PATTERNS, TREATMENT AND EARLY COMPLICATIONS OF DEGLOVING INJURIES IN PATIENTS MANAGEDAT MOI TEACHING AND REFERRAL HOSPITAL

DENNIS MUNYAO MUTISO

SM/PGORT/08/15

THESIS SUBMITTED IN PARTIAL FULFILLMENT OF REQUIREMENTS FOR THE AWARD OF THE DEGREEOF MASTER OF MEDICINE IN ORTHOPAEDIC SURGERY OF MOI UNIVERSITY

DECLARATION

Declaration by the Candidate

This research is the candidate's original work and has not been presented for a degree or any academic credit in any other University or examining body. No part of this thesis may be reproduced without the prior written permission of the author and/or Moi University.

Dennis Munyao Mutiso Signature: ___________________ Date :___________

Admission Number: SM/PGORT/08/15

Declaration by the Supervisors

This research has been submitted for examination with our approval as Moi university supervisors.

Dr. B. R. Ayumba Signature: ___________________ Date: ___________

Senior Lecturer and Consultant Orthopedic Surgeon

Moi University School of Medicine

Dr. E. M. Ashraf Signature: ___________________ Date:___________

Lecturer and Consultant Plastic and Reconstructive Surgeon

Moi University School of Medicine

DEDICATION

This work is dedicated to all my teachers who over the years have made great sacrifices in mentoring me to become a better person and doctor and also to my dear parents and family for the immense effort in educating me.

ACKNOWLEDGMENT

The researcher wishes to thank his supervisors Dr. B. R. Ayumba, Dr. E. M. Ashraf, and Dr. C. Anderson for their contributions, tireless corrections, and advice that was given to enable the successful completion of this research. Finally to my family for the support and encouragement they accorded me.

LIST OF ABBREVIATIONS AND ACRONYMS

CT	Computer tomography
DM	Diabetes Mellitus
DR	Doctor
FTSG	Full-Thickness Skin Graft
HIV	Human Immunodeficiency Virus
HTN	Hypertension
IREC	Institutional Research and Ethics Committee
MLL	Morel-Lavallee lesions
MRI	Magnetic Resonance Imaging
MTRH	Moi Teaching and Referral Hospital
Prof	Professor
RTA	Road Traffic Accidents
STSG	Split Thickness Skin Graft
U/S	Ultra-sound
VAC	Vacuum-assisted closure

OPERATIONAL DEFINITION OF KEY TERMS

Characteristics of degloving injuries: Social demographics of patients with degloving injuries, mechanism of injury i.e. cause of degloving injuries, classification of degloving injuries, and anatomical distributions of degloving injuries.

Degloving injuries: a form of avulsion of soft tissue, in which an extensive portion of skin and subcutaneous tissue detaches from the underlying fascia and muscles (Latifi, R., et al., 2014). The study will only include patients with degloving injuries that are greater than one-fourth of the circumference of the affected part.

Early complications: complications occurring between the time of injury and 30 days after definitive treatment (Lekuya et al., 2018).

Patterns: Extent of degloving injury.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Background: Degloving injuries are a form of avulsion of soft tissue in which an extensive portion of skin and subcutaneous tissue detaches from the underlying fascia and muscles. These injuries are common among Orthopedics patients and the treatment is compounded by blood loss, concomitant injuries, and contamination. There is a paucity of data on patterns, treatment modalities, and complications of degloving injuries.

Objective: To determine the pattern, treatment, and early complications of degloving injuries in patients managed at Moi Teaching and Referral Hospital (MTRH).

Methods: A prospective descriptive study was conducted at Moi Teaching and Referral Hospital between 1st December 2016 and 30TH November 2017. This was a census study where all 48 patients admitted with degloving injuries who met the inclusion criteria were included in the study. Diagnosis of open degloving injuries was made through physical examination while closed degloving injuries were made through both physical examination and confirmed by the use of ultrasound. After informed consent, a researcher administered questionnaire was used to collect data on demographics, mechanism of injury, time from injury to hospital, and location of injury. At the time of wound exposure and assessment, photo-documentations was done. Patients were followed up from the time of admission up to 30 days after definitive management. Those who were discharged before 30 days after definitive treatment were seen in outpatient clinic. Data on treatment modalities and complications was obtained during the follow-up period. Fisher's exact test was used to test for association between the presence of complications and various treatment modalities. Confidence level was set at 95%.

Results: There were 48 patients recruited into the study. The male to female ratio was 1.5: 1. The median age of the patients was 26 IQR (18.5, 42.5). Forty-four patients (92%) had acquired primary or secondary education. Motor vehicle and motorcycle accidents contributed to 75% of the injuries. Lower limbs were involved in 23 (47.9%) patients. Open degloving injuries comprised the majority (92%). Non-circumferential involvement was seen in 26 (59.1%) patients. All patients with open degloving injuries (n=44) underwent either single debridement (n=29) or serial debridement (n=15). Definitive treatment modalities for open degloving injuries included primary closure (n=22), split-thickness skin graft (n=10), full-thickness skin graft (n=7), muscle flap (n=5) while for closed degloving injuries included conservative management (n=2), and drainage (n=2).Complications were observed in 15 (31.2%) patients. Of the patients who developed complications, 40% had local wound infection. Other complications included skin graft failure (20%), massive hemorrhage (26.7%), and primary flap necrosis (13.3%). There was a significant association (p=0.002) between the patterns of degloving injuries and the presence of complications.

Conclusion: Most degloving injuries occurred among young males. Most degloving injuries were open and affected the lower limb. The main treatment modalities were primary closure and skin grafting. Local wound infection was the main early complication. There was an association between the need for serial debridement and complications.

Recommendations: Development of an institutional protocol for the treatment of degloving injuries to reduce complications.

CHAPTER ONE: INTRODUCTION

1.1 Background Information

Degloving injury or degloving soft tissue injury has been defined as an avulsion of soft tissue, in which an extensive portion of skin and subcutaneous tissue is detached from the underlying fascia, muscles, or bone surface. Frequently the skin is disconnected and the injury is readily diagnosed. A large portion of skin is completely separated from underlying structures, cutting off its blood supply and exposing cartilage, the bone, tendon, or nerve (Lekuya et al., 2018b).

Degloving injuries usually have severe contamination and may be associated with fractures and bone loss requiring extensive secondary reconstructive procedures (Latifi et al., 2014).

The injury is produced by an extremely powerful shearing force applied to the part of the body affected. Degloving then occurs in the plane where the attachment of the skin or subcutaneous tissue to the deeper structures is weakest (Latifi, et al. 2014). Degloving injuries are more commonly observed in males due to a disproportionately higher burden of traumatic injuries. Although it may occur anywhere in the body, the main sites of degloving injuries are lower extremities, trunk, scalp, and face (Hakim et al., 2016).

The injuries were present in 3% of patients managed for post-traumatic exposed bones at Moi Teaching and Referral Hospital (MTRH), Eldoret, Kenya (Ayumba et al., 2015).

1.2 Problem Statement

Degloving injuries contribute to a sizable proportion of all patients admitted in the orthopedics wards. At MTRH, an average of 43 out of 1525 (2.8%) patients with degloving injuries are admitted every year.

Treatment of degloving injuries is quite challenging and the outcomes are sometimes unfavorable due to the severity of the injury, a high percentage of serious concomitant injuries, severe contamination, and massive blood loss.

Degloving injuries cause extensive tissue damage to the skin and subcutaneous tissues, neurovascular bundles, bones, and joints. Degloving injuries have been shown to results in devastating early complications including vascular injuries and severe infections.

The pattern, treatment modalities, and complications of these injuries are not documented locally as there is a paucity of publications.

1.3 Justification

The patterns, treatment modalities, and early complications of degloving injuries vary in different institutions and are influenced by various patient and institutional factors. These include the age of patients, mechanism of injury, location of the injury, early diagnosis, other systemic illnesses, and timing of treatment offered among others.

There is only scanty information regarding the management and outcome of these patients in Kenya and no such research has been done locally. This study aimed at determining the characteristics, treatment, and early complications in these patients managed at MTRH. The information generated will hopefully be useful not only to MTRH in its quest to improve patient care but also to contribute to the body of knowledge in the management of this common surgical emergency.

Many institutions including MTRH do not have evidence-based treatment guidelines or protocols for the treatment of patients with degloving injuries. There is a need to develop institutional guidelines to aid in the proper management of patients with degloving injuries presenting in different surgical units. This research will provide the much-needed research information which will help in developing a treatment guideline not only for MTRH but also for other institutions in Kenya.

Degloving soft-tissue injuries are underreported yet potentially devastating. They require early recognition and early management. A multidisciplinary approach is usually needed to ensure the effective rehabilitation of these patients. This research will hopefully also provide evidence-based research information on the importance of early recognition and intervention for patients with degloving injuries which is currently unavailable at MTRH.

The information on characteristics of degloving injuries will help in strategizing preventive measures of degloving injuries. Information on treatment modalities and early complications will help to improve on the management of patients with degloving injuries.

1.4 Research Question

What are the patterns, treatment modalities and early complications of degloving injuries in patients managed at MTRH?

1.5 Objectives

1.5.1 Broad Objective

To determine the patterns, treatment modalities, and early complications of degloving injuries in patients managed at MTRH.

1.5.2 Specific Objectives

1. To describe the characteristics of degloving injuries.
2. To evaluate the treatment modalities of patients with degloving injuries at MTRH.
3. To evaluate early complications of degloving injuries in patients managed at MTRH.

CHAPTER TWO: LITERATURE REVIEW

2.1 CHARACTERISTICS

2.1.1 Definition

Degloving injuries are a form of avulsion of soft tissue, in which an extensive portion of skin and subcutaneous tissue detaches from the underlying fascia and muscles (Lekuya et al., 2018). It is named by the analogy of removing a glove (Latifi et al., 2014).

The first reports date back to the early twentieth century, in upper limb injuries caused by occupational accidents with drying machines in laundries, known in the literature as wringer arm (Mello et al., 2015).

2.1.2 Anatomy and physiology of the skin

The largest organ of the body is the skin. It accounts for about 15% of the total adult body weight. It performs many vital functions, including protection against external physical, chemical, and biologic assailants, as well as prevention of excess water loss from the body and a role in thermoregulation. The skin is continuous, with the mucous membranes lining the body's surface (Kanitakis et al., 2002).

The integumentary system is formed by the skin and its derivative structures. The skin is composed of three layers: the epidermis, the dermis, and subcutaneous tissue. The outermost level, the *epidermis,* consists of a specific constellation of cells known as *keratinocytes,* which function to synthesize keratin, a long, threadlike protein with a protective role. The middle layer, the *dermis,* is fundamentally made up of the fibrillar structural protein known as *collagen*. The dermis lies on the subcutaneous tissue, or *panniculus,* which contains small lobes of fat cells known as *lipocytes*. The thickness of these layers varies considerably, depending on the geographic location on the anatomy of the body. The eyelid, for example, has the thinnest layer of the epidermis, measuring less than 0.1 mm, whereas the palms and soles of the feet have the thickest epidermal layer, measuring approximately 1.5 mm. The dermis is thickest on the back, where it is 30-40 times as thick as the overlying epidermis (Charkoudian et al., 2003).

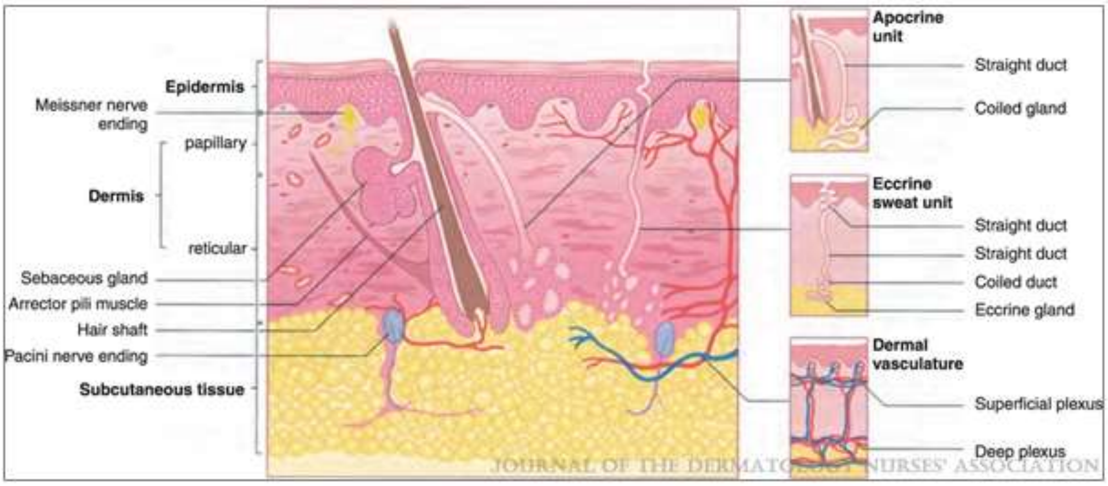

Figure 1: Anatomy of the Skin (Journal of Dermatology Nurses Association 2011)

EPIDERMIS

The epidermis is a stratified, squamous epithelium layer that is composed primarily of two types of cells: keratinocytes and dendritic cells. The keratinocytes differ from the "clear" dendritic cells by possessing intercellular bridges and ample amounts of stainable cytoplasm. The epidermis harbors several other cell populations, such as melanocytes, Langerhans cells, and Merkel cells, but the keratinocyte cell type comprises the majority of the cells by far. The epidermis commonly is divided into four layers according to keratinocyte morphology and position as they differentiate into horny cells, including the basal cell layer (stratum germinativum), the squamous cell layer (stratum spinosum), the granular cell layer (stratum granulosum), and the cornified or horny cell layer (stratum corneum).The lower three layers that constitute the living, nucleated cells of the epidermis are sometimes referred to as the stratum malpighii and rete malpighii (Kanitakis et al., 2002).

THE DERMAL-EPIDERMAL JUNCTION

The interface between the epidermis and dermis is formed by a porous basement membrane zone that allows the exchange of cells and fluid and holds the two layers together. Basal keratinocytes are the most important components of structures of the dermal-epidermal junction; dermal fibroblasts are also involved but to a lesser extent (Danby et al., 2005).

The basal lamina is a layer synthesized by basal cells of the epidermis consisting mainly of type IV collagen as well as anchoring fibrils and dermal microfibrils. This includes an electron-lucent zone known as the lamina lucida as well as the lamina densa. The plasma membranes of basal cells are attached to the basal lamina by rivet-like hemidesmosomes that distribute tensile or shearing forces through the epithelium. The dermal-epidermal junction acts as a support for the epidermis, establishes cell polarity and direction of growth, directs the organization of the cytoskeleton in basal cells, provides developmental signals, and functions as a semipermeable barrier between layers (Yousef & Sharma, 2018).

THE DERMIS

The *dermis* is an integrated system of fibrous, filamentous, and amorphous connective tissue that accommodates stimulus-induced entry by nerve and vascular networks, epidermally derived appendages, fibroblasts, macrophages, and mast cells. Other blood-borne cells, including lymphocytes, plasma cells, and other leukocytes, enter the dermis in response to various stimuli as well. The dermis comprises the bulk of the skin and provides its pliability, elasticity, and tensile strength. It protects the body from mechanical injury, binds water, aids in thermal regulation, and includes receptors of sensory stimuli. The dermis interacts with the epidermis in maintaining the properties of both tissues. The two regions collaborate during development in the morphogenesis of the dermal-epidermal junction and epidermal appendages and interact in repairing and remodeling the skin as wounds are healed. The dermis does not undergo an obvious sequence of differentiation that parallels epidermal differentiation, but the structure and organization of the connective tissue components are predictable in a depth-dependent manner. The matrix components, including collagen and elastic connective tissue, also vary in a depth-dependent manner and undergo turnover and remodeling in normal skin, in pathologic processes, and in response to external stimuli (Yousef & Sharma, 2018).

SUBCUTANEOUS FAT

Embryologically, toward the end of the fifth month, fat cells begin to develop in the subcutaneous tissue. These lobules of fat cells or lipocytes are separated by fibrous septa made up of large blood vessels and collagen. The panniculus varies in thickness depending on the skin site. Considered an endocrine organ, the subcutaneous tissue provides the body with buoyancy and functions as a storehouse of energy. Hormone conversion takes place in the panniculus, converting androstenedione into estrone by aromatase. Lipocytes produce leptin, a hormone that regulates body weight by way of the hypothalamus (Kanitakis et al., 2002).

Blood Supply and Lymphatics

Blood vessels and lymphatic vessels are found in the dermal layer of the skin. Blood supply to the skin is an arrangement of two plexuses, the first lies between the papillary and reticular layers of the dermis and the second lie between the dermis and subcutaneous tissues. Supply to the epidermis is by way of the superficial arteriovenous plexus (subepidermal/papillary plexus). These vessels are important for temperature regulation. The mechanism by which the body regulates temperature through the skin is very effective and works by increased blood flow to the skin, transferring heat from the body to the environment. The changes in blood flow are controlled by the autonomic nervous system, sympathetic stimulation resulting in vasoconstriction (heat retention), and while vasodilation results in heat loss. Vasodilation of the blood vessels is the response to increased body temperature and is the result of inhibition of the sympathetic centers in the posterior hypothalamus whereas decreased body temperature will cause vasoconstriction of skin blood vessels (Charkoudian et al 2003).

2.1.3Morbidity of degloving injuries

In this locality (MTRH), 3% of 196 patients managed for post-traumatic exposed bones had degloved injuries (Ayumba et al., 2015). Degloving injuries have been recorded to occur more in the male population and young population with a male: female ratio of 2:1 (Lekuya et al., 2018) and a mean age of 30.5 years (Hakim et al., 2016).

Degloving injuries can affect any part of the body, in particular, the limbs, trunk, scalp, face, and genitalia. Although degloving soft-tissue injuries can be present in any part of the body, the lower limb degloving injuries are the most common ones

(Khan et al., 2004; Latifi et al., 2014).

The bearer of this type of injury is usually a multiple trauma patient, with a high incidence of associated injuries, particularly fractures and vascular lesions. Fractures and soft tissue injuries are commonly encountered in all age groups (Mello et al., 2015).

If degloving injuries are not managed optimally, they are associated with high rates of morbidity and potential mortality. Scalp, upper limb, and heel degloving injuries may cause significant blood loss and hemodynamic instability. Degloving injuries involving the external genitalia, though uncommon, can also be life-threatening, with incapacitating and psychologically devastating consequences (Latifi et al., 2014).

Swelling of soft tissue, smoking, and co-morbidities such as diabetes mellitus and peripheral vascular disease should be considered when planning a management schedule. Careful attention should be paid to neurovascular status and the soft tissue envelope to the effective management of these injuries especially where crush injuries have occurred. These factors have been shown to affect wound healing and increase the risk of complications thus increasing the disease burden (Lefèvre et al., 2011).

Degloving injuries can lead to permanent disabilities if mismanaged. Workers with persistent disabilities have a significantly higher incidence of occupational injuries and higher medical costs compared with workers without persistent disabilities (Kumar & Dharanipriya 2014).

2.1.4 Pathophysiology of degloving injuries

The skin is the most extended organ of the human organism. It has a multifunctional role (excretory, protective, temperature-regulatory, and sensory) which gives a high level of importance in case of skin injury. Skin can be damaged in the following ways: direct trauma, stretching, degloving, and undermining during an operation.

In the hand or arm, it is commonly caused by the limb being crushed between rollers, while in the leg it may result from the shearing effect of a vehicle wheel passing over the limb in a run-over accident. Degloving tissue injuries can interrupt large vessels and the continuity of capillary beds (Boernert et al., 2018).

Edema soon forms', increasing the distance oxygen needs to diffuse from functioning capillaries. Any injured tissue swells and must have room to expand if there is no room for expansion the tissue will become ischaemic.This often creates a vicious circle, causing complications such as compartment syndrome (a condition in which pressure within a confined space results in tissue ischemia and resulting dysfunction) and frank sloughing of compromised tissue (Weinand et al., 2018).

The skin may remain unbroken, in which case the limb feels like a fluid-containing bag, owing to the presence of an extensive hematoma between the skin and the fascia (compartment syndrome). If the skin is torn, the effect is the creation of a large flap of full-thickness skin. In either case, massive sloughing is likely unless the injury is properly managed. Depending on the type of skin or tissue damage several plastic surgical techniques are possible for tissue repair:If the skin is in good condition it may be de-fatted and re-applied immediately as a full-thickness graft, (although failure is not uncommon). If the skin is damaged, split skin grafts may be taken from it (before its excision); these may be used immediately if the site is suitable or stored for a secondary procedure (Ju, Li, & Hou, 2015).

The flap may be marked for later orientation and excised. After refrigeration storage in a sterile container (storage temperature is important), it is replaced after 1-2 weeks as a single sheet graft, after the deeper layers have been removed using special equipment (Ju, Li, & Hou, 2015).

According to Adani et al., (1995), wound coverage after a complete degloving injury of the hand and fingers is one of the most difficult problems in hand surgery. Important structures such as tendons, nerves, and bones are exposed and will necrose if not covered adequately. The main problem in degloving injuries is the extensive damage to long segments of vessels which makes direct suture of the structures difficult. Various techniques have been proposed over the years to bypass the segment of an injured vessel (Adani et al., 1995).

2.1.3 Mechanism of injury

Degloving injuries result from the application of high-intensity forces with tangential vectors that determine compression, stretch, twist, and tissue friction, causing avulsion of skin and subcutaneous tissue from the fascia and muscle planes, with damage to the musculocutaneous and fasciocutaneous perforating vessels (Mello et al., 2015).

The injury is produced by an extremely powerful shearing force applied to the part of the body affected. Degloving then occurs in the plane where the attachment of the skin or subcutaneous tissue to the deeper structures is weakest (Latifi et al., 2014).

Degloving injuries occur as a result of blunt shearing or tangential forces that separate the mobile subcutaneous tissue and skin from the immobile underlying fascia (Yan et al., 2013)

2.1.4 Causes of degloving injuries

Degloving injuries most frequently results from industrial, traffic, and rural accidents. Occupational and industrial injuries are important problems in public health due to fatality and destabilizing outcomes in, particularly new-developing countries. The injury results from accidents at the workplace and more than half of this injury burden occurs among workers and is one of the most common surgical consultations in the outpatient or emergency room setting (Wójcicki et al., 2011).

Trauma of the foot and knee are commonly encountered in the emergency departments. The most common mechanisms of degloving injuries are motor vehicle accidents, falls, recreational and sports activity, and direct injuries from striking objects. Overall the main cause of degloving injuries is usually trauma (Pilanci et al., 2013).

Motorcycle accidents are one of the major causes of degloving injuries. Abrasion on the pavement after fall from the motorcycle causes degloving mostly in the hands, legs, shoulder, and knee (Lekuya et al., 2018; Sisimwo & Onchiri, 2018).

Motor vehicle accidents also cause degloving injuries. This occurs mostly when a pedestrian is stepped by the tires of a moving vehicle. Sometimes a pedestrian can be dragged by the vehicle resulting in scrapes, abrasions, and degloving injury (Hakim et al., 2016).

Bicycle accidents can also lead to degloving injuries especially if the victim was cycling at high speed. Farm accidents are other causes of degloving injuries, occurring from the heavy machinery used in farms. The most common causes of degloving injuries in children are being run over by motor vehicle and farm machinery accidents (Rha et al., 2013).

2.1.5 Classification and patterns of degloving injuries

Degloving injuries are classified into either open or closed degloving injuries. They are further sub-classified into various patterns ranging from limited avulsion and minimal tissue loss to circumferential multiplane involvement of muscle groups. These patterns can occur either in isolation or in combination (Latifi et al., 2014).

Degloving injuries can also be classified into four patterns which are determined by the extent of the tissue injury. These patterns of injuries are; abrasion/avulsion, non-circumferential degloving, circumferential single plane, and circumferential multi-plane (Arnez et al., 2010).

Another classification is the Yan's Classification, which classifies degloving injuries into three patterns of injuries, that is, a purely degloving injury (Pattern 1), a degloving injury with the involvement of deep soft tissues (Pattern 2), and a degloving injury with long-bone fractures (Pattern 3) (Yan et al., 2013).

Pattern 1: Purely Degloving Injury

According to the clinical findings, this pattern consists of two sub patterns based on the extent of the injury: noncircumferential and circumferential degloving

In this pattern, the plane of avulsions is confined between the deep fascia and the subcutaneous fat and skin, and no obvious damage to the deep soft tissues (deep fascias, muscles, and bones) is present. It is either an open or closed injury, in which loss of skin is seldom encountered (Yan et al., 2013).

Pattern 2: Degloving Injury with the Involvement of Deep Soft Tissues

In this pattern, a higher degree of energy transfer to the limb than in Pattern 1 is indicated. Deep soft tissues, such as deep fascia and muscles, are involved, but no long-bone fractures (tibia, fibula, or femur) occur. It is also divided into two sub-patterns: noncircumferential degloving and circumferential degloving. It is usually an open injury, and there may be friction burning on the part of the degloved skin, but a loss of skin is also rare (Yan et al., 2013).

Pattern 3: Degloving Injury with Long-Bone Fractures

In this pattern, the highest degree of energy transfer to the extremity occurs. This high-energy injury first causes the degloving injury to the superficial skin and then continuously transfers to the deep soft tissues and even the long bones, resulting in varying damage of soft tissue and different types of fractures. Mostly, it is a circumferential degloving, and friction burning on the part of the degloved skin is often present. However, a direct skin defect is not common, and secondary skin loss is often a result of surgical debridement because of severe skin contusion (Yan et al., 2013).

Closed degloving wounds are uncommon but important injuries because they may be overlooked in the multiply injured patient and if not treated correctly, they are a potential cause of mortality (Hudson et al., 1992).

Morel-Lavallee lesions are significant soft tissue injuries associated with pelvic trauma although they can be present in any anatomical location. Morel-Lavallee lesion (MLL) is a closed, soft-tissue degloving injury that is accompanied by disruption of perforating vessels and lymphatics. It occurs as a result of blunt shearing or tangential forces that separate the mobile subcutaneous tissue from the immobile underlying fascia. In this disorder, hemolymphatic collection is formed in the closed space between the two detached layers. The diagnosis of MLL is routinely made based on clinical and radiological examination. In 1/3 of cases, there is a possibility that clinicians might fail to diagnose MLL due to its inconsistent clinical manifestations and because it often involves initial skin bruising due to underlying soft tissue injury (Rha et al., 2013).

The MLL mostly occurs in the greater trochanter and hip (30%), followed by the thigh (20%), pelvis (19%), knee (15%), gluteal region (6%); it can also occur in the sacrum and lumbar region (3%), abdomen (1.5%), calf (1.5%) and the head (0.5%) (Latifi et al., 2014).

2.1.6 Diagnosis of degloving injuries

An open degloving injury is a clinically self-evident condition that usually presents as a soft tissue loss of variable extent together withavulsed skin, subcutaneous tissue flaps from the under-lying deep tissues which are the hallmark of physical finding together with overlying abrasion, ecchymosis, or skin wound. Thus diagnosis is made from the history, physical examination, some relevant investigations, and scrutinizing the differential diagnoses. Degloving soft-tissue injuries are challenging to diagnose. Clinical assessment of the degloved skin is a weak predictor of the extent of the injury. The use of intravenous fluorescein has been proposed as a better assessment method but may overestimate the line of demarcation between viable and nonviable skin. If the arterial inflow is adequate, the soft tissue can be debrided and closed without tension. After incomplete avulsion, skin color, skin temperature, pressure reaction, and bleeding or lack of bleeding should be examined carefully to assess tissue viability (Latifi et al., 2014).

Accurate diagnosis of MLL is delayed in up to one-third of patients, because of inconsistent clinical presentation and because initial skin bruising can mask the importance of the underlying soft-tissue injuries (Hudson et al., 1992).

In most patients, diagnosis is made from clinical detection of a fluctuant area combined with the findings of appropriate imaging modalities. Serum inflammatory markers sometimes are within the normal range. Ultrasound, computed tomography (CT), and magnetic resonance imaging (MRI) are all useful tools for proper diagnosis, but MRI is the modality of choice for evaluating MLL (Latifi et al. 2014).

As ultrasound typically shows these lesions as anechoic orhypoechoic, with or without echogenic foci or even fluid/fluid levels. Therefore, for such cases, MRI is the modality of choice which determines the relationship of thecollection with the underlying fascia. Direct injury to the cutaneous layers may result in necrosis of the skin overlying the degloved area. It can alsooccur on a delayed basis secondary to swelling of the degloved cavity, resulting in ischemia of the overlying skin. To prevent potential complications such as secondary infection and necrosis, early diagnosis and intervention are needed.

2.2 TREATMENT MODALITIES

2.2.1 Treatment modalities for open degloving injuries

It is generally believed that the golden time for avulsing injury treatment is eight hours after an injury because some avulsed skins have blood circulation at the early time, but gradually develop ischemia and necrosis due to circulation disorder as time goes by. This phenomenon is often unpredictable. A possible explanation is the cascade reaction that damaged vascular endothelial cells under stress lead to a change in the biological effects, which further changes blood coagulability. While the rough inner wall of the blood vessels is very conducive to thrombosis, which finally causes skin microcirculation dysfunction. Some studies have shown that delays in the treatment of degloving injuries to be associated with a higher incidence of infection and flap complications. Therefore, patients' therapeutic effects, including the survival rate of the flap and extremity and the infection rate, are closely related to the operation time, which should be controlled within 8 h after injury (Chen & Liu, 2016).

The principles of local treatment consist in evaluating the viability of the flaps, debridement of necrotic or mutilated tissues, use of non-viable flap areas as the donor of skin grafts in partial or total thickness, fixation and immobilization of both grafts and fractures (Mello et al., 2015).

Treatment of degloving soft-tissue injuries may be complex and requires careful assessment of the extent of the devitalized tissue and the blood supply to the affected tissues. The general treatment principles include preservation of as much tissue as possible, early primary definitive skin cover, good-quality skin cover, early return of function, and the necessity of any secondary procedures (Latifi et al., 2014).

Although a widely accepted protocol may not exist, treatment principles may require: tetanus prophylaxis, and intravenous antibiotics; emergent, aggressive incision and debridement in operation room; repeat incision and debridement every 48 hours until healthy tissue bed (without further necrosis) is present; soft tissue coverage (local and distant flaps) is performed once wound is clean; and early, adequate debridement leads to earlier soft tissue coverage, which correlates with better long- term outcomes (Krishnamoorthy & Karthikeyan, 2011).

Degloving injuries may partially be salvaged by placing the degloved skin back on the wound like a skin graft. Besides, the replacement of clean avulsed tissue can effectively provide wound coverage as a biologic dressing. As injured tissues declare their viability throughout the post-injury period, necrotic debris is removed. Areas of uncovered wound bed undergo delayed primary closures and are allowed to granulate in or undergo definitive reconstruction (Halikis & Taleisnik, 1996).

Some authors suggest the possibility of skin grafting from the avulsed skin, provided the avulsed skin quality allows such a procedure. Such a treatment option enables to spare donor area and to reduce the whole wound surface area. To maximize the total area of skin grafts, especially in case of extensive degloving injuries, a three-layer grafting technique from an avulsed flap is proposed. Two outer (superficial) layers, consisting of the epidermis and dermis superficial layer and dermis, respectively, are used to cover the wounds. The most profound layer deprived of subcutaneous tissue serves as a temporary biological dressing. Skin grafts obtained from avulsed skin may also be prepared by de-fatting and perforating using incision or fenestration before wound coverage. In the case of upper limb degloving, a delayed split-thickness skin graft from avulsed flaps is described. After twelve days from the injury, a well – developed granulating wound bed is covered with a frozen skin graft. Microsurgical technique can therefore enable wider use of avulsed skin flaps (Wójcicki et al., 2011).

Extensive degloving injuries can be problematic for reconstructive surgeons regarding treatment and closure because of the complexity of the injury. As early as the 1980s, these wounds have to be treated with repeated serial debridements and painful dressing changes, with the eventual placement of skin graft (Mandel et al., 1981).

Some studies have shown that immediate use of the degloved skin as a skin graft gives the most satisfactory coverage to the denuded areas, especially using the full-thickness skin graft (Jeng & Wei, 1997).

The grafting methods used for closure of degloving injuries in clinical practice vary. Jeng et al., refined the techniques in the primary treatment of such patients, with satisfactory results. In their practice, multiple stabbing over the skin graft was performed, allowing fluid drainage when the defatted skin was repositioned. The fixation of the skin graft to the underlying bed with multiple staples was advocated to provide enough stability. The full-thickness skin graft with such a pattern of perforation healed well and produced a satisfactory cosmetic appearance (Jeng et al., 2004).

Some authors have advocated the use of vacuum sealing drainage (VSD) system for the closure of degloving injuries. The vacuum-assisted closure or vacuum sealing drainage system applies even pressure to the entire wound and configures precisely to the intrinsic three-dimensional structure of the wound, reducing or eliminating movement or tenting (DeFranzo et al., 1999). This system can remove excess tissue edema, increase tissue blood flow, and decrease the number of localized bacteria. It also can remove third-space fluid effectively (Hou et al., 2011).

Historically, defatted full-thickness degloved skin has been difficult to hold in position because edema and bleeding in the underlying tissue are associated with a poor take, despite fastidious time-consuming suturing, dressing, and splinting of such injuries. The VSD system seems to meet the needs of the treatment of degloving injuries and has been used in dealing with such patients with success (Dini et al., 2012).

Chen and Liu, (2016) proposed three surgical techniques based on the viability of the skin flap and the site of the wound area: -

Technique 1: - involves the preservation of a subcutaneous vascular network with a vertical mattress suture of full-thickness skin flap and tube drainage. When the skin proved to have a good vascular network after the capillary test, the subcutaneous soft tissue and vascular network should be reserved directly without thinning. The flap can be directly secured to its original anatomical site with a multi-point vertical mattress suture. Thereafter several tubes need to be placed at different directions of the wound area for negative pressure drainage. Finally, pressure dressing of the wound was done. This was mostly done on avulsed skin tissue from the back of the thigh/leg which was thick and had a rich vascular network and perforating branches.

Technique 2: - involves split-thickness skin meshing and grafting and VSD. If the vascular network of the avulsed skin is damaged seriously, but the wound base has a good blood supply after debridement, this technique can be used. The avulsed skin flap was thinned and subdermal vascular is retained. Thinning must be stopped at 2 cm away from the skin pedicle. By every 2 to 3 cm, a 1 cm-long hole was punctured on the flap using a small sharp knife. After then, the mesh split-thickness flap is reattached and covered with VSD for drainage. This technique is mostly done in the dorsum of the leg and foot where the skin and subcutaneous tissues are thin.

Technique 3: - involves debridement and VSD in stage I + reattachment of autologous frozen split-thickness mesh graft in stage II. If the wound base, usually the front leg and foot, had a poor blood supply, serious contamination after debridement, or even with partial bone and tendon exposure, the wound should be covered with VSD in stage I. Split thickness skin flap can be first reserved and frozen, which will be later retranslated to the wound area in about a week (Chen & Liu 2016).

In cases of extensive degloving injuries, some authors have advocated for 3 layer grafting technique from the avulsed flap to maximize the total area of skin graft. Two outer (superficial) layers, consisting of the epidermis and dermis superficial layer and dermis, respectively, are used to cover the wounds. The most profound layer deprived of subcutaneous tissue serves as a temporary biological dressing. Skin grafts obtained from avulsed skin may also be prepared by de-fatting and perforating through incision or fenestration before wound coverage (Wójcicki et al., 2011).

Most authors recommend defatting of primary graft prior to grafting (Yan et al., 2013).

For finger injuries, the first and best surgical option is always a replantation and revascularization procedure. Often, when the degloved skin is removed from the patient's body, it can be put back by replantation. This dual procedure, however, requires great expertise and vast resources. Furthermore, trauma patients often may have other life-threatening injuries that do not allow for lengthy replantation and revascularization procedures (Adani et al., 1995).

For patients with more limited degloving injuries with abrasion and/or avulsion, free tissue transfer procedures can be performed to cover any exposed underlying tendons, bones, and joints. Also, it is recommended to carry on minimal tissue excision (including minimal wound circumcision). Flap reconstruction leads to prompt primary healing. Free tissue transfer techniques include the single-stage microvascular technique. The tissue that is transferred may be either an anterolateral thigh flap, which is a skin flap, or a latissimus dorsi muscle flap, which is covered with a skin graft. Unfortunately, only a very few centers in the world can perform such types of tissue that can be transferred; free tissue transfer procedures have also been limited by the need for expertise in microvascular surgery. Moreover, after reconstruction of a degloved hand or finger, certain secondary procedures may be required (such as scar revision, flap thinning, or syndactyly release) (Latifi et al. 2014).

The avulsed skin has been used as a source of (split- or full-thickness) skin grafts. Surgeons often need to combine defatting of the avulsed skin with fenestration, followed by negative-pressure dressing. If the degloving is extensive, another option is to commit the patient to serial excisions before reconstruction; a theoretical disadvantage is a potential for bone desiccation and nosocomial infection (Latifi et al. 2014).

For patients with extensive avulsion of the skin including narrow or distal pedicles, with or without the involvement of superficial subcutaneous tissue- who do not have damage to deeper tissue, the best treatment is to completely divide the pedicle, defat the skin, and replace the avulsed skin as a full-thickness skin graft. If the wound is too contaminated or too swollen, the avulsed tissue should be cleansed with pulsatile lavage, left open, and addressed at a second exploration. For patients with non-circumferential degloving injuries, tissue excision is always needed. But, with either the application of skin grafts or flap reconstruction, the wound heals by primary intention. For patients with single-plane circumferential degloving injuries, flaps are excised while for patients with circumferential multiplane degloving injuries; a staged reconstruction is suggested. Degloving injuries associated with open fractures should be managed by a comprehensive excision of devitalized hard and soft tissue, followed by appropriate skeletal fixation and the application of vascularized soft-tissue cover (Harma et al., 2004).

Although many methods have been defined to reform the tissue integrity; defatting and readaptation of the avulsed flap still comprise one of the most effective methods (Pilanci et al., 2013).

Vacuum therapy is an effective and safe treatment of degloving injuries. Wounds that are grossly contaminated or associated with extensive soft tissue defects often require a multistage approach before delayed primary wound closure or plastic surgical procedures can be performed. Vacuum therapy can be used for temporary soft tissue coverage and has been shown to improve bacterial clearance, to increase local blood flow, and to promote granulation tissue formation. In contrast, plastic surgical procedures initially achieve safe and stable wound closure; however, the absence of sensitivity can lead to secondary problems. This is of particular relevance if the graft recipient site is subject to heavy stress and the restoration of function is of paramount importance (Andres et al., 2016).

Negative pressure dressings (VAC) use is also advocated in case of impaired wound healing, especially coexisting with open bone fractures, to accelerate the wound healing process (Wójcicki et al., 2011).

Traditional repair involves debridement followed by skin grafting or flap reconstruction. Many degloving injuries, however, extend to bone or tendon and the decreased vascularity of the wound bed can compromise the success of traditional repairs. Additionally, medical comorbidities make some patients poor candidates for flap reconstruction. Placement of a dermal regeneration template followed by a split-thickness autograft is a viable alternative to traditional methods of repair for these patients (Ozturk et al., 2015).

For degloving injuries of the foot, the core principles of management consist of maintaining the soft tissue envelope; to obtain appropriate alignment; restoration of joint surfaces, and rehabilitation to obtain optimum function. Amputation is one of the treatment options in acute trauma settings when the potential risks of the salvage efforts outweigh the potential benefits. A free-flap application can be planned as an alternative method for amputation. Nevertheless, the long-term outcomes of this protective procedure have been controversial (Boernert et al., 2018).

2.2.2 Treatment modalities for closed degloving injuries

Different treatment modalities have been advocated for closed degloving injuries. The management of acute Morel-Lavallée lesions is controversial. In the last decade, there has been an evolution in the surgical treatment from aggressive debridement with wound healing by secondary intention, to a more minimally invasive approach. The main concerns in acute lesions are possible sepsis, skin and soft-tissue sloughing, and the timing of surgery for the associated fractures. Surgery can be performed as a single step or two-stage procedure, depending on the extent of the injury (Motsitsi et al., 2008).Some authors have advocated for compressive bandaging or more invasive methods such as open drainage from a small incision followed by compressive bandaging (Harma et al., 2003).

Some authors recommend that once a closed degloving injury is suspected, aspiration in a sterile manner is done and if the aspirate is more than 50mls,then open surgical procedure should be done for drainage (Remy et al., 2017).

2.3 Complications and Prognosis

Complications are quite common, occurring in upto 62% of patients in some settings (Mello et al., 2015).

Degloving injuries complications may be divided into general and local – both early and late. Serious infection or sepsis and lower limbs deep vein thrombosis constitute a grave threat. The consequences of massive blood transfusions are also to be taken into account. Early local complications include hemorrhage, distal ischemia, and skin graft healing disorders, infection, and limb amputation necessity in life – saving indications. Late local complications consist of limb contour deformity, chronic wounds, and ulcerations, potentially leading to Marjolin ulcer, contracting scars, sensation disorders, and lymphedema (Wójcicki et al., 2011).

Early complications of degloving injuries include local wound infection, skin graft failure or loss, generalized skin loss, and sepsis. Local wound infection contributes to 24% of all complications and is the main early complication that is observed in patients with degloving injuries (Mello et al., 2015).

Prognosis of degloving injuries depends on several factors, these include; the extent of degloving, early diagnosis, and the anatomical site where the injury has occurred (Latifi et al. 2014), adequate debridement, adequate antibiotic cover, early and adequate skin cover, other comorbidities, other concurrent injuries (Hak et al., 1997).

Patients who receive adequate debridement especially if done early have a better prognosis due to decreased risk of infections. The mean time for wound healing is 29 days to 50 for children with total foot degloving injuries after treatment with a full-thickness skin graft. The use of the degloved skin as a full-or split-thickness skin graft gives the most satisfactory coverage to the denuded areas (Hak et al., 1997).

CHAPTER THREE: METHODOLOGY

3.1 Study Area

This study was carried out at Moi Teaching and Referral in Eldoret, Kenya. Moi Teaching and Referral Hospital is located in Uasin Gishu County, in the North Rift Region of Western Kenya. This is about 310 kilometers northwest of Nairobi, the capital city of Kenya. It is the second-largest referral hospital in Kenya. It serves the greater Western Kenya, Eastern Uganda, and parts of Southern Sudan, the catchment area of at least 20 million people. The study was carried out at the surgical wards of the hospital.

3.2 Study Design

This was a prospective descriptive study design where patients presenting with degloving injury were evaluated and variables of interest were determined.

3.3 Study Population

This included all patients admitted with a diagnosis of degloving injuries at MTRH between 1st December 2016 and 30th November 2017 who met the eligibility criteria.

3.4 Eligibility Criteria

3.4.1 Inclusion Criteria

- All patients with a degloved skin greater than one-fourth of the circumference of the affected parts.
- All patients admitted with closed degloving injuries.

3.4.2 Exclusion Criteria

- Patients who had already developed complications after definitive treatment in peripheral facilities.

3.5 Sampling Method and sample size

A census study was conducted whereby all patients with degloving injuries who met our inclusion criteria were enrolled. Over the last three years, an average of 43 patients with degloving injuries was admitted at MTRH annually.

3.6 Data Collection, Handling, Analysis and Presentation

3.6.1 Data Collection and Handling

Patients were enrolled at the time the diagnosis of degloving injury was made. These patients were identified by the investigator or his assistant at the Emergency department and in the wards. Diagnosis of open degloving injuries was made through physical examination while closed degloving injuries were made through both physical examination and confirmed by the use of ultrasound.

Data was collected using a researcher administered questionnaire and recorded in the datasheet. The datasheet was filled in the course of the patients' hospital stay starting from the time of admission.

The data collected included social demographics, causes/mechanism of injury, time from injury to hospital, debridement and skin grafting, classification, location of injury, complications, and hospital stay.

At the time of wound exposure and assessment, adequate photo-documentations of degloving injuries using a digital camera was done, at least two different views were required with adequate focus. Further information was acquired through physical examination of the patient.

Complications were documented from the time of injury to 30 days after definitive treatment. Patients who were discharged earlier than 30 days were followed up in the outpatient clinic.

3.6.2 Data Analysis and Presentation

Data collected using a data collection sheet was entered into an access database daily for storage and preliminary data management. After completion of data collection and entry into the access database, the data was imported into STATA/MP version 13 where it was coded, cleaned, and analyzed.

Categorical variables such as sex, education level, comorbidities, and causes of injuries among others were summarized as frequencies and the corresponding percentages. While numerical variables such as age, time to surgery, and hospitalization period were summarized as median and corresponding interquartile range.

Pearson's Chi-Square and Fisher's exact tests were used to test the association between the presence of complications and various treatment modalities appropriately. While Mann Whitney test was used to compare the median length of stay among those who developed complications and who did not Mann Whitney test was also used to compare the average time taken from injury to debridement among those who developed complications and those who did not develop complications.

All statistical tests were performed at 95% level of significance.

Tables, graphs, and box plot were used for data presentation.

3.7. Ethical Considerations

1. Approval was obtained from IREC.
2. Permission was sought from the Director of MTRH before the commencement of the study.
3. Informed consent to conduct the study was sought:

- Directly from adult patients (above 18yrs)
- From an adult guardian/parent for patients below 18 years together with assent from all children between 7 and 18 years of age.
- For children below 7 years of age, consent was sought from the parent or the guardian.

4. Information gathered was confidential and used only for this study
5. No patient names or other identifying characteristics were used in the course of the study; instead, patients were given codes.
6. All patients were free to withdraw from the study at any point in time as they wished and without need to seek prior authorization to do so and without any consequences whatsoever for so doing.
7. The results of the study will be disseminated to Moi University and IREC through bound books (thesis). Manuscripts for publication will also be written to relevant journals.
8. There was no direct benefit to the patients of the study. However, the information gathered from the study will be used to improve the future management of patients with degloving injuries at MTRH.

3.8. Limitations of the Study

There was a possibility of missed closed degloving injuries which was mitigated by a high index of suspicion, thorough physical examination, and investigations (use of ultrasound) for patients with a pelvic, acetabular and proximal femur fractures.

CHAPTER FOUR: RESULTS

4.1 Introduction

The findings presented here are based on 48 patients who were admitted with a diagnosis of degloving injuries at MTRH between 1st December 2016 and 30th November 2017. During this period, there were 1185 admissions in orthopaedic wards where 48 of them had degloving injuries, thus 4.05% of patients admitted in orthopaedics wards at MTRH had degloving injuries.

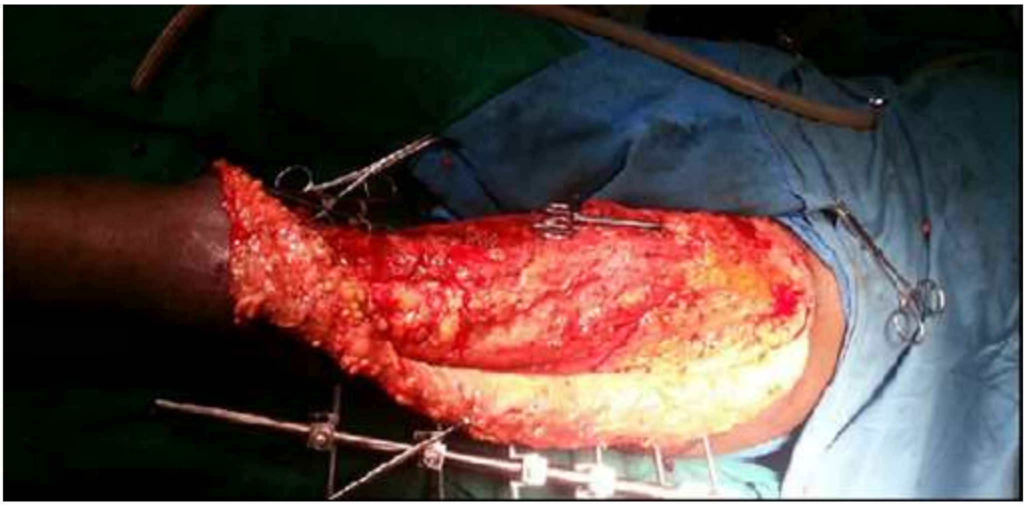

Figure 2: Degloving Injury of the Right Thigh

4.2 Characteristics

4.2.1 Demographics

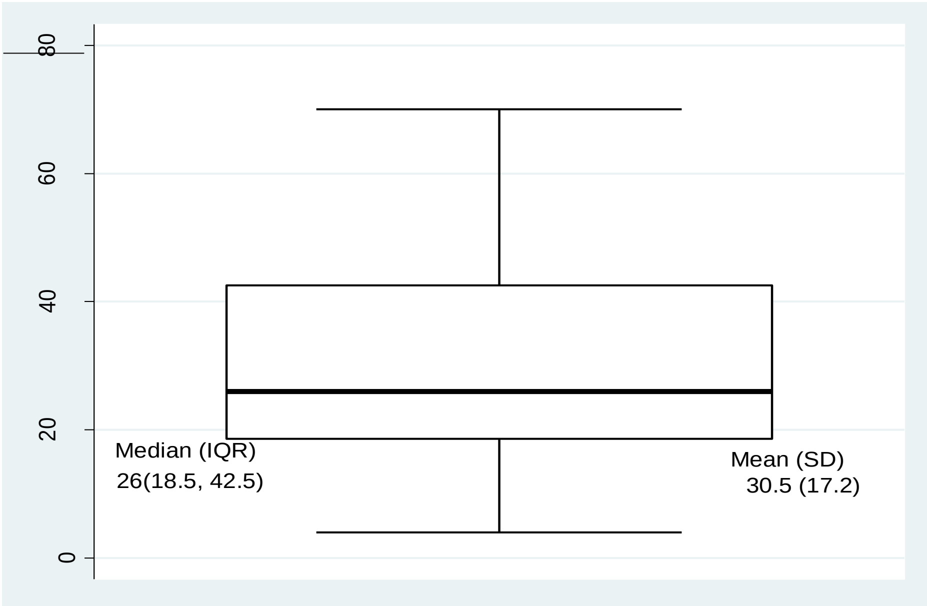

Figure 3: Age distribution

The median age of the patients was 26 (IQR 18.5, 42.5) ranging from 4 to 70 years where 75% of the patients were aged 18 years and above.

Table 1: Age distribution

Age	Frequency	Percent
<16yrs	**8**	**16.67**
16-60yrs	**36**	**75**
>60yrs	**4**	**8.33**
Total	**48**	**100**

Patients were divided into paediatrics, youth, and the elderly. Patients who were aged sixty and above were considered as an elderly group as defined by the world health organization. Patients younger than sixteen years were grouped as paediatrics while those patients who were aged between 16 and 60 were grouped as youth. Most of the patients (seventy-five percent) who had degloving injuries were aged between 16 and 60 years (youth). Sixteen percent of the patients were paediatrics and 8.33% were elderly.

Table 2: Social Demographics

	Category	Frequency	Percentage
Sex	Female	19	39.58
	Male	29	60.42
Education level	None	3	6.25
	Primary	22	45.83
	Secondary	22	45.83
	Higher education	1	2.08
Alcohol intake	No	33	68.75
	Yes	15	31.25
Comorbidities	Asthma	1	25.00
	DM	1	25.00
	HIV	1	25.00
	HTN	1	25.00

Of the 48 patients, 29 (60.42%) were males and 19 (39.58%) were females, with a male to female ratio of 1.5: 1. About 91.66% had acquired primary or secondary education as their highest level with only 1(2.08%) patient having had higher education. The majority of the patients (68.75%) reported not to have been under the influence of alcohol at the time of injury. Comorbidities noted were asthma, diabetes mellitus, HIV, and hypertension.

Table 3: Causes of degloving injuries

Variable	Category	Frequency	Percentage
Cause of Injury	Motor cycle	21	43.75
	Motor vehicle	15	31.25
	Farm accident	7	14.58
	Industrial accident	4	8.33
	Bicycle	1	2.08

Road traffic accidents were the leading cause of degloving injuries. Most patients (43.75%) were in a motorcycle accident while 31.25% were in motor vehicle accidents. Other causes of degloving injuries that were noted include farm accidents and industrial accidents.

Table 4: Time between injury and arrival to the hospital

Variable	Category	Frequency	Percentage
Time between injury to arrival at the hospital	< 12 hours	15	31.25
	12 – 24 hours	15	31.25
	25 – 48 hours	14	29.17
	> 48 hours	4	8.33

About 31.25% of patients arrived within 12 hours after injury, 62.5% arrived within 24 hours after injury while 91.77% arrived within 48 hours after injury. Only 8.33% of patients arrived 48 hours after injury.

Table 5: Classification

Variable	Category	Frequency	Percentage
Status	Closed	4	8.33
	Open	44	91.67
Subtype	Non-circumferential degloving	26	59.09
	Circumferential multiple plane	7	15.91
	Abrasions/avulsion	6	13.64
	Circumferential single plane	5	11.36

The majority of the patients (91.67%) had open degloving injuries, with 8.33% having closed degloving injuries. Of the 44 patients who had open degloving injuries, 59.09% had non-circumferential degloving injuries, 15.9% had circumferential multiplane injuries, 11.36% had circumferential single plane injuries and 13.64% had avulsion injuries.

Table 6: Patterns of degloving injuries

Pattern	Frequency	Percent
1	24	50
2	16	33.33
3	8	16.67
Total	48	100

Degloving injuries were further grouped into three patterns according to Yan's classification, whereby pattern 1 is pure degloving injury, pattern 2 is a degloving injury with deep tissue injuries and pattern 3 is degloving injuries with an associated bone fracture at the site of degloving injury. Most patients (50%) had pattern 1, 33.33% had pattern 2 and 16.7% had pattern 3 degloving injuries.

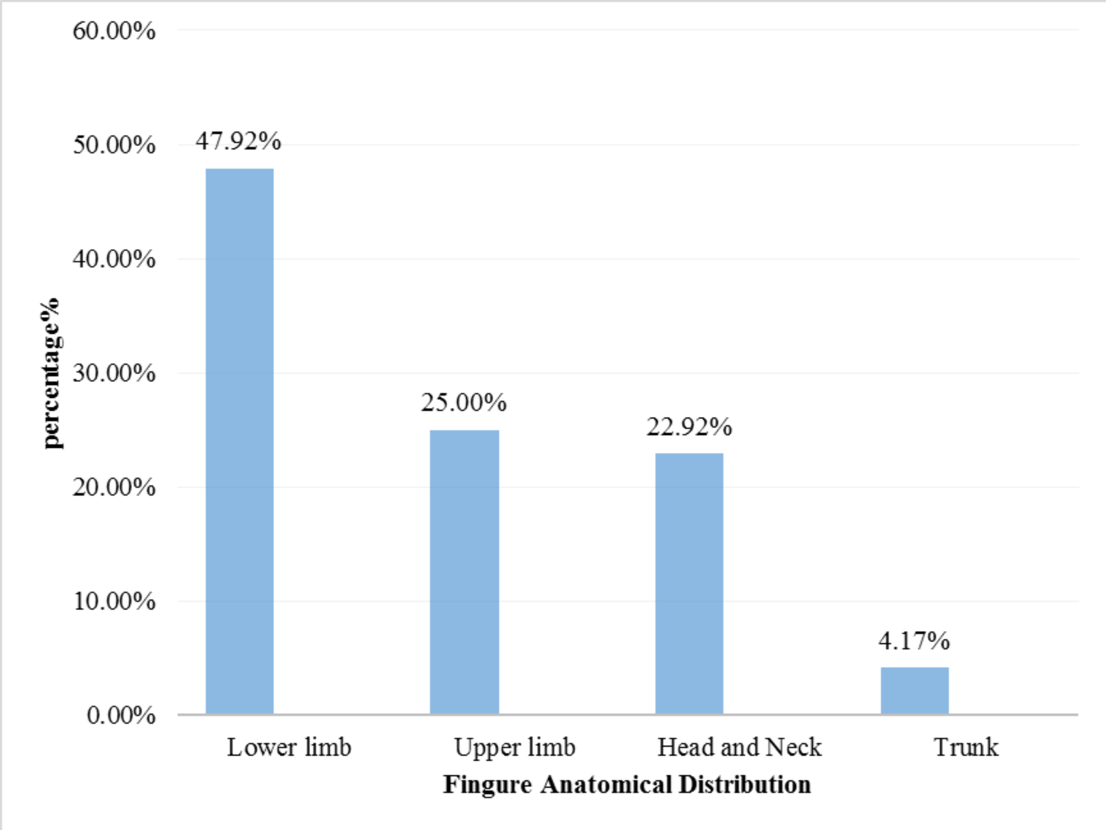

Figure 4: Anatomical Location of Degloving Injuries

Most degloving injuries (72.92%) occurred at the extremities, with 47.92% occurring at the lower limb, 25% occurred at the upper limb, 22.92% occurred in the head and neck region and 4.17% occurred at the trunk.

Category		Frequency	Percentage
Fracture at site	No	40	83.33
Of degloving	Yes	8	16.67
Total		48	100
Other injuries	Traumatic amputation	4	36.36
	Vascular injury	2	18.18
	Head injury	2	18.18
	Lung contusion	1	9.09
	Radius fracture	1	9.09
	Neck of femur	1	9.09
Total		11	100

Table 7: Associated Injuries

Other than the degloving injury, eight (16.67%) patients had an associated long bone fracture at the site of degloving injury. Other injuries that occurred at different sites included traumatic amputation, vascular injury, head injury, lung contusion, radius fracture, and fracture neck of femur. The highest associated injuries (36.36%) were traumatic amputations.

4.2 Treatment Modalities

The treatment of degloving injury was determined by the type of degloving injury. Patients were first divided into either open degloving injury or closed degloving injury.

4.2.1 Treatment modalities for open degloving injuries

All the patients who had open degloving injuries underwent debridement. Debridement was either done once (single debridement) or multiple times (serial debridement) depending on the extent of the injury, level of contamination, and occurrence of complications.

After debridement was done patients were then done definitive treatment either at the time of debridement or at a later date. The definitive treatment modalities included: closure of degloved primary flap, split-thickness skin grafting, full-thickness skin grafting, and muscle flap.

Table 8: Debridement

Variable	Category	Frequency	Percentage
Debridement	Single debridement	29	65.9
	Serial debridement	15	34.1
TOTAL		44	100

There were forty-four patients with open degloving injuries. All of them underwent debridement. The majority of them (65.9%) underwent a single debridement and there was no need for further debridement while 34.1% underwent serial debridement before the definitive management.

Table 9: Definitive treatment Modalities for open degloving injuries

Category	Frequency	Percentage
Primary closure	22	50
Split thickness Skin graft	10	22.7
Full-thickness skin graft	7	15.9
Muscle flap	5	11.4
TOTAL	44	100

Fifty percent of patients with open degloving injuries underwent primary closure of degloved flap as their definitive treatment. About 22.7% of patients underwent splint thickness skin grafting, 15.9% were done full-thickness skin graft and 11.4% of patients were done muscle flap.

On average patients took 19 hours before debridement, where the duration ranged from 4 hours to 336 hours. However, time to skin graft was on average longer (5 days) ranging from 2 – 30 days.

Table 10: Management according to pattern

	Pattern			
Management	**1**	**2**	**3**	**Total**
Serial debri/ftsg	0	2	1	3
Serial debri/muscle flap	0	1	3	4
Serial debri/primary closure	2	1	1	4
Serial debri/stsg	3	1	0	4
Single debri/ftsg	0	2	2	4
Single debri/muscle flap	0	0	1	1
Single debri/primary closure	12	6	0	18
Single debri/stsg	3	3	0	6
Total	20	16	8	44

debri= debridements; ftsg= full thickness skin graft; stsg= split thickness skin graft

Table 11: Mode of definitive treatment and debridement

Treatment	Single debridement	Serial Debridement	Total
Primary closure	18	4	22
Split thickness skin graft	6	4	10
Full-thickness skin graft	4	3	7
Muscle flap	1	4	5
Total	29	15	44

Out of the twenty-two patients who underwent primary closure as their definitive management eighteen underwent single debridement while four of them underwent a single debridement before their definitive management.

In the group of patients who were done splint thickness skin grafting (stsg) as their definitive management, four had to undergo serial debridement prior while six were done single debridement then definitive treatment was done at the time of debridement.

For patients who underwent full-thickness skin grafting (ftsg), three of them had to undergo serial debridement prior to definitive treatment while four of them were done single debridement and definitive treatment was then offered.

Most patients who underwent muscle flap as their definitive treatment had to undergo serial debridement prior to the definitive treatment.

Figure 5: pattern 3 Degloving injury, post bone fixation with an external fixator, and skin coverage with medial gastrocnemius muscle flap

Figure 6: Pattern 3 Degloving injury, post medial gastrocnemius flap and fixation with an external fixator

4.2.2 Treatment modalities for closed degloving injuries

Four patients had closed degloving injuries. Two of them were treated conservatively whereby antibiotics and analgesics were given, close monitoring through physical examination and laboratory works (complete blood count and Erythrocyte Sedimentation Rate) to look for any signs of infection was then done.

The other two patients with closed degloving injury had to undergo surgical drainage. In one patient, surgical drainage was done at the time of underlying fracture fixation while the other was done as the standalone procedure.

4.3 Early complications

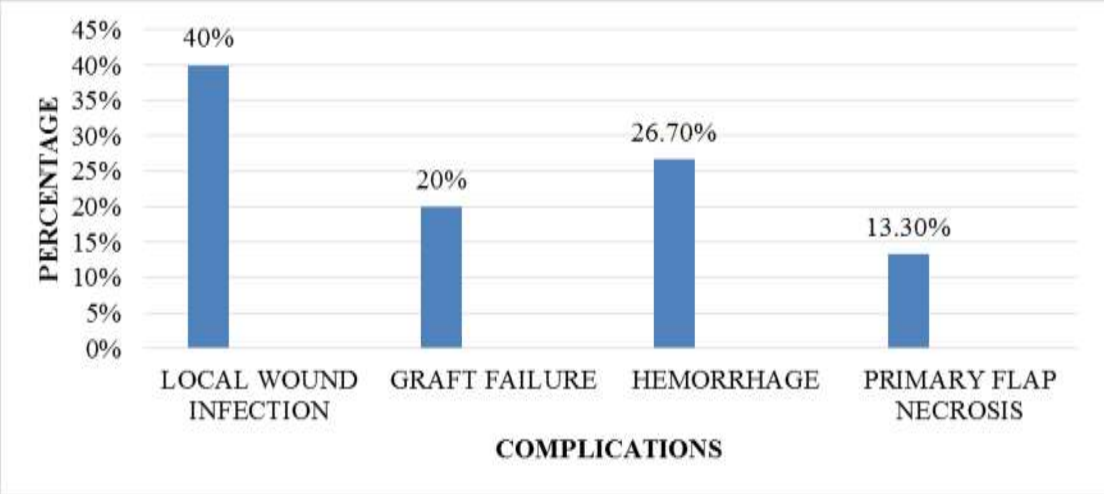

Figure 7: Early Complications of Degloving Injuries

The study found that 15 (31.2%) of patients admitted with degloving injuries developed complications. Complications only occurred in patients with open degloving injuries.

Local wound infection was the highest noted complication. Six (40%) of patients who developed complications had local wound infection. Other complications that were noted include skin graft failure (20%), hemorrhage (26.7%), and flap necrosis (13.3%).

Table 12: Association between complication and treatment modality

Treatment	Complication		p-value
	No (n=33)	Yes (n=15)	
Single Debridement	22	7	0.189^{c}
Serial debridement	7	8	0.043^{f}
Primary closure	17	5	0.241^{c}
FTSG	4	3	0.662^{f}
FTSG	6	4	0.703^{f}
Muscle flap	2	3	0.307^{f}
Antibiotics	2	0	-
Drainage	2	0	-

^{f} Fishers Exact test; ^{c} Chi-Square test

There was a significant association between serial debridement and complication where 53.3 % (8/15) of the done serial debridement ended up with a complication compared to 21.2 % (7/33) among those who did not have serial debridement.

Table 13: Complications among patients done serial debridement

	Serial debridement		
Complication	No	Yes	Total
Local wound Infection	2	4	6
Massive Hemorrhage	1	3	4
Primary Flap necrosis	1	1	2
Skin graft failure	3	0	3
Total	7	8	15

Generally, patients who required serial debridement developed complications as compared to patients who did not require serial debridement. This trend was not observed in skin graft failure whereby patients who developed skin graft failure had not undergone serial debridement.

Table 14: Early complications according to pattern

	Complications		
Pattern	No	Yes	p-value
1	22(91.7)	2(8.3)	
2	8(50.0)	8(50.0)	0.002[f]
3	3(37.5)	5(62.5)	

[f] Fishers Exact test

There was a statistically significant (p=0.002) association between the pattern of degloving injuries and the presence of complications. Among those with pattern 1, only 8.3% developed complications. This is a smaller proportion compared to those who had pattern 3 where 62.5% had complications.

Table 15: Complications among age groups

Age	Complications: No	Yes	Total
<16yrs	**8**	**0**	**8**
16-60yrs	**22**	**14**	**36**
>60yrs	**3**	**1**	**4**
Total	**33**	**15**	**48**

Although most of the patients in this study were youth, complications occurred more commonly among the age group 16-60 years.

On average those who did not develop complications took 16 hours (IQR 12, 25) from injury to debridement as compared to 22 hours (IQR 18, 72) among those who developed complications. However, the difference in the average time taken was not statistically significant (p=0.066).

Those who developed complications after surgery stayed significantly (p=0.005) longer (median=19; IQR 7, 36) days in hospital compared to those who had no complication (median=7; IQR 5, 12).

Figure 8: Primary flap necrosis of the left leg post-primary closure

CHAPTER FIVE: DISCUSSION

The research was set to explore the pattern, treatment, and early complications of degloving injuries in Moi Teaching and Referral Hospital. Forty-eight patients were admitted with the diagnosis of degloving injury at Moi Teaching and Referral Hospital between 1st Dec 2016 and 30th November 2017.

5.1 characteristics

The median age of the patients was 26 (IQR 18.5, 42.5) ranging from 4 to 70 years where 75% of the patients were aged 18 years and above. This concurs with other studies done on degloving injuries around the world. *Lekuya et al.,* (2018) found a similar mean age of 28.8 years in Uganda. *Hakim et al.,* (2016) also found a mean age of 30.5 years in a study done in Qatar. *Chen et al.,* (2016) found a mean age of 35.7 years in a study done in China. Yan et al also found the mean age of patients with degloving injuries to be 32.4 years with a range of 6-75 years.

Degloving injuries were found to occur more frequently among the male population in this study. This study showed that 60.4% of degloving injuries occurred in males. This concurs with other studies done on degloving injuries. A study done by Yan et al found that degloving injuries occurred more in the male population. In his study, degloving injuries occurred in 87 male patients and 15 female patients. *Lekuya et al.,* (2018) found a male: female ratio of 2:1 in Uganda while *Hakim et al.,* (2016) found that 91% of degloving injuries occurred in male, in a study done in Qatar. This might be so because young men are involved in risky activities that predispose them to trauma.

The prevalent (75%) etiology of the degloving injuries was motor vehicle and motorcycle accidents. A study that was done in Qatar by *Hakim et al.,* (2016) also found that three-quarters of degloving injuries were caused by road traffic accidents. *Lekuya et al.,* (2018) found that 84% of degloving injuries were caused by road traffic accidents in Uganda. The reason why road traffic accident is the main cause of degloving injury might be due to the increase in the use of motorcycle as a means of public transport in western Kenya (Sisimwo & Onchiri, 2018).

The study showed that 91.7% of degloving injuries occurring in MTRH are open degloving injuries with only 8.3% been closed. A study done in Qatar found that 79.8% of degloving injuries were open (Hakim et al., 2016). The study showed that degloving injuries occur more commonly on the lower limb (47%), this is in agreement with other studies done on degloving injuries. Daniel Francisco Mello et al found that the lower limb was the most affected anatomical site with a prevalence of 95.7% (Mello et al., 2015). *Khan et al.,*(2004) reported that 72% of degloving injuries occur in the lower limb. The lower limb is the most exposed part of the body at the time of injury, there is also minimal use of protective gear on the lower limb among motorcycle riders and passengers, and these might be the reasons why there are more degloving injuries on the lower limb as compared to other body parts.

According to the classification proposed by *Arnez et al*., (2010) soft tissue degloving can be distinguished by four patterns: abrasion/avulsion, noncircumferential degloving, and circumferential single-plane degloving, and circumferential multiplane degloving. This classification system can be useful in the management of certain patients; however, it is difficult to estimate the prognosis of patients using this classification. Some patterns may coexist in the same limb. Based on the *Arnez et al*., (2010) classification we for that most of the patients (59.1%) admitted at MTRH with degloving injuries had non-circumferential degloving injuries.

Yan et al., (2013) described three patterns of degloving injuries from Pattern 1 to Pattern 3. The higher the pattern the higher the energy at the time of injury and the higher the tissue damage to the limbs. This leads to a tendency for unfavorable prognosis with increasing pattern number. Most of the patients (50 %) in this study had pattern 1 degloving injuries.

5.2 Treatment

The golden time for the treatment of open degloving injuries is eight hours (Chen & Liu, 2016). On average patients at MTRH took 19 hours before debridement and five days for grafting to take place. This could be attributed to late presentation to the hospital and delay at casualty before the patients are taken to theatre.

Extensive degloving injuries can be problematic for reconstructive surgeons regarding treatment and closure because of the complexity of the injury. As early as the 1980s, these wounds have to be treated with repeated serial debridements and painful dressing changes, with the eventual placement of skin graft (Mandel et al., 1981).

Some studies have shown that immediate use of the degloved skin as a skin graft gives the most satisfactory coverage to the denuded areas, especially using the full-thickness skin graft (Jeng & Wei, 1997).

The grafting methods used for closure of degloving injuries in clinical practice vary. *Jeng et al.,* (2004) refined the techniques in the primary treatment of such patients, with satisfactory results. In their practice, multiple stabbing over the skin graft was performed, allowing fluid drainage when the defatted skin was repositioned. The fixation of the skin graft to the underlying bed with multiple staples was advocated to provide enough stability. The full-thickness skin graft with such a pattern of perforation healed well and produced a satisfactory cosmetic appearance (Jeng et al., 2004).

Some authors have advocated the use of Vacuum sealing drainage (VSD) system for the closure of degloving injuries. The vacuum-assisted closure or vacuum sealing drainage system applies even pressure to the entire wound and configures precisely to the intrinsic three-dimensional structure of the wound, reducing or eliminating movement or tenting (DeFranzo et al., 1999). This system can remove excess tissue edema, increase tissue blood flow, and decrease the number of localized bacteria. It also can remove third-space fluid effectively (Hou et al., 2011).

Historically, defatted full-thickness degloved skin has been difficult to hold in position because edema and bleeding in the underlying tissue are associated with a poor take, despite fastidious time-consuming suturing, dressing, and splinting of such injuries. The VSD system seems to meet the needs of the treatment of degloving injuries and has been used in dealing with such patients with success (Dini et al., 2012).

The treatment modalities at MTRH for open degloving injuries include primary closure of avulsed flap, split-thickness skin graft, full-thickness skin graft, muscle flap while for closed degloving injuries patients are treated by drainage and intravenous antibiotics. Most patients in Moi teaching and referral hospital were treated by primary closure of the avulsed flap. This contrasts with other studies that recommend for wound debridement and coverage of the defect with split or full-thickness skin grafts (Wójcicki, et al., 2011).

The surgical technique performed at Moi Teaching and Referral hospital for reattachment of degloved flap deferred from others described by numerous authors.

The key differences noted at MTRH include: once debridement was satisfactory, primary flap reattachment was done without defatting, no meshing was done to the primary flap and VAC dressing was not used.

These differences in the surgical technique could be postulated to be due to the lack of a multidisciplinary approach towards the treatment of degloving injuries, especially not involving the plastic surgeons. VAC dressing might not of have been used because of high cost.

5.3 Complications

Degloving injuries are occasionally benign in appearance, and may be associated with high morbidity and mortality if mismanaged (Jeng & Wei, 1997).

This study found that 15 (31.2%) of patients admitted with degloving injuries developed complications. Complications only occurred in patients with open degloving injuries.

Local wound infection was the highest noted complication. Forty percent of patients who developed complications had local wound infection. Other complications that were noted include skin graft failure (20%), vascular injury (26.7%), and flap necrosis (13.3%).

Mello et al., (2015) observed complications in 62% of patients with degloving injuries.

A study done by *Lekuya et al.,* (2018) in Uganda found that about 29.41% of degloving injuries resulted in haemorrhagic shock. Hakim et al., (2016) found that complications such as infection and skin necrosis occurred in 3.9 % and 1.1 % cases, respectively.

There was a significant association (p=0.002) between the pattern of degloving injuries and the presence of complications. Among those with pattern 1, only 8.3% developed complications. This is a smaller proportion compared to those who had pattern 3 where 62.5% had complications. This is in agreement with Yan et al who noted better healing in patterns 1 and 2 as compared to pattern 3.

Although most of the patients were aged between 16 and 60 years, the study showed that most of the complications occurred among this group. A study done by *Yan et al.*, (2013) showed that age had little impact on graft take except in severe cases of pattern 3 whereby they observed a better graft take in younger patients.

The reason for local wound infection might be due to a high level of contamination at the time of injury, delays before treatment (more time was taken from time of injury to debridement), and lack of use of VAC dressing which has been shown to decrease infections in other studies.

The occurrence of primary flap necrosis might be due to poor technique in the definitive treatment i.e. not meshing the primary flap, not using VAC dressing, and not defatting the primary flap.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

1. There was a predilection of the male and young population to degloving injuries. Most degloving injuries were open and occurred at the lower limb. The main cause of degloving injuries was road traffic accidents. The most common patterns of degloving injuries at MTRH were pattern 2 and non-circumferential degloving injuries. Degloving injuries occurred more commonly in the extremities, especially on the lower limbs.
2. Debridement, primary closure, skin grafting, and muscle flap remained the main treatment modalities for open degloving injuries while the treatment modality for closed degloving was either conservative management or surgical drainage. It took an average of 19 hours from the time of injury to debridement and 5 days for grafting.
3. Local skin infection was the main early complication. Other early complications noted included, graft failure, primary flap necrosis, and vascular injury. There was a significant association between different patterns and the occurrence of complications.

6.2 Recommendation

1. On characteristics of degloving injuries, the study found that there is no standard classification of degloving injury that is currently being used. The researcher thus recommends that another study be done to look at the different classifications and patterns to come up with a universal classification system that can be used to give guidelines on treatment and to predict complications. The study also found

that the main cause of degloving injuries was a road traffic accident; the researcher thus recommends that preventive measures to be put in place so as to decrease road traffic accidents among the young male population.

2. On treatment modalities, the study found that there were no treatment guidelines for the treatment of degloving injuries. The researcher thus recommends the development of a standard treatment protocol for the management of degloving injuries at Moi Teaching and Referral Hospital. The protocol should consider including the new techniques that have been recommended by other authors used in the management of degloving injuries. These techniques include defatting of primary flap before reattachment, meshing of the degloved flap, and use of VAC dressing. These techniques have been shown to have better outcomes than the ones used at MTRH whereby defatting of the flap is not done prior to reattachment, meshing the flap is not done, as well as not using VAC dressing. Adaptation of these techniques will most likely improve outcomes by decreasing the complication rate. The researcher further recommends a multidisciplinary approach towards the management of degloving injuries with contributions from different specialties including orthopaedics surgery, plastic surgery, vascular surgery, and physicians.
3. The study found that the main early complication that occurred at MTRH was local wound infection. The time taken from injury to debridement of open degloving injuries was 19 hours, while the recommended time should be 8 hours. The researcher thus recommends that degloving injury should be considered as a surgical emergency and thus patients with degloving injuries should be treated immediately without any delays. Another study can also be done to look at the reasons for the delay in the treatment of degloving injuries at MTRH.

REFERENCES

Adani, R., Castagnetti, C., & Landi, A. (1995). Degloving injuries of the hand and fingers. *Clinical Orthopaedics and Related Research*, (314):19–25. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/7634634.

Andres, T., von Lübken, F., Friemert, B., & Achatz, G. (2016). Vacuum-Assisted Closure in the Management of Degloving Soft Tissue Injury: A Case Report. *Journal of Foot and Ankle Surgery*, 55(4):852–856. https://doi.org/10.1053/j.jfas.2015.12.002.

Arnez, Z. M., Khan, U., & Tyler, M. P. H. (2010). Classification of soft-tissue degloving in limb trauma. *Journal of Plastic, Reconstructive & Aesthetic Surgery*, 63(11):1865–1869. https://doi.org/10.1016/j.bjps.2009.11.029.

Ayumba, B., Lelei, L., Emarah, A., & Lagat, D. (2007). *East African Orthopaedic Journal*. *East African Orthopaedic Journal* (Vol. 9):1-26. Kenya Orthopaedic Association. Retrieved from https://www.ajol.info/index.php/eaoj/article/view/120346.

Boernert, K., Ganot, G., Ulrich, M. K., & Iselin, L. D. (2018). Preserving the lower extremity after severe devolving injuries to meet the patient’s demand in two cases: (Limb salvage after degloving injury). *Trauma Case Reports*, 15:8–15. https://doi.org/10.1016/j.tcr.2018.04.003.

Charkoudian, N. (2003). Skin blood flow in adult human thermoregulation: how it works, when it does not, and why. *Mayo Clinic Proceedings*, 78(5):603–612. https://doi.org/10.4065/78.5.603.

Chen, Y., & Liu, L. (2016). Clinical analysis of 54 cases of large-area soft tissue avulsion in the lower limb. *Chinese Journal of Traumatology - English Edition*, 19(6):337–341. https://doi.org/10.1016/j.cjtee.2016.09.003.

Danby, F. W. (2005). Why we have sebaceous glands. *Journal of the American Academy of Dermatology*, 52(6):1071–1072. https://doi.org/10.1016/j.jaad.2005.02.016.

DeFranzo, A. J., Marks, M. W., Argenta, L. C., & Genecov, D. G. (1999). Vacuum-Assisted Closure for the Treatment of Degloving Injuries. *Plastic and Reconstructive Surgery*, 104(7):2145–2148. https://doi.org/10.1097/00006534-199912000-00031.

Dini, M., Quercioli, F., Mori, A., Romano, G. F., Lee, A. Q., & Agostini, T. (2012). Vacuum-assisted closure, dermal regeneration template, and degloved cryopreserved skin as useful tools in subtotal degloving of the lower limb. *Injury*, 43(6):957–959. https://doi.org/10.1016/j.injury.2011.03.020.

Hak, D. J., Olson, S. A., & Matta, J. M. (1997). Diagnosis and management of closed internal degloving injuries associated with pelvic and acetabular fractures: the

Morel-Lavallée lesion. *The Journal of Trauma*, 42(6):1046–1051. https://doi.org/10.1097/00005373-199706000-00010.

Hakim, S., Ahmed, K., El-Menyar, A., Jabbour, G., Peralta, R., Nabir, S., … Al-Thani, H. (2016a). Patterns and management of degloving injuries: a single national level 1 trauma center experience. *World Journal of Emergency Surgery : WJES*, 11(1):35-37. https://doi.org/10.1186/s13017-016-0093-2.

Halikis, M. N., & Taleisnik, J. (1996). Soft-tissue injuries of the wrist. *Clinics in Sports Medicine*, 15(2):235–259. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/8726316.

Harma, A., Inan, M., & Ertem, K. (2003). [The Morel-Lavallée lesion: a conservative approach to closed degloving injuries]. *Acta Orthopaedica et Traumatologica Turcica*, *38*(4):270–273. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/15618769.

Hou, Z., Irgit, K., Strohecker, K. A., Matzko, M. E., Wingert, N. C., Desantis, J. G., & Smith, W. R. (2011). Delayed flap reconstruction with vacuum-assisted closure management of the open IIIB tibial fracture. *Journal of Trauma - Injury, Infection and Critical Care*, 71(6):1705–1708. https://doi.org/10.1097/TA.0b013e31822e2823.

Hudson, D. A., Knottenbelt, J. D., & Krige, J. E. (1992). Closed degloving injuries: results following conservative surgery. *Plastic and Reconstructive Surgery*, 89(5):853–855. https://doi.org/10.1097/00006534-199205000-00013.

Jeng, S.-F., Hsieh, C.-H., Kuo, Y.-R., & Wei, F.-C. (2004). Technical refinement in the management of circumferentially avulsed skin of the leg. *Plastic and Reconstructive Surgery*, 114(5):1225–1227. https://doi.org/10.1097/01.prs.0000135869.57955.35.

Jeng, S. F., & Wei, F. C. (1997). Technical refinement in the management of circumferentially avulsed skin of the leg. *Plastic and Reconstructive Surgery*, 100(6):1434–1441. https://doi.org/10.1097/00006534-199711000-00009.

Ju, J., Li, J., & Hou, R. (2015). Microsurgery in 46 cases with total hand degloving injury. *Asian Journal of Surgery*, 38(4):205–209. https://doi.org/10.1016/j.asjsur.2015.01.004.

Kanitakis, J. (2002). European Journal of Dermatology Anatomy , histology and immunohistochemistry of normal human skin The epidermis General architecture Keratinocytes. *European Journal of Dermatology*, 12:390–401.

Khan, A. T., Tahmeedullah, & Obaidullah. (2004). Degloving injuries of the lower limb. *Journal of the College of Physicians and Surgeons--Pakistan : JCPSP*, 14(7):416–418. https://doi.org/07.2004/JCPSP.416418.

Krishnamoorthy, R., & Karthikeyan, G. (2011, May). Degloving injuries of the hand. *Indian Journal of Plastic Surgery*.44(2):227-236. https://doi.org/10.4103/0970-0358.85344.

Kumar, S. G., & Dharanipriya, A. (2014). Prevalence and pattern of occupational injuries at workplace among welders in coastal south India. *Indian Journal of Occupational and Environmental Medicine*, 18(3):135–139. https://doi.org/10.4103/0019-5278.146911.

Latifi, R., El-Hennawy, H., El-Menyar, A., Peralta, R., Asim, M., Consunji, R., & Al-Thani, H. (2014). The therapeutic challenges of degloving soft-tissue injuries. *Journal of Emergencies, Trauma, and Shock*, 7(3):228–232. https://doi.org/10.4103/0974-2700.136870.

Lefèvre, Y., Mallet, C., Ilharreborde, B., Jehanno, P., Frajmann, J. M., Penneçot, G.-F., … Fitoussi, F. (2011). Digital Avulsion With Compromised Vascularization. *Journal of Pediatric Orthopaedics*, 31(3):259–265. https://doi.org/10.1097/BPO.0b013e31820fc620.

Lekuya, H. M., Alenyo, R., Kajja, I., Bangirana, A., Mbiine, R., Deng, A. N., & Galukande, M. (2018b). Degloving injuries with versus without underlying fracture in a sub-Saharan African tertiary hospital: a prospective observational study. *Journal of Orthopaedic Surgery and Research*, 13(1):2-4. https://doi.org/10.1186/s13018-017-0706-9.

Mandel, M. A. (1981). The management of lower extremity degloving injuries. *Annals of Plastic Surgery*, 6(1):1–5. https://doi.org/10.1097/00000637-198101000-00001.

Mello, D. F., Assef, J. C., Soldá, S. C., & Helene Jr, A. (2015). Degloving injuries of trunk and limbs: comparison of outcomes of early versus delayed assessment by the plastic surgery team. *Revista Do Colégio Brasileiro de Cirurgiões*, 42(3): 143–148. https://doi.org/10.1590/0100-69912015003003.

Motsitsi, N. S. (n.d.).,BomelaL.N.,& Basson, H. (2008)*Morel-Lavallée lesion: A review*. Retrieved from http://www.scielo.org.za/pdf/saoj/v7n2/07.pdf.

Ozturk, C. N., Opara, P., Ozturk, C., & Djohan, R. (2015). Treatment of Foot Degloving Injury With Aid of Negative Pressure Wound Therapy and Dermal Regeneration Template. *Journal of Foot and Ankle Surgery*, 54(6):1132–1135. https://doi.org/10.1053/j.jfas.2014.06.014.

Pilanci, Ö., Saydam, F. A., Başaran, K., Datlı, A., & Güven, E. (2013). Management of soft tissue extremity degloving injuries with full-thickness grafts obtained from the avulsed flap. https://doi.org/10.5505/tjtes.2013.64928

Remy, L. F., Azurdia, J., Fansa, A., & Ebraheim, N. A. (2017). Closed Internal Degloving of the Flank. *The Archives of Bone and Joint Surgery*, 5(4):259–262. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/28913385.

Rha, E. Y., Kim, D. H., Kwon, H., & Jung, S.-N. (2013). Morel-lavallee lesion in children. *World Journal of Emergency Surgery : WJES*, 8(1):60-61. https://doi.org/10.1186/1749-7922-8-60.

Sisimwo, P. K., & Onchiri, G. M. (2018). Epidemiology of head injuries and helmet use among motorcycle crash injury: a quantitative analysis from a local hospital in Western Kenya. *The Pan African Medical Journal*, 31:*70-71*. https://doi.org/10.11604/PAMJ.2018.31.70.16988.

Weinand, C. (2018). Degloving Injuries of Upper Extremity: A Strategy with Full-Thickness Skin Mesh. *World J Plast Surg*, 7(3):372–376. https://doi.org/10.29252/wjps.7.3.372.

Wójcicki, P., Wojtkiewicz, W., & Drozdowski, P. (2011). Severe Lower Extremities Degloving Injuries - Medical Problems and Treatment Results. *Polish Journal of Surgery*, 83(5):276–282. https://doi.org/10.2478/v10035-011-0043-3.

Yan, H., Gao, W., Li, Z., Wang, C., Liu, S., Zhang, F., & Fan, C. (2013). The management of degloving injury of lower extremities. *Journal of Trauma and Acute Care Surgery*, 74(2):604–610. https://doi.org/10.1097/TA.0b013e31827d5e00.

Yousef, H., & Sharma, S. (2018). *Anatomy, Skin (Integument), Epidermis*. *StatPearls*. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/29262154.

APPENDICES

Appendix 1: IREC Approval

INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE (IREC)

MOI TEACHING AND REFERRAL HOSPITAL
P.O. BOX 3
ELDORET
Tel: 33471/2/3

MOI UNIVERSITY
SCHOOL OF MEDICINE
P.O. BOX 4606
ELDORET

Reference: IREC/2016/99
Approval Number: 0001686

28th July, 2016

INSTITUTIONAL RESEARCH & ETHICS COMMITTEE
28 JUL 2016
APPROVED
P. O. Box 4606-30100 ELDORET

Dr. Dennis Munyao Mutiso,
Moi University,
School of Medicine,
P.O. Box 4606-30100,
ELDORET-KENYA.

Dear Dr. Munyao,

RE: FORMAL APPROVAL

The Institutional Research and Ethics Committee has reviewed your research proposal titled:-

"Pattern, Treatment and Early Complications of Degloving Injuries in Patients at Moi Teaching and Referral Hospital".

Your proposal has been granted a Formal Approval Number: ***FAN: IREC 1686*** on 28th July, 2016. You are therefore permitted to begin your investigations.

Note that this approval is for 1 year; it will thus expire on 27th July, 2017. If it is necessary to continue with this research beyond the expiry date, a request for continuation should be made in writing to IREC Secretariat two months prior to the expiry date.

You are required to submit progress report(s) regularly as dictated by your proposal. Furthermore, you must notify the Committee of any proposal change (s) or amendment (s), serious or unexpected outcomes related to the conduct of the study, or study termination for any reason. The Committee expects to receive a final report at the end of the study.

Sincerely,

PROF. E. WERE
CHAIRMAN
INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE

cc	CEO	-	MTRH	Dean	-	SOP	Dean	-	SOM
	Principal	-	CHS	Dean	-	SON	Dean	-	SOD

Appendix 2: Approval to conduct the study at MTRH

MOI TEACHING AND REFERRAL HOSPITAL

Telephone: 2033471/2/3/4
Fax: 61749
Email: director@mtrh.or.ke
P. O. Box 3
ELDORET

Ref: ELD/MTRH/R.6/VOL.II/2008

25th August, 2016

Dr. Dennis Munyao Mutiso,
Moi University,
School of Medicine,
P.O. Box 4606-30100,
ELDORET-KENYA.

RE: APPROVAL TO CONDUCT RESEARCH AT MTRH

Upon obtaining approval from the Institutional Research and Ethics Committee (IREC) to conduct your research proposal titled:-

"Pattern, Treatment and Early Complications of Degloving Injuries in Patients a Moi Teaching and Referral Hospital".

You are hereby permitted to commence your investigation at Moi Teaching and Referral Hospital.

26/08/2016

DR. WILSON ARUASA
CHIEF EXECUTIVE OFFICER
MOI TEACHING AND REFERRAL HOSPITAL

CC - Deputy Director (CS)
- Chief Nurse
- HOD, HRISM

Appendix 3: Continuing approval

INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE (IREC)

MOI TEACHING AND REFERRAL HOSPITAL
P.O. BOX 3
ELDORET
Tel: 33471/2/3

MOI UNIVERSITY
SCHOOL OF MEDICINE
P.O. BOX 4606
ELDORET
Tel: 33471/2/3

Reference: IREC/2016/99
Approval Number: 0001686

28th July, 2017

INSTITUTIONAL RESEARCH & ETHICS COMMITTEE
28 JUL 2017
APPROVED
P. O. Box 4606 - 30100 ELDORET

Dr. Dennis Munyao Mutiso,
Moi University,
School of Medicine,
P.O. Box 4606-30100,
ELDORET-KENYA.

Dear Dr. Munyao,

RE: CONTINUING APPROVAL

The Institutional Research and Ethics Committee has reviewed your request for continuing approval to your study titled:-

"Pattern, Treatment and Early Complications of Degloving Injuries in Patients at Moi Teaching and Referral Hospital".

Your proposal has been granted a Continuing Approval with effect from 28th July, 2017. You are therefore permitted to continue with your study.

Note that this approval is for 1 year; it will thus expire on 27th July, 2018. If it is necessary to continue with this research beyond the expiry date, a request for continuation should be made in writing to IREC Secretariat two months prior to the expiry date.

You are required to submit progress report(s) regularly as dictated by your proposal. Furthermore, you must notify the Committee of any proposal change (s) or amendment (s), serious or unexpected outcomes related to the conduct of the study, or study termination for any reason. The Committee expects to receive a final report at the end of the study.

Sincerely,

DR. S. NYABERA
DEPUTY-CHAIRMAN
INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE

cc:	CEO	-	MTRH	Dean	-	SOD
	Principal	-	CHS	Dean	-	SPH
	Dean	-	SOM	Dean	-	SON

Appendix 4: Introduction Letter

Dennis Munyao Mutiso,

P O Box 1343, 90100

Machakos, Kenya.

Tel 0725450279.

Date: 1st sept 2016.

Dear Sir/Madam,

Ref: Introduction

I hereby want to inform you that I am currently conducting a study on pattern, treatment and early complications of degloving injuries managed in patients at Moi Teaching and Referral Hospital, Eldoret, Kenya.

Once the study has been completed, the results will be used to provide more information on the pattern, treatment and early complications of degloving injuries. This will help in provision of better management of patients in the future.

Yours Faithfully,

Dennis Munyao Mutiso.

Appendix 5: Consent Form

CONSENT FORM

PATTERN, TREATMENT AND EARLY COMPLICATIONS OF DEGLOVING INJURIES IN PATIENTS MANAGED AT THE MOI TEACHING AND REFERRAL HOSPITAL (MTRH), ELDORET.

INVESTIGATOR –DENNIS MUTISO OF P.O BOX 4606, ELDORET, KENYA

I…………………………………………….of P.O Box……………………

Tel……………………………..hereby give informed consent to participate in this study at MTRH. The study has been explained to me clearly by DENNIS MUTISO (or his appointed assistant) of P.O. Box 4606 Eldoret.

I have understood that to participate in this study, I shall volunteer information regarding my illness and other co-morbidities and undergo medical examination. I am aware that I can withdraw from this study at any time without prejudice to my right of treatment at MTRH now or in the future. I have also been assured that all information shall be treated and managed in confidence. I have not been induced or coerced by the investigator (or his appointed assistant) to cause my signature to be appended in this form and by extension participate in this study.

Name (initials) of participant……………………………

Signature………………………

Date………………………………

Name of witness………………………………………………………

Signature………………...............

Date………………………………

Appendix 6: Consent form in Swahili

FOMU YA DHAMBI

Mimi……………………………………… wa sanduku la posta …………………….

Simu …………………………apa ridhaa ya kutosha kushiriki katika utafiti huu katika MTRH. Utafiti huo nimeelezea wazi na DENNIS MUTISO (au msaidizi wake aliyeteuliwa) wa P.O. Sanduku 4606 Eldoret.

Nimeelewa kuwa kushiriki katika utafiti huu, nitajitolea habari kuhusu ugonjwa wangu na matibabu mengine ya kijeshi na kufanyia uchunguzi wa kimatibabu. Ninajua kuwa naweza kujiondoa kutoka kwa utafiti huu wakati wowote bila kuathiri haki yangu ya matibabu huko MTRH sasa au kwa siku zijazo. Pia nimehakikishiwa kuwa habari zote zitatibiwa na kusimamiwa kwa ujasiri. Sijachochewa au kulazimishwa na upelelezi (au msaidizi wake aliyeteuliwa) kusababisha saini yangu kusongezwa kwa fomu hii na kwa kuongezewa kushiriki katika utafiti huu.

Jina (initials) la mshiriki ……………………………

Sahihi………………………

Tarehe………………………………

Jina la shahidi ………………………………………………………

Sahihi………………..............

Tarehe………………………………

Appendix 7: Assent Form
ASSENT FORM

PATTERN, TREATMENT AND EARLY COMPLICATIONS OF DEGLOVING INJURIES IN PATIENTS AT THE MOI TEACHING AND REFERRAL HOSPITAL (MTRH), ELDORET.

INVESTIGATOR –DENNIS MUTISO OF P.O BOX 4606, ELDORET, KENYA

I…………………………………………….of P.O Box……………………

Tel……………………………..hereby give informed assent to participate in this study at MTRH. The study has been explained to me clearly by DENNIS MUTISO (or his appointed assistant) of P.O. Box 4606 Eldoret.

I have understood that to participate in this study, I shall volunteer information regarding my illness and other co-morbidities and undergo medical examination. I am aware that I can withdraw from this study at any time without prejudice to my right of treatment at MTRH now or in the future. I have also been assured that all information shall be treated and managed in confidence. I have not been induced or coerced by the investigator (or his appointed assistant) to cause my signature to be appended in this form and by extension participate in this study.

Name (initials) of participant……………………………

Signature………………………

Date………………………………

Name of witness (parent/guardian)…………………………………

Signature………………..............

Date………………………………

Appendix 6: Data Sheet

1. Demographic Data

Patient's Code............. Age.................. Gender: male ☐ female ☐

2. Level of Education

NONE ☐

Primary School ☐

Secondary school ☐

High learning ☐

3. Prior co-morbidities: Yes ☐ No ☐

If yes above, please specify...

4. Cause of injury…………………………………………….

5. Duration between injury and coming to hospital:

<12 hrs ☐ 12-24 hrs ☐ 24-48hrs ☐ >48 hrs ☐

6. History of alcohol intake before injury: YES ☐ NO ☐

7. Type of degloving injury: CLOSED ☐ OPEN ☐

If open: -

Avulsion ☐

Non circumferential ☐

Circumferential single plane ☐

Circumferential multi plane ☐

8. Location of the injury:

Upper limb: - a) Arm ☐

b) Forearm ☐

c) Hand ☐

d) Elbow joint ☐

e) Wrist joint ☐

Lower limb: - a) Thigh ☐

b) Leg ☐

c) Foot ☐

d) Knee joint ☐

e) Ankle joint ☐

Trunk

Scalp ☐

Face ☐

Genitalia ☐

Internal

9. Management offered: conservative ☐

Operative ☐

Analgesics ☐

Antibiotics ☐

Debridement ☐

Duration from injury to debridement …………………..

Skin graft ☐

Duration from injury to skin graft………………………..

Type of skin graft …………………………………………...

Compressive bandaging ☐

Drainage ☐

10. Complications:

a) Local wound infection ☐

b) Disseminated tissue necrosis ☐

c) Skin graft failure ☐

d) Generalized sepsis ☐

11. Duration of hospital stay: ……………………………………………

12. Fracture at site of degloving injury ☐

Appendix 7: Work Plan

Table 1: The work plan

Date	Activity	Duration	Responsible persons
Sept- Nov, 2015	Selection of topic	3 months	Researcher
Nov,2015- Jan, 2016	Literature review	3 months	Researcher
Feb, 2016	Writing proposal	1 month	Researcher and Supervisors
March, 2016	Submission to IREC	1 month	Researcher
April 2016	Approval by IREC	1 month	IREC reviewers
Dec 2016-Dec 2017	Data collection	12 months	Researcher and assistant
JAN 2018-April 2019	Writing the thesis report	14 months	Researcher and Supervisors
May 2019	Departmental oral defense	1 month	Researcher, faculty and public
June -Sept 2019	Submission of thesis for marking	3 months	Researcher
August 2020	Oral defense via zoom platform (online)	-	Researcher, board of examiners, faculty and public
September 2020	Editing/ correction of thesis	1 month	Researcher and supervisors
October 2020	Submission of bound thesis and publication	-	Researcher

Appendix 8: Budget

Table 2: Budget

Code	Item	Cost (K Sh.)
1	Six Reams of plain and ruled paper @ 500	3,000.00
2	Pens, pencils, folder and other stationery	2,000.00
3	Two Computer Flash discs	3,000.00
4	Printing research proposals	10,000.00
5	Printing thesis, six copies	5,000.00
6	Binding thesis	3,000.00
7	Research assistant	15,000.00
8	IREC fee	2,000.00
9	Data handling	20,000.00
10	Miscellaneous	5000.00
11	**Add 10% contingency**	**6700.00**
12	**AIRTIME**	**10,000**
	TOTAL	**84,700.00**