum formation and osteomyelitis. In this species mature animals were better able to overcome osteomyelitis associated with open fractures than juveniles, where growth plate injuries and joint infections occurred commonly.[49] The proportion of open fractures in small animal patients has been reported as between 5% to 10% of trauma-induced fractures.[54] However a recent study found open fractures in 14% and 29% of trauma induced fractures in dogs and cats respectively.[55] Interestingly this study also found that even though younger dogs were more likely to have a traumatic fracture, older dogs were more likely to have an open fracture. The authors speculated that the physical properties of a mature skeleton could possibly influence the fracture configuration and the likelihood of an open fracture.[55] Body weight was also found to be a risk factor for the occurrence of open fractures, where larger dogs were four times more likely to develop open fractures than small dogs.[55] It is possible that the amount and rate of the applied load necessary to cause a fracture in a larger dog is of such an extent that it will disrupt the soft tissue integrity. Our study found open fractures occurred more in skeletally immature (67%) than skeletally mature (33%) impala. Despite the high number of open fractures recorded in our study, the majority of the fractures had no periosteal reaction associated with the fracture at the time of diagnosis, which could be due to the possible acute nature of the fracture.

Comminuted fractures were the only fracture configuration found to be a significant risk factor for the development of open fractures in both dogs and cats, which is consistent with the fact that high energy and velocity trauma causes both open and comminuted fractures.[55] Interestingly, our study found that a relatively high proportion of open fractures were associated with simple type fractures. In these cases, the limited soft tissue envelope of the more distal long bones in impala, might have rendered simple fractures open, and not as result of excessive force. Our study also found that most of the fractured bones that also had fissure lines, were simple fractures. This result questions whether fissure lines are caused by rapidly applied forces (in which case more fissure lines would be associated with multi-fragmentary fractures), or rather other biomechanical properties intrinsic to the forces applied or the impala long bones. No conclusion can be drawn from the amount of fracture displacement recorded. Multiple variables were created due to the influence of positioning and magnification on fracture displacement.

As in our study, primary causes of fractures in alpacas and llamas are thought to be traumatic, though the exact cause is not reported and mostly unknown by the owners.[50] The fracture cause in impala was difficult to determine due to the extensive nature of their habitat. High impact trauma during in-fighting or escape from predation are suspected causes. In a study done on the causes of impala mortality in 20 game farms in Zimbabwe, it was found that 45% of all mortalities were associated with capture. Two long bone fractures were reported to be associated with capture and another two long bone fractures associated with non-capture traumatic injuries.[56] The excessive flight response of impala during capture or other managerial activities, combined with small camps or unknown environments, could predispose to long bone fractures in impala. The morphological and radiographic anatomy of the metacarpal and phalangeal bones of impala, when compared to domesticated ruminants, are narrower, shorter and lighter. The distal segments of impala long bones are believed to represent a distinctive, evolutionary structural modification to facilitate movement to escape predation.[57] This modification could however have predisposed to the development of long bone fractures.

Domesticated ruminants are ideal patients for conservative treatment of appendicular fractures because they are easily confined, spend most of the day being recumbent, are more resistant than other animals to contralateral stress laminitis, and generally do not resist external coaptation.[35] Long bone fractures can be treated with either external coaptation, like low-limb or full-limb casting, a modified Thomas splint, external skeletal fixation, internal fixation or combinations of these fixation methods.[35] In small domestic ruminants and llamas, external skeletal fixation is indicated for severely comminuted fractures, distal or proximal metaphyseal fractures and fractures that can't be repaired with internal fixation. In these species fractures of the metacarpal and metatarsal bones, radius and ulna, and tibia are commonly stabilised with external skeletal fixation.[58]

Our study recorded a wide variety of different fracture fixation methods used to treat long bones fractures in impala. Even though most of the patients were treated with external skeletal fixation, only 28% of the treated fractures were multi-fragmentary. Due to the high anaesthetic risk in impala and relative ease of application, treating veterinarians often revert to external skeletal fixation, irrespective of the fracture morphology. Facilities and equipment needed for internal fixation, when fracture morphology dictates it, is frequently unavailable or is accompanied with significant anaesthetic risk and logistical issues. The limited follow-up data available, unfortunately prohibited the authors from making any meaningful conclusion on the outcome of the different treatment options recorded in this study.

To date no fracture classification system for long bone fractures in ungulate species has been published. According to the authors this is the first fracture classification system for long bone fractures in ungulate species, containing the metacarpus and metatarsus. The results of this study will form the foundation for further anatomical, biomechanical and clinical studies of the more common fractures reported, to ultimately develop an ideal fracture treatment methodology for impala and other small antelope.

6 LIMITATIONS

The retrospective nature of this study precluded the use of standardized radiographic positioning and exposure setting. However the quality of the majority of the radiographs were rated good to excellent by the authors. This is due to the digital radiography systems used by the participating veterinarians. The relatively low total number of radiographs and fracture recorded in this study is inherent to the fact that impala are not domesticated. The limited follow-up data of the diferent fracture fixation methods applied, as well as the diversity of methods, prohibited the authors from making any meaningful conclusion or recommendation based on the different treatment options.

7 CONCLUSION

The modified-Unger fracture classification was found to be applicable in classifying 58 long bone fractures in impala, and facilitated determining long bone fracture distribution. This classification, resultant fracture distribution and reported fracture fixation methods, should provide a foundation for further advances in veterinary and comparative ungulate, and particularly antelope, orthopaedics and traumatology.

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ANNEXURES

ANNEXURE A: Animal ethics committee approval form

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Animal Ethics Committee

PROJECT TITLE	**Radiographic study of appendicular fractures in impala *(Aepyceros melampus)***
PROJECT NUMBER	**V141-16**
RESEARCHER/PRINCIPAL INVESTIGATOR	**Dr. FG van Heerden**

STUDENT NUMBER (where applicable)	**UP_043 726 738**
DISSERTATION/THESIS SUBMITTED FOR	**MMedVet**

ANIMAL ANIMALS	**Impala *(Aepyceros melampus)***	
NUMBER OF ANIMALS		
Approval period to use animals for research/testing purposes		**November 2016-November 2017**
SUPERVISOR	**Dr. MJ Hartman**	

KINDLY NOTE:

Should there be a change in the species or number of animal/s required, or the experimental procedure/s - please submit an amendment form to the UP Animal Ethics Committee for approval before commencing with the experiment

APPROVED	Date 28 November 2016
CHAIRMAN: UP Animal Ethics Committee	Signature

S4285-15

ANNEXURE B: Invitation letter

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Veterinary Science

Department of Companion Animal Clinical Studies

Small Animal Surgery Section

January 2017

RE: Radiographic study of appendicular fractures in impala (*Aepyceros melampus*).

Dear Wildlife or Mixed practice veterinarian

With the increase in the incidence and complication rate associated with appendicular fractures in small and large antelope species, the Small Animal Surgery Section at the Onderstepoort Veterinary Academic Hospital (OVAH) is currently in the process of researching and developing an appendicular fracture treatment methodology for small antelope species.

The above study will focus on fracture distribution and fracture classification of appendicular fractures in impala and other small antelope species, which will serve as a foundation for further anatomical, biomechanical and clinical studies.

If your practice is in possession of digital or computerised radiographs of any appendicular fractures of small antelope species (impala, springbuck, blesbuck, nyala, steenbuck, duiker, oribi, ect.) and you are prepared to contribute to this study, please contact the primary investigator to arrange for the collection of the digital or computerised radiographs as well as available patient records. If required I will personally come to collect the radiographic images and associated data from your practise.

Thank you in anticipation for your contribution and for being prepared to assist us in studying treatment options for wildlife ungulate fractures.

Yours in science

Dr. Frans van Heerden BSc. BVSc.
Primary Investigator
frans.vanheerden@up.ac.za
012 529 8087/8012
0823221127

Dr. M. Hartman BVSc. MSc. MMedVet. PhD.
Research Supervisor
marthinus.hartman@up.ac.za
012 529 8555

OVAH building 4-55
University of Pretoria
PRETORIA 0002
Republic of South Africa

Tel: +27 12 529 8012
Cell: +27 82 322 1127

Email : frans.vanheerden@up.ac.za
www.up.ac.za

ANNEXURE C: Individual patient information consent form

I, Dr. ……………………………………………………………. practising at ……………………………………………. veterinary hospital/clinic, grant Dr. F.G. van Heerden, the primary investigator of the study, **Radiographic study of appendicular fractures in impala (*Aepyceros melampus*)**, permission to access and include in the study, any recorded patient details, history or data, of the radiographs submitted to the study.

ANNEXURE D: Individual patient data capture sheet

Date of collection:	__/__/____	Owner name:	
Species:		Owner tel:	
Case number:	I - /O -	Town:	
Patient ID/name:		Province	
Bone fractured:	1 2 3 4 5 6 7 8 9 10 11 12		
Patient sex:	M F	Practise name:	
Body condition:	1 2 3	Practise tel:	
Reprod. status:	Breeding Lactating Pregnant	Attending Vet:	
Camp size:	Captive <2ha Small <10ha Medium <50ha Large >50ha	Number of radiographs:	Pre-op________ Post-op_______ Follow-up_____ Total__________
Number of animals in camp:	Impala________ Other________	Diet: Veld Supplemental	Lucern Lick block Pellets Other
Type of terrain:	Grassland Trees Brush Thicket Other	Surface types:	Rocky Sandy Clay Loam soil Other
Date of birth:	__/__/____	Est. date of birth:	__/__/____
Age at rad:	Months	Est age at rad:	months
Date of #:	__/__/____	Date of rad:	__/__/____
Date of Rx:	__/__/____		
Fractured limb:	F H	Fractured side:	L R
Soft tissues:	Open Closed		
Cause of #:	D-relocation D-diseased In-transit Fight Flight Boma Other Unknown		
Treatment:	External fixation	MRJ Cast Thomas-splint	Pin cast Ex-fix 1 2 3 C ILL
	Internal fixation	IM pin Positional pin Cross pin Tension band wires Cerclage wires	Lag screw Positional screw DCP plate+screws Interlock plate+screws Other plate+screws
	Other external method		
	Other internal method		
	No Rx		
	Euth		
Date of follow-up rad:	__/__/____	Follow-up info:	
Date of follow-up rad:	__/__/____	Follow-up info:	

Date of follow-up rad:	__/__/____	Follow-up info:	

OTHER INFO:

____

____

Radiographic study of appendicular fractures in Impala (*Aepyceros melampus*) in South Africa.

Primary Investigator:
Dr. F.G. van Heerden

Cell: +27 82 322 1127
Tel: +27 12 529 8012
Email : frans.vanheerden@up.ac.za

ANNEXURE E: Fracture classification and distribution

																	Bone												Segment				Simple - A			Wedge - B			Complex - C		
	File nr	ID/Name	Nr of digital images(fracture)	Nr of digital images(normal bones)	Orthogonal views - Yes - 0 / No - 1	Joint surfaces included - Yes - 0 / No - 1	Dx quality - 1 - 1	Dx quality - 2 - 1	Dx quality - 3 - 1	Dx quality - 4 - 1	Dx quality - 5 - 1	Dx quality - 6 - 1	Dx quality - 7 - 1	Dx quality - 8 - 1	Dx quality - 9 - 1	Dx quality - 1 0- 1	Humerus - 1	Radius/Ulna - 2	Femur - 3	Tibia - 4	Metacarpal - 5	Metatarsal - 6	Scapula - 7	Carpus - 8	Tarsus - 9	Front digits - 10	Hind digits -11	Combinations	Proximal - 1	Shaft - 2	Distal - 3	Combinations	Incomplete - 1	Oblique - 2	Transverse - 3	One wedge - 1	Two or more wedges - 2	Non-reducible wedges - 3	Reducible wedges - 1	Segmental - 2	Non-reducible wedges - 3
1	I-001	Black Impala ET1 #252814	4	X	0	0	X	X	X	X	X	X	X	1	X	X	X	X	3	X	X	X	X	X	X	X	X	X	X	2	X	X	X	X	X	1	X	X	X	X	X
2	I-002	Impala #451813	4	2	0	0	X	X	X	X	X	X	X	X	X	1	X	X	X	4	X	X	X	X	X	X	X	X	X	2	X	X	X	X	X	X	X	X	1	X	X
3	I-003	Impala 945 # 856513	2	X	0	0	X	X	X	X	X	X	X	X	X	1	X	X	X	X	5	X	X	X	X	X	X	X	X	2	X	X	X	X	X	X	X	3	X	X	X
4	I-004	Impala #2027714	2	X	0	0	X	X	X	X	X	X	X	X	X	1	X	X	3	X	X	X	X	X	X	X	X	X	X	2	X	X	X	X	X	X	2	X	X	X	X
5	I-005	Black Impala #2600315	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	4	X	X	X	X	X	X	X	X	X	2	X	X	X	X	X	X	X	X	X	X	X
6	I-006	14A #3066215	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5	X	X	X	X	X	X	X	X	2	X	X	X	X	X	X	X	X	1	X	X
7	I-007	Black Impala #3772216	3	1	0	0	X	X	X	X	X	X	X	1	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	2	X	X	X	X	X	X	X	X	1	X	X
8	I-008	Saddleback Impala #3953916	3	X	0	0	X	X	X	X	X	X	1	X	X	X	X	2	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	3	X	X	X	X	X	X
9	I-009	Impala #3970016	2	X	0	0	X	X	X	X	X	X	X	X	X	1	X	X	X	4	X	X	X	X	X	X	X	X	X	2	X	X	X	X	X	X	X	X	1	X	X
10	I-010	Rooibok #929613	3	X	0	1	X	X	X	X	X	1	X	X	X	X	X	X	X	4	X	X	X	X	X	X	X	X	X	2	X	X	X	X	X	1	X	X	X	X	X
11	I-011	Vaalwater Black Impala	3	X	0	0	X	X	X	X	X	X	1	X	X	X	X	2	X	X	X	X	X	X	X	X	X	X	X	2	X	X	X	X	X	X	2	X	X	X	X
12	I-012	Black Impala	2	X	0	1	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	6	X	X	X	X	X	X	X	2	X	X	X	2	X	X	X	X	X	X	X
13	I-013	Rooibok	2	X	0	0	X	X	X	X	X	1	X	X	X	X	X	2	X	X	X	X	X	X	X	X	X	X	X	2	X	X	X	X	X	1	X	X	X	X	X
14	I-014	Swart Rooibok	11	X	0	1	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	6	X	X	X	X	X	X	X	2	X	X	X	X	3	X	X	X	X	X	X
15	I-017	Swart Rooibok	2	X	0	1	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	6	X	X	X	X	X	X	X	X	3	X	X	X	3	X	X	X	X	X	X
16	I-018	Rooibok	2	X	1	1	X	X	X	X	X	1	X	X	X	X	X	2	X	X	X	X	X	X	X	X	X	X	X	X	3	X	X	X	3	X	X	X	X	X	X
17	I-019	Rooibok nr 9	2	X	0	0	X	X	X	X	X	1	X	X	X	X	X	X	X	4	X	X	X	X	X	X	X	X	1	X	X	X	X	2	X	X	X	X	X	X	X
18	I-020	Rooibok	1	1	1	0	X	X	X	X	1	X	X	X	X	X	X	2	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	3	X	X	X	X	X	X
19	I-021	Rooibok split	2	X	0	0	X	X	X	X	X	X	X	1	X	X	X	X	X	X	5	X	X	X	X	X	X	X	X	2	X	X	X	X	X	X	X	X	1	X	X
20	I-022	Swart Rooibok	3	X	0	0	X	X	X	X	X	1	X	X	X	X	X	X	X	X	5	X	X	X	X	X	X	X	X	2	X	X	X	X	X	X	2	X	X	X	X
21	I-023	Swart ram lam	2	X	0	0	X	X	X	X	X	X	1	X	X	X	X	X	X	4	X	X	X	X	X	X	X	X	X	2	X	X	X	X	X	X	2	X	X	X	X
22	I-024	Saddleback	2	X	0	0	X	X	X	X	X	1	X	X	X	X	X	X	X	4	X	X	X	X	X	X	X	X	X	2	X	X	X	X	X	1	X	X	X	X	X
23	I-025	Black ewe	1	X	1	1	X	X	X	X	X	X	X	1	X	X	X	X	X	4	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	1	X	X
24	I-027	Ram	2	X	0	0	X	X	X	X	X	X	1	X	X	X	X	X	X	X	5	X	X	X	X	X	X	X	X	2	X	X	X	X	X	1	X	X	X	X	X
25	I-029	Rooi 161	2	X	1	0	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	6	X	X	X	X	X	X	X	2	X	X	X	X	X	X	2	X	X	X	X
26	I-030	Swart ram	2	X	0	0	X	X	X	X	X	X	1	X	X	X	X	X	X	4	X	X	X	X	X	X	X	X	X	2	X	X	X	X	X	X	X	X	1	X	X
27	I-031	Rooi 24971	2	X	0	0	X	X	X	X	X	X	X	1	X	X	X	X	X	4	X	X	X	X	X	X	X	X	X	2	X	X	X	X	X	X	2	X	X	X	X
28	I-033	Split ewe	1	X	1	0	X	X	X	X	X	1	X	X	X	X	X	X	X	4	X	X	X	X	X	X	X	X	X	2	X	X	X	X	3	X	X	X	X	X	X
29	I-034	Rooi 15v13	2	X	0	1	X	X	X	X	X	X	X	1	X	X	X	X	X	4	X	X	X	X	X	X	X	X	X	2	X	X	X	X	X	X	2	X	X	X	X
30	I-035	Swart Rammetjie	2	X	0	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	6	X	X	X	X	X	X	X	2	X	X	X	2	X	X	X	X	X	X	X
31		SAME PATIENT	1	X	1	0	X	X	X	X	X	1	X	X	X	X	X	2	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	2	X	X	X	X	X	X	X
32	I-036	Wit ram	1	X	1	0	X	X	X	X	X	X	X	1	X	X	X	X	X	X	5	X	X	X	X	X	X	X	X	2	X	X	X	X	3	X	X	X	X	X	X
33		SAME PATIENT	1	1	1	0	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	6	X	X	X	X	X	X	X	2	X	X	X	2	X	X	X	X	X	X	X
34	I-037	Rooi T3	2	X	0	1	X	X	X	X	X	1	X	X	X	X	X	X	X	4	X	X	X	X	X	X	X	X	X	2	X	X	X	2	X	X	X	X	X	X	X
35	I-038	Rooi 14g09	2	X	0	0	X	X	X	X	X	X	X	X	1	X	X	2	X	X	X	X	X	X	X	X	X	X	X	2	X	X	X	X	X	X	X	X	1	X	X
36	I-039	Rooi 3	2	X	0	1	X	X	X	X	X	X	X	1	X	X	X	2	X	X	X	X	X	X	X	X	X	X	X	X	3	X	X	X	3	X	X	X	X	X	X
37	I-041	Wit ooitjie	2	X	0	0	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	6	X	X	X	X	X	X	X	2	X	X	X	2	X	X	X	X	X	X	X
38	I-042	Ooitjie	2	X	0	1	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	6	X	X	X	X	X	X	X	X	3	X	X	X	3	X	X	X	X	X	X
39	I-043	Swart lam vr	2	X	0	0	X	X	X	X	X	X	1	X	X	X	X	X	X	X	5	X	X	X	X	X	X	X	X	2	X	X	X	X	X	X	X	X	1	X	X
40	I-045	Rooibok ooi	2	X	0	1	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	6	X	X	X	X	X	X	X	X	3	X	X	X	3	X	X	X	X	X	X
41	I-046	Witooilam	2	X	0	0	X	X	X	X	X	1	X	X	X	X	X	X	X	X	5	X	X	X	X	X	X	X	X	2	X	X	X	2	X	X	X	X	X	X	X
42	I-048	Red 2	2	X	0	0	X	X	X	X	X	X	X	X	1	X	X	X	X	X	5	X	X	X	X	X	X	X	X	2	X	X	X	X	X	X	X	X	1	X	X
43	I-049	Split ewe	2	X	0	0	X	X	X	X	X	X	1	X	X	X	X	X	X	X	5	X	X	X	X	X	X	X	X	2	X	X	X	X	X	1	X	X	X	X	X

44	I-050	Du Toit	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5	X	X	X	X	X	X	X	X	2	X	X	X	X	X	X	X	X	X	X	X
45	I-052	Swart ooi	2	X	0	1	X	X	X	X	X	X	X	1	X	X	X	X	X	4	X	X	X	X	X	X	X	X	X	X	3	X	X	X	X	X	X	3	X	X	X
46	I-053	Rooi 20882	2	X	0	0	X	X	X	X	X	X	X	X	1	X	X	2	X	X	X	X	X	X	X	X	X	X	X	2	X	X	X	2	X	X	X	X	X	X	X
47	I-054	Rooi m28	2	X	0	0	X	X	X	X	X	X	1	X	X	X	X	X	X	4	X	X	X	X	X	X	X	X	X	2	X	X	X	2	X	X	X	X	X	X	X
48	I-056	Yellow ram	2	X	0	0	X	X	X	X	X	1	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	2	X	X	X	2	X	X	X	X	X	X	X
49	I-057	Wit ram	4	X	0	0	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	6	X	X	X	X	X	X	X	2	X	X	X	X	3	X	X	X	X	X	X
50	I-058	Swart ooi	2	X	0	1	X	X	X	X	X	X	1	X	X	X	X	X	X	4	X	X	X	X	X	X	X	X	X	2	X	X	X	2	X	X	X	X	X	X	X
51	I-059	Rooi green 22	4	2	0	0	X	X	X	X	X	X	1	X	X	X	X	X	3	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	3	X	X	X	X	X	X
52	I-062	Black Impala 000653	1	X	1	0	X	X	X	X	X	1	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	2	X	X	X	X	X	1	X	X	X	X	X
53		SAME PATIENT	1	X	1	0	X	X	X	X	X	1	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	2	X	X	X	X	X	X	X	X	X	2	X
54	I-063	Rooibok	2	X	0	0	X	X	X	X	X	X	1	X	X	X	X	X	X	4	X	X	X	X	X	X	X	X	X	2	X	X	X	X	X	X	X	X	1	X	X
55	I-064	102216111223	2	X	0	1	X	X	X	X	X	X	X	X	X	1	X	2	X	X	X	X	X	X	X	X	X	X	X	2	X	X	X	X	X	X	X	X	1	X	X
56	I-026	Swart ram	2	X	0	1	X	X	X	X	X	X	X	1	X	X	X	X	X	X	5	x	X	X	X	X	X	X	X	X	3	X	X	X	3	X	X	X	X	X	X
57	I-040	Swart rammetjie	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5	x	X	X	X	X	X	X	X	2	X	X	X	X	X	X	X	X	X	X	X
58	I-051	Swart ram	2	X	0	1	X	X	X	X	X	1	X	X	X	X	X	X	X	X	x	6	X	X	X	X	X	X	X	2	X	X	X	X	3	X	X	X	X	X	X

ANNEXURE F: Skeletal maturity

				Physis - % closure (P%), Apophysis - % fusion (A%), Other - % ossification (O%)																											Skeletal maturity		
			Sex	Humerus					Radius		Ulna		Crp	Mtc		Femur					Tibia				Trs	Metatarsus			Comments				
	File nr	ID/Name	Male - 0 / Female - 1	Greater tubercle - A%	Prox Physis - P%	Medial epicondyle - A%	Lat and Med trochlea - A%	Dist Physis - P%	Prox Physis - P%	Distal Physis - P%	Olecranon - A%	Distal Physis - P%	Ass crp bone - O%	Distal Physis Mc 3+4 - P%	Rudimentary Mc 2+5 - O%	Head - P%	Greater trochanter - A%	Lesser trochanter - A%	Distal Physis - P%	Patella - O %	Tuberosity - A%	Prox Physis - P%	Distal Physis - P%	Lateral malleolus - A%	Tuber calcis - A%	MetaT ses - O%	Distal Physis Mt 3+4 - P%	Rudimentary Mt 2+5 - O%			Mature - 1	Immature - 1	Very immature - 1
1	I-001	Black Impala ET1 #252814	1	X	X	X	X	X	X	X	X	X	X	X	X	100	100	100	100	100	100	100	X	X	X	X	X	X		Tibial	1	X	X
2	I-002	Impala #451813	0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	95	100	100	100	100	X	X	X		Tibial	1	X	X
3	I-003	Impala 945 # 856513	0	X	X	X	X	X	X	0	X	0	100	0	100	X	X	X	X	X	X	X	X	X	X	X	X	X			X	1	X
4	I-004	Impala #2027714	1	X	X	X	X	X	X	X	X	X	X	X	X	100	50	X	0	100	0	0	X	X	X	X	X	X			X	1	X
5	I-005	Black Impala #2600315	0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	0	0	X	X	X	X	X	X		Difficu	X	1	X
6	I-006	14A #3066215	0	X	X	X	X	X	X	0	X	0	100	0	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	1	X
7	I-007	Black Impala #3772216	1	100	100	100	100	100	100	X	100	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			1	X	X
8	I-008	Saddleback Impala #3953916	0	100	0	X	X	X	0	X	0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		patien	X	1	X
9	I-009	Impala #3970016	0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	100	100	50	100	100	0	100	100	X	X			1	X	X
10	I-010	Rooibok #929613	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	50	X	0	0	0	0	0	100	X	X			X	1	X
11	I-011	Vaalwater Black Impala	X	X	X	50	X	X	100	0	0	0	100	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		only o	X	1	X
12	I-012	Black Impala	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	50	X	X	100	50	X			X	1	X
13	I-013	Rooibok	X	X	X	100	X	X	100	100	100	100	100	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			1	X	X
14	I-014	Swart Rooibok	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	100	100	X			1	X	X
15	I-017	Swart Rooibok	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	100	X			X	X	1
16	I-018	Rooibok	X	X	X	X	X	X	0	0	X	0	50	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X	1
17	I-019	Rooibok nr 9	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	50	100	0	0	50	X	0	100	X	X		Distal	X	1	X
18	I-020	Rooibok	X	100	0	0	X	0	0	0	0	0	100	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		9mm r	X	1	X
19	I-021	Rooibok split	X	X	X	X	X	X	X	0	X	0	100	0	100	X	X	X	X	X	X	X	X	X	X	X	X	X			X	1	X
20	I-022	Swart Rooibok	X	X	X	X	X	X	X	0	X	0	100	50	100	X	X	X	X	X	X	X	X	X	X	X	X	X		Distall	X	1	X
21	I-023	Swart ram lam	0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	50	100	0	0	0	0	0	100	X	X			X	1	X
22	I-024	Saddleback	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	0	0	50	50	0	100	X	X			X	1	X
23	I-025	Black ewe	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	100	100	100	X	X	X	X	X	X	X		can't e	1	X	X
24	I-027	Ram	0	X	X	X	X	X	X	0	X	0	100	0	100	X	X	X	X	X	X	X	X	X	X	X	X	X			X	1	X
25	I-029	Rooi 161	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	0	X	0	100	0	X			X	1	X
26	I-030	Swart ram	0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	100	100	100	100	100	X	100	X	X	X			1	X	X
27	I-031	Rooi 24971	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	0	X	0	0	0	X	0	X	X	X			X	1	X
28	I-033	Split ewe	1	X	X	XX	X	X	X	X	X	X	X	X	X	X	X	X	100	100	50	100	100	X	100	100	X	X			1	X	X
29	I-034	Rooi 15v13	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	100	50	0	0	0	100	X	X			X	1	X
30	I-035	Swart Rammetjie	0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	0	0	0	100	0	X			X	1	X
31		SAME PATIENT	0	50	100	50	X	100	100	0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	1	X
32	I-036	Wit ram	0	X	X	X	X	X	X	X	X	X	X	0	50	X	X	X	X	X	X	X	X	X	X	X	X	X			X	1	X
33		SAME PATIENT	0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	100	0	X			X	1	X
34	I-037	Rooi T3	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	0	X	100	50	50	100	X	X			X	1	X

35	I-038	Rooi 14g09	X	X	X	100	100	100	100	0	0	0	100	X	50	X	X	X	X	X	X	X	X	X	X	X	X	X			X	1	X
36	I-039	Rooi 3	X	X	X	X	X	X	X	0	X	0	100	X	100	X	X	X	X	X	X	X	X	X	X	X	X	X			X	1	X
37	I-041	Wit ooitjie	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	0	X	100	0	X			X	1	X
38	I-042	Ooitjie	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		cant e	1	X	X
39	I-043	Swart lam vr	X	X	X	X	X	X	X	0	X	0	100	0	100	X	X	X	X	X	X	X	X	X	X	X	X	X			X	1	X
40	I-045	Rooibok ooi	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		cant e	1	X	X
41	I-046	Witooilam	1	X	X	X	X	X	X	X	X	X	100	0	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	1	X
42	I-048	Red 2	X	X	X	X	X	X	X	0	X	0	100	50	100	X	X	X	X	X	X	X	X	X	X	X	X	X			X	1	X
43	I-049	Split ewe	1	X	X	X	X	X	X	X	X	X	X	100	100	X	X	X	X	X	X	X	X	X	X	X	X	X			1	X	X
44	I-050	Du Toit	0	X	X	X	X	X	X	0	X	0	100	0	X	X	X	X	X	X	X	X	X	X	X	X	X	X		length	X	1	X
45	I-052	Swart ooi	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	0	0	0	100	X	X		fractur	X	1	X
46	I-053	Rooi 20882	X	X	X	0	X	X	100	0	0	0	100	X	50	X	X	X	X	X	X	X	X	X	X	X	X	X			X	1	X
47	I-054	Rooi m28	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	0	50	100	50	0	X	X	X			X	1	X
48	I-056	Yellow ram	0	100	100	100	100	100	100	X	100	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			1	X	X
49	I-057	Wit ram	0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	0	X			X	1	X
50	I-058	Swart ooi	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	100	100	50	100	100	100	X	X	X	X			1	X	X
51	I-059	Rooi green 22	X	X	X	X	X	X	X	X	X	X	X	X	X	X	50	X	0	100	0	0	X	X	X	X	X	X		major	X	1	X
52	I-062	Black Impala 000653	1	0	X	X	X	X	50	X	0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		prox ra	X	1	X
53		SAME PATIENT	1	X	X	X	X	X	100	X	0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	1	X
54	I-063	Rooibok	0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	0	0	0	0	0	X	X	X			X	1	X
55	I-064	102216111223	X	X	X	X	X	X	100	100	X	X	100	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			1	X	X
56	I-026	Swart ram	0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	100	X		difficul	1	X	X
57	I-040	Swart rammetjie	0	X	X	X	X	X	X	X	X	X	X	100	X	X	X	X	X	X	X	X	X	X	X	X	X	X			1	X	X
58	I-051	Swart ram	0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	100	X			1	X	X

ANNEXURE G: Soft tissues and articular fractures

			Salter-Harris					Joint						Radiographic soft tissues													
	File nr	ID/Name	Type - 1 - 1	Type - 2 - 1	Type - 3 - 1	Type - 4 - 1	Type - 5 - 1	# extend to joint dist - 1	# extend to joint prox - 1	f-lines extend to joint prox (n)	f-lines extend to joint distal (n)	Luxation - 1 + bone codes	Subluxation - 1 + bone codes	Open - 0 / Closed - 1	Fracture ass skin defects - 1	Opacity - Gas - 1	Gas bubbles <10mm (n)	Gas bubbles >10mm (n)	Gas bubbles Prox zone - 1	Gas bubbles Shaft zone - 1	Gas bubbles Distal zone - 1	Dart gas tract*	No swelling	Swelling - 1 - 1	Swelling - 2 - 1	Swelling - 3 - 1	Swelling - 4 - 1
1	I-001	Black Impala ET1 #252814	X	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	1	X	X	X
2	I-002	Impala #451813	X	X	X	X	X	X	X	X	X	X	X	0	1	1	8	X	X	1	X	X	X	X	1	X	X
3	I-003	Impala 945 # 856513	X	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	1	X	X	X
4	I-004	Impala #2027714	X	X	X	X	X	X	X	X	X	X	X	0	1	1	26	X	X	1	X	1	X	1	X	X	X
5	I-005	Black Impala #2600315	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6	I-006	14A #3066215	X	X	X	X	X	X	X	1	X	X	X	1	X	X	X	X	X	X	X	X	X	X	1	X	X
7	I-007	Black Impala #3772216	X	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	1	X	X
8	I-008	Saddleback Impala #3953916	X	X	X	X	X	X	1	X	X	X	1	0	1	1	300	6	1	X	X	X	X	X	1	X	X
9	I-009	Impala #3970016	X	X	X	X	X	X	X	X	1	X	X	0	1	1	40	4	1	1	1	X	X	X	1	X	X
10	I-010	Rooibok #929613	X	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	1	X	X
11	I-011	Vaalwater Black Impala	X	X	X	X	X	X	X	X	X	X	X	0	1	1	X	1	1	X	X	X	X	X	1	X	X
12	I-012	Black Impala	X	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	1	X	X
13	I-013	Rooibok	X	X	X	X	X	X	X	X	X	X	X	0	1	1	6	5	1	1	X	X	X	X	1	X	X
14	I-014	Swart Rooibok	X	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	1	X	X
15	I-017	Swart Rooibok	X	X	X	X	X	X	X	X	X	X	X	0	1	1	5	X	X	X	1	X	X	1	X	X	X
16	I-018	Rooibok	X	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	1	X	X	X
17	I-019	Rooibok nr 9	X	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	1	X	X
18	I-020	Rooibok	X	X	X	X	X	X	1	X	X	1	X	1	X	X	X	X	X	X	X	X	X	1	X	X	X
19	I-021	Rooibok split	X	X	X	X	X	X	X	X	X	X	X	0	1	1	X	4	1	X	1	X	X	X	1	X	X
20	I-022	Swart Rooibok	X	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	1	X	X	X
21	I-023	Swart ram lam	X	X	X	X	X	X	X	X	X	X	X	0	X	1	50	4	1	1	X	X	X	X	1	X	X
22	I-024	Saddleback	X	X	X	X	X	X	X	X	X	X	X	0	1	1	40	10	1	1	1	X	X	X	1	X	X
23	I-025	Black ewe	X	X	X	X	X	X	1	X	X	X	X	1	X	X	X	X	X	X	X	X	1	X	X	X	X
24	I-027	Ram	X	X	X	X	X	X	X	X	X	X	X	0	X	1	4	X	X	1	X	X	X	X	1	X	X
25	I-029	Rooi 161	X	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	1	X	X	X
26	I-030	Swart ram	X	X	X	X	X	X	X	X	X	X	X	0	1	1	12	1	X	1	X	X	X	1	X	X	X
27	I-031	Rooi 24971	X	X	X	X	X	X	X	X	X	X	X	0	X	1	60	10	1	1	X	X	X	X	1	X	X

28	I-033	Split ewe	X	X	X	X	X	X	X	X	X	X	X	0	X	1	X	X	1	1	X	X	X	X	X	X	X
29	I-034	Rooi 15v13	X	X	X	X	X	X	X	X	X	X	X	0	1	1	45	6	X	1	1	X	X	1	X	X	X
30	I-035	Swart Rammetjie	X	X	X	X	X	X	X	X	X	X	X	0	1	1	15	3	1	1	X	X	X	1	X	X	X
31		SAME PATIENT	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
32	I-036	Wit ram	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
33		SAME PATIENT	X	X	X	X	X	X	X	X	X	X	X	0	1	1	35	1	1	1	1	X	X	X	1	X	X
34	I-037	Rooi T3	X	X	X	X	X	X	X	X	X	X	X	0	1	X	3	4	1	1	X	X	X	X	X	X	X
35	I-038	Rooi 14g09	X	X	X	X	X	X	X	X	X	X	X	0	1	1	25	X	X	1	X		X	1	X	X	X
36	I-039	Rooi 3	X	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	1	X	X
37	I-041	Wit ooitjie	X	X	X	X	X	X	X	X	X	X	X	0	1	X	X	X	X	X	X	X	X	1	X	X	X
38	I-042	Ooitjie	1	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	1	X	X	X
39	I-043	Swart lam vr	X	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	1	X	X
40	I-045	Rooibok ooi	X	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X
41	I-046	Witooilam	X	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X
42	I-048	Red 2	X	X	X	X	X	X	X	X	X	X	X	0	X	1	14	X	1	X	X	X	X	X	X	X	X
43	I-049	Split ewe	X	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	1	X	X	X
44	I-050	Du Toit	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
45	I-052	Swart ooi	X	X	X	X	X	X	X	X	X	X	X	0	1	X	X	X	X	X	X	X	X	X	1	X	X
46	I-053	Rooi 20882	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
47	I-054	Rooi m28	X	X	X	X	X	X	X	X	X	X	X	0	1	1	35	2	1	1	1	X	X	X	1	X	X
48	I-056	Yellow ram	X	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	1	X	X	X
49	I-057	Wit ram	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
50	I-058	Swart ooi	X	X	X	X	X	X	X	X	X	X	X	0	1	1	45	8	1	1	X	X	1	X	X	X	X
51	I-059	Rooi green 22	1	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	1	X	X	X	X
52	I-062	Black Impala 000653	X	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	1	X	X	X
53		SAME PATIENT	X	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	1	X	X	X	X
54	I-063	Rooibok	X	X	X	X	X	X	X	X	X	X	X	0	1	1	5	1	1	1	X	X	X	X	1	X	X
55	I-064	102216111223	X	X	X	X	X	X	X	X	X	X	X	0	X	1	24	X	X	1	1	X	X	1	X	X	X
56	I-026	Swart ram	X	X	X	X	X	X	X	X	X	X	X	0	X	1	15	55	X	1	1	X	X	X	1	X	X
57	I-040	Swart rammetjie	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
58	I-051	Swart ram	X	X	X	X	X	X	X	X	X	X	X	0	X	1	2	1	X	1	X	X	X	X	X	1	X

ANNEXURE H: Fissure line and fracture displacement

			Fissure lines								Periosteal reaction			Displacement									Cause of fracture							
	File nr	ID/Name	Yes - 0 / No - 1	fissure line prox (n)	fissure line distal (n)	Total Nr of fissure lines (n)	Length of f-line 1 - mm prox	Length of f-line 2 - mm prox	Length of f-line 1 - mm distal	Length of f-line 2 - mm distal	No reaction - 1	Non-aggressive - 1	Aggressive - 1	Cranio-caudal - 1	Cranio-caudal measurement - mm	Prox-distal - 1	Prox-distal measurement - mm	Medio-lateral - 1	Medio-lateral measurement - mm	Rotation - 1	Rotation measurement - degrees	Telescoping yes - 0 / no - 1	Dart - Relocation - 1	Dart - Diseased - 1	Boma - 1	In-transit - 1	Flight - 1	Fight - 1	Other - 1	Unknown - 1
			18	19	17	31	40	92	24	53																				
1	I-001	Black Impala ET1 #252814	1,00	X	X	X	X	X	X	X	1	X	X	1	60	1	136	X	X	1	90	X	1	X	X	X	X	X	X	X
2	I-002	Impala #451813	0,00	X	1,00	1,00	X	X	31,00	X	1	X	X	X	X	X	X	1	35	X	X	X	X	X	X	X	X	1	X	X
3	I-003	Impala 945 # 856513	0,00	5,00	3,00	8,00	39,00	26,00	51,00	17,00	1	X	X	1	10	1	15	X	X	X	X	X	1	X	X	X	X	X	X	X
4	I-004	Impala #2027714	1,00	X	X	X	X	X	X	X	1	X	X	1	37	1	98	X	X	1	90	X	1	X	X	X	X	X	X	X
5	I-005	Black Impala #2600315	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
6	I-006	14A #3066215	0,00	2,00	X	2,00	22,00	23,00	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
7	I-007	Black Impala #3772216	1,00	X	X	X	X	X	X	X	1	X	X	1	17	1	43	X	X	X	X	X	X	X	X	X	X	X	X	1
8	I-008	Saddleback Impala #3953916	1,00	X	X	X	X	X	X	X	1	X	X	1	32	1	24	X	X	X	X	X	X	X	X	X	X	X	1	X
9	I-009	Impala #3970016	0,00	X	2,00	2,00	X	X	22,00	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
10	I-010	Rooibok #929613	1,00	X	X	X	X	X	X	X	1	X	X	1	23	X	X	1	25	X	X	X	X	X	X	X	X	X	X	1
11	I-011	Vaalwater Black Impala	0,00	X	1,00	X	X	X	15,00	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
12	I-012	Black Impala	0,00	1,00	X	1,00	18,00	X	X	X	1	X	X	1	5	X	X	1	12	X	X	X	X	X	X	X	X	X	X	1
13	I-013	Rooibok	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
14	I-014	Swart Rooibok	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	1	16	X	X	X	X	X	X	X	X	X	X	1
15	I-017	Swart Rooibok	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	1	3	X	X	X	X	X	X	X	X	X	X	1
16	I-018	Rooibok	0,00	X	1,00	1,00	X	X	13,00	X	1	X	X	1	4	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
17	I-019	Rooibok nr 9	0,00	2,00	0,00	2,00	28,00	20,00	X	X	1	X	X	X	X	1	5	X	X	X	X	0	X	X	X	X	X	X	X	1
18	I-020	Rooibok	1,00	X	X	X	X	X	X	X	1	X	X	1	20	1	7	X	X	X	X	X	X	X	X	X	X	X	X	1
19	I-021	Rooibok split	1,00	X	X	X	X	X	X	X	X	1	X	1	7	X	X	1	13	X	X	X	X	X	X	X	X	X	X	1
20	I-022	Swart Rooibok	0,00	1,00	X	1,00	33,00	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
21	I-023	Swart ram lam	0,00	1,00	1,00	2,00	50,00	X	23,00	X	1	X	X	1	8	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
22	I-024	Saddleback	0,00	X	1,00	1,00	X	X	36,00	X	1	X	X	1	24	1	55	1	45	X	X	X	X	X	X	X	X	X	X	1
23	I-025	Black ewe	1,00	X	X	X	X	X	X	X	1	X	X	1	15	1	37	X	X	X	X	X	1	X	X	X	X	X	X	X
24	I-027	Ram	0,00	1,00	1,00	2,00	15,00	X	28,00	X	X	X	1	1	4	1	5	1	9	X	X	X	X	X	X	X	X	X	X	1
25	I-029	Rooi 161	1,00	X	X	X	X	X	X	X	X	1	X	1	12	1	27	X	X	X	X	X	X	X	X	X	X	X	X	1
26	I-030	Swart ram	1,00	X	X	X	X	X	X	X	1	X	X	1	28	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
27	I-031	Rooi 24971	1,00	X	X	X	X	X	X	X	1	X	X	1	23	1	15	1	12	1	90	X	1	X	X	X	X	X	X	X
28	I-033	Split ewe	X	X	X	X	X	X	X	X	1	X	X	1	27	1	24	X	X	X	X	X	X	X	X	X	X	X	X	1
29	I-034	Rooi 15v13	X	X	X	X	X	X	X	X	1	X	X	1	12	1	40	1	17	X	X	X	X	X	X	X	X	X	X	1
30	I-035	Swart Rammetjie	0,00	X	1,00	1,00	X	X	21,00	X	1	X	X	1	5	1	9	1	14	X	X	X	X	X	X	X	X	X	X	1
31		SAME PATIENT	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
32	I-036	Wit ram	X	X	X	X	X	X	X	X	X	1	X	1	3	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
33		SAME PATIENT	X	X	X	X	X	X	X	X	1	X	X	1	37	1	64	X	X	X	X	X	X	X	X	X	X	X	X	1

34	I-037	Rooi T3	0,00	1,00	X	X	56,00	X	X	X	1	X	X	1	8	1	39	1	18	X	X	X	X	X	X	X	X	X	X	1
35	I-038	Rooi 14g09	1,00	X	X	X	X	X	X	X	1	X	X	1	29	1	14	X	X	X	X	X	X	X	X	X	X	X	X	1
36	I-039	Rooi 3	1,00	X	X	X	X	X	X	X	1	X	X	1	20	1	23	1	14	X	X	X	X	X	X	X	X	X	X	1
37	I-041	Wit ooitjie	0,00	X	1,00	1,00	X	X	15,00	X	1	X	X	1	7	1	12	1	9	X	X	X	X	X	X	X	X	X	X	1
38	I-042	Ooitjie	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
39	I-043	Swart lam vr	0,00	3,00	X	X	53,00	23,00	X	X	1	X	X	1	7	X	X	1	5	X	X	X	X	X	X	X	X	X	X	1
40	I-045	Rooibok ooi	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
41	I-046	Witooilam	0,00	X	2,00	2,00	X	X	26,00	17,00	1	X	X	X	X	X	X	1	3	X	X	X	X	X	X	X	X	X	X	1
42	I-048	Red 2	0,00	X	2,00	2,00	X	X	12,00	19,00	1	X	X	X	X	X	X	1	6	X	X	X	X	X	X	X	X	X	X	1
43	I-049	Split ewe	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
44	I-050	Du Toit	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
45	I-052	Swart ooi	X	X	X	X	X	X	X	X	1	X	X	X	X	1	23	1	27	X	X	X	X	X	X	X	X	X	X	1
46	I-053	Rooi 20882	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
47	I-054	Rooi m28	0,00	1,00	X	1,00	50,00	X	X	X	1	X	X	1	39	X	X	1	19	X	X	X	X	X	X	X	X	X	X	1
48	I-056	Yellow ram	1,00	X	X	X	X	X	X	X	1	X	X	X	X	1	21	1	23	X	X	X	X	X	X	X	X	X	X	1
49	I-057	Wit ram	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
50	I-058	Swart ooi	0,00	1,00	X	1,00	74,00	X	X	X	1	X	X	1	20	1	10	X	X	X	X	X	X	X	X	X	X	X	X	1
51	I-059	Rooi green 22	1,00	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
52	I-062	Black Impala 000653	X	X	X	X	X	X	X	X	1	X	X	X	X	1	25	X	X	X	X	X	X	X	X	X	X	X	X	1
53		SAME PATIENT	X	X	X	X	X	X	X	X	1	X	X	1	12	1	11	X	X	X	X	X	X	X	X	X	X	X	X	1
54	I-063	Rooibok	X	X	X	X	X	X	X	X	1	X	X	1	10	1	56	1	15	X	X	X	1	X	X	X	X	X	X	X
55	I-064	102216111223	1,00	X	X	X	X	X	X	X	1	X	X	X	X	X	X	1	15	X	X	X	X	X	X	X	X	X	X	1
56	I-026	Swart ram	1,00	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	1	90	X	X	X	X	X	X	X	X	1
57	I-040	Swart rammetjie	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
58	I-051	Swart ram	1,00	X	X	X	X	X	X	X	1	X	X	1	3	X	X	1	8	X	X	X	X	X	X	X	X	X	X	1

ANNEXURE I: Fracture treatments

			Post-operative images														Implants																							
	File nr	ID/Name	Date of post-op rad	Nr of digital images	Orthogonal views - Yes - 0 / No - 1	Joint surfaces included - Yes - 0 / No - 1	Dx quality - 1 - 1	Dx quality - 2 - 1	Dx quality - 3 - 1	Dx quality - 4 - 1	Dx quality - 5 - 1	Dx quality - 6 - 1	Dx quality - 7 - 1	Dx quality - 8 - 1	Dx quality - 9 - 1	Dx quality - 1 0 - 1	Pin cast Postive profile - 1	Pin cast Negative profile - 1	Pin cast Smooth pins - 1	Pin cast prox pins (n)	Pin cast dist pins (n)	IM Pin (n)	Positional pin (n)	Cross pins (n)	Tension band wires (n)	Lag screw (n)	Positional screw (n)	Exfix - Type 1 - 1	Exfix - Type 2 - 1	Exfix - Type 3 - 1	Exfix - Type Circular - 1	Exfix - Type ILLIZAROV - 1	Exfix Negative profile - 1	Exfix Pos profile - 1	Exfix Smooth pins - 1	Exfix Olive wires - 1	Exfix prox pins (n)	Exfix dist pins (n)	C wire - Twist knot - 1	C wire - Single loop - 1
1	I-001	Black Impala ET1 #252814	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2	I-002	Impala #451813	2013/03/06	2	0	0	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	1	X	X	3	2	X	X
3	I-003	Impala 945 # 856513	14/10/2014	2	0	0	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	1	X	X	1	X	X	1	X	1	2	3	X	X
4	I-004	Impala #2027714	2014/06/11	3	0	0	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5	I-005	Black Impala #2600315	2015/11/05	4	0	1	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1	X
6	I-006	14A #3066215	2015/05/09	2	0	0	X	X	X	X	X	X	X	1	X	X	1	X	X	3	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7	I-007	Black Impala #3772216	29/02/2016	3	0	0	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	1	X	1	X	X	X	X	X	1	X	X	2	2	1	X
8	I-008	Saddleback Impala #3953916	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
9	I-009	Impala #3970016	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
10	I-010	Rooibok #929613	2013/03/11	2	0	0	X	X	X	X	5	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1	X
11	I-011	Vaalwater Black Impala	24/06/2015	1	1	0	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1	X	X	1	X	1	1	X	X
12	I-012	Black Impala	X	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1	X	X	1	X	4	3	X	X
13	I-013	Rooibok	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
14	I-014	Swart Rooibok	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
15	I-017	Swart Rooibok	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
16	I-018	Rooibok	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
17	I-019	Rooibok nr 9	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
18	I-020	Rooibok	24/06/2015	1	1	0	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
19	I-021	Rooibok split	24/06/2015	1	1	1	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
20	I-022	Swart Rooibok	24/06/2015	2	0	0	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1	X	X	1	X	4	2	X	X
21	I-023	Swart ram lam	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
22	I-024	Saddleback	2016/07/06	2	1	0	X	X	X	X	X	6	X	X	X	X	X	X	X	X	X	2	X	X	X	X	X	1	X	X	X	X	X	X	1	X	2	1	1	X
23	I-025	Black ewe	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
24	I-027	Ram	2016/06/06	2	0	0	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1	X	X	1	X	4	4	X	X
25	I-029	Rooi 161	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
26	I-030	Swart ram	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
27	I-031	Rooi 24971	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
28	I-033	Split ewe	21/11/2015	1	1	1	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1	X
29	I-034	Rooi 15v13	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
30	I-035	Swart Rammetjie	14/11/2015	1	1	0	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1	X	X	1	X	4	3	X	X
31		SAME PATIENT	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
32	I-036	Wit ram	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
33		SAME PATIENT	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
34	I-037	Rooi T3	2015/10/11	2	1	1	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1	X	X	1	X	4	4	X	X
35	I-038	Rooi 14g09	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

36	I-039	Rooi 3	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
37	I-041	Wit ooitjie	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
38	I-042	Ooitjie	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
39	I-043	Swart lam vr	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
40	I-045	Rooibok ooi	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
41	I-046	Witooilam	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
42	I-048	Red 2	13/03/2015	1	1	1	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1	X	X	1	X	3	4	X	X
43	I-049	Split ewe	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
44	I-050	Du Toit	17/11/2014	2	0	0	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	1	X	X	X	1	X	X	1	X	6	4	X	X
45	I-052	Swart ooi	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
46	I-053	Rooi 20882	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
47	I-054	Rooi m28	2014/04/11	1	1	1	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	1	X	X	X	X	X	1	X	X	X	X	3	X	X	X	2	1	1	X
48	I-056	Yellow ram	20/10/2014	1	1	0	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1	X
49	I-057	Wit ram	2014/12/12	4	0	0	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1	X	X	1	X	2	2	X	X
50	I-058	Swart ooi	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
51	I-059	Rooi green 22	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
52	I-062	Black Impala 000653	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
53		SAME PATIENT	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
54	I-063	Rooibok	27/08/2016	1	1	0	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1	X
55	I-064	102216111223	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
56	I-026	Swart ram	29/05/2016	1	1	1	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	1	1	X	X
57	I-040	Swart rammetjie	2015/01/06	2	0	1	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1	X	X	1	X	4	4	X	X
58	I-051	Swart ram	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

																				fixation as		Follow-up											Follow-up										
C wire - Double loop - 1	C wire - Amount (n)	DPS - Holes (n)	DPS - Screws (n)	DPS - Monocort screws prox (n)	DPS - Monocort screws dist (n)	DPS - Bicort screws prox (n)	DPS - Bicort screws dist (n)	IPS - Holes (n)	IPS - Screws (n)	IPS - Monocort screws prox (n)	IPS - Monocort screws dist (n)	IPS - Bicort screws prox (n)	IPS - Bicort screws dist (n)	OPS - Holes (n)	OPS - Screws (n)	OPS - Monocort screws prox (n)	OPS - Monocort screws dist (n)	OPS - Bicort screws prox (n)	OPS - Bicort screws dist (n)	bone alignment (%)	implant usage (%)	Date	bone alignment (%)	implant stability (%)	comments	implant failure - Yes - 0 / No - 1	severity of implant failure (%)	Bone healing - stage 1 - 1	Bone healing - stage 2 - 1	Bone healing - stage 3 - 1	Bone healing - stage 4 - 1	Bone healing - stage 5 - 1	Date	bone alignment (%)	implant sstability (%)	comments	implant failure - Yes - 0 / No - 1	severity of implant failure (%)	Bone healing - stage 1 - 1	Bone healing - stage 2 - 1	Bone healing - stage 3 - 1	Bone healing - stage 4 - 1	Bone healing - stage 5 - 1
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	90	90	#####	80	80	Destab	1	X	X	1	X	X	X	2013	70	80	Proxim	1	X	X	X	X	1	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	75	80	#####	75	95	3rd dis	1	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	8	7	2	2	1	2	X	X	X	X	X	X	100	80	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	3	X	X	X	X	X	X	9	8	1	0	3	4	X	X	X	X	X	X	100	95	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	80	100	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	1	X	X	X	X	X	X	9	7	5	1	X	1	X	X	X	X	X	X	100	80	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	3	X	X	X	X	X	X	11	7	X	X	3	4	X	X	X	X	X	X	95	50	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	50	50	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	90	90	24/06/2015	90	90	Good s	1	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	5	4	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	50	50	24/06/2015	50	90	severe	1	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	50	90	24/06/2015	50	90	mature	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	80	95	24/06/2015	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	5	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	100	50	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	100	100	18/06/2016	100	100	mature	1	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	6	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	95	50	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	100	60	#####	90	X	constru	1	X	X	X	X	1	X	2015	90	X	constr	1	X	X	X	X	1	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	75	50	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	90	50	X	X	X	X	1	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	75	50	#####	75	0	implan	1	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	5	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	100	60	#####	80	90	implan	1	X	X	X	1	X	X	2017	90	80	distal p	1	X	X	X	X	1	X
X	4	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	100	90	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	100	50	13/01/ 2015	100	100	cortica	1	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	8	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	100	70	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	75	50	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	80	100	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X