RECENT TRENDS IN SURGICAL MANAGEMENT OF THE DIABETIC FOOT

Essay

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LIST OF ABBERIVIATIONS

BES	Bio-Engineered Skin
CTA	Computed Topography Angiogram
DFU	Diabetic Foot Ulcer
DM	Diabetes Mellitus
ECM	Extra Cellular Matrix
ES	Electrical Stimulation
FDA	Food and Drug Association
HBOT	Hyperbaric Oxygen Therapy
IGF	Insulin-like Growth Factor
NPWT	Negative Pressure Wound Therapy
PAD	Peripheral Arterial Disease
PDGF	Platelet Derived Growth Factor

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Aim of Work

This study will focus on the anatomy of the foot and its layers, the magnitude of the problem of diabetic foot, the multidisciplinary approach for dealing with a patient having diabetic foot, wound care and the recent trends for diabetic foot reconstruction.

INTRODUCTION

Diabetes mellitus (DM) is one of the main problems in health systems and a global public health threat that has increased dramatically over the past 2 decades. *(**Shahbazian** et al., 2013)*

According to epidemiological studies, the number of patients with DM increased from about 30 million cases in 1985, 177 million in 2000, 285 million in 2010, and estimated if the situation continues to reach to more than 360 million people by 2030 will have DM *(**Shaw** et al., 2010)*

Patients with DM are prone to multiple complications such as diabetic foot ulcer (DFU). DFU is a common complication of DM that has shown an increasing trend over previous decades. (***Cavanagh** et al.*, 2005)

In total, it is estimated that 15% of patients with diabetes will suffer from DFU during their lifetime. *(**Leone** et al., 2012)*

It is estimated that approximately 20% of hospital admissions among patients with DM are the result of DFU. Indeed, DFU can

lead to infection, gangrene, amputation, and even death if necessary care is not provided. *(**Snyder** et al., 2009)*

On the other hand, once DFU has developed, there is an increased risk of ulcer progression that may ultimately lead to amputation. Overall, the rate of lower limb amputation in patients with DM is 15 times higher than patients without diabetes. *(**Leone** et al., 2012)*

Although accurate figures are difficult to obtain for the prevalence of DFU, the prevalence of this complication ranges from 4%-27% *(**Shahbazian** et al., 2015)*

The foot is highly specialized to cope with a large degree of repetitive stress. Fatty tissue on the plantar surface and thickened dermis and epidermis cushion and absorb repeated forces of compression, torsion, and shear during locomotion and standing *(**McCartan** et al., 2014)*

Three major pathologies -mutually interacting- result in the diabetic foot: ischemia, neuropathy, and infection *(**Connor**., 2008)*

Pure ischemic ulcers probably represent only 10% of DFU and 90% are caused by neuropathy, alone or with ischemia. *(**Prompers** et al., 2007)*

The most common pathway to develop foot problems in patients with diabetes is peripheral sensori-motor and autonomic neuropathy that leads to high foot pressure, foot deformities, and gait instability, which increases the risks of developing ulcers. *(**Formosa** et al., 2012)*

Additionally, it has been demonstrated that foot deformities and gait instability increases plantar pressure, which can result in foot ulceration. *(**Fernando** et al., 2014)*

However, numerous studies have shown that proper management of DFU can greatly reduce, delay, or prevent complications such as infection, gangrene, amputation, and even death. *(**DiPrita** 2014)*

The primary management goals for DFU are to obtain wound closure as expeditiously as possible. *(**Markowitz** et al. 2006)*

Treatment options maybe classified into established measures including management of diabetes as an etiology, along with surgical interventions, and advanced modalities. *(**Papanas** et al., 2007)*

As diabetes is a multi-organ systemic disease, all comorbidities that affect wound healing must be managed by a multidisciplinary team for optimal outcomes with DFU. *(**Driver** et al., 2005)*

Established treatment addresses the three major etiological factors, restore blood flow to the limb, off-load high pressure areas and tackle infection *(**Frykberg** et al., 2006)*

Diabetic foot surgery plays an essential role in the prevention and management of DFU *(**Capobianco** et al., 2010)*

In general, surgery for DFU healing includes non-vascular foot surgery, vascular foot surgery, and in some cases amputation. *(**Armstrong** et al., 2004)*

Restoration of blood flow is called revascularization or arterial reconstruction. This is achieved either by the open surgical approach (bypass graft surgery) or by endovascular techniques i.e percutaneous transluminal angioplasty (PTA). Both modalities have proved effective in restoring adequate arterial perfusion among diabetic patients. *(**Sigala** et al., 2006)*

Debridement is the removal of necrotic and senescent tissues as well as foreign and infected materials from a wound, which is considered as the first and the most important therapeutic step leading to wound closure and a decrease in the possibility of limb amputation in patients with DFU. *(**Tallis** et al., 2013)*

While the primary goal of DFU management focuses on limb salvage, in some cases amputation may offer a better functional outcome, although this is often not clearly defined. *(**Lepäntalo** et al., 2011)*

In general, amputation is considered as an urgent or curative surgery and should be the last resort after all other salvage techniques have been explored, and the patient must be in agreement. *(**Frykberg** et al., 2000)*

Indications for an amputation include the removal of infected or gangrenous tissues, control of infection, and creation of a functional foot or stump that can accommodate footwear or prosthesis *(**Abou-Zamzam** et al., 2007)*

Hyperbaric oxygen therapy (HBOT) has shown promise in the treatment of serious cases of non-healing DFU, which are resistant to other therapeutic methods. *(**Oliviera** et al., 2014)*

HBOT involves intermittent administration of 100% oxygen, usually in daily sessions. *(**Barnes** et al., 2006)*

Negative pressure wound therapy (NPWT) is a non-invasive wound closure system that uses controlled, localized negative pressure to help heal chronic and acute wounds. This system uses latex-free and sterile polyurethane or polyvinyl alcohol foam dressing that is fitted at the bedside to the appropriate size for every wound, and then covered with an adhesive drape to create an airtight seal. *(**Vikatmaa** et al., 2008)*

Electrical stimulation (ES) has been reported as a perfect adjunctive therapy for DFU healing in recent literature. Currently, there is a substantial body of work that supports the effectiveness of ES for DFU healing *(**Mulder** et al., 2014)*

Bio-engineered skin (BES) has been used during the last decades as a new therapeutic method to treat DFU. *(**Kim** et al., 2007)*

This method replaces the degraded and destructive milieu of extra cellular matrix (ECM) with the introduction of a new ground substance matrix with cellular components to start a new healing trajectory *(**Futrega** et al., 2014)*

DFU has demonstrated the benefits from growth factors (GFs) such as platelet derived growth factor (PDGF), fibroblast growth factor, vascular endothelial growth factor, insulin-like growth factors (IGF1, IGF2), epidermal growth factor, and transforming growth factor b. *(**Papanas** et al., 2008)*

Among the aforementioned GFs, only recombinant human PDGF (rhPDGF)(Becaplermin or Regranex), which is a hydrogel that contains 0.01% of PDGF-BB (rhPDGF-BB), has demonstrated increased healing rates when compared with controls in a number of clinical trials and has shown sufficient DFU repair efficacy to earn Food and Drug Administration (FDA) approval. *(**Barrientos** et al., 2008)*

A controversial ancient modality, biological debridment by application of sterile maggots that selectively remove necrotic tissue is considered the most promising surgical mode of debridement. *(**Papanas** et al., 2007)*

Management of infection is of vital importance. Antibiotics should be prescribed without delay when there is clinical suspicion of infection, such as pain, erythema, discoloration or friable granulation tissue. Clinical presentation does not reveal the species of bacteria. As a general rule, though, the initial regimen should cover staphylococcus and other gram positive cocci. (**Papanas** et al., 2007)

More recently, linezolid, ertapenem and Piperacillin/Tazobactam have been approved by the FDA for diabetic foot infections. *(**Frykberg** et al., 2006)*

ANATOMY OF THE FOOT

The foot is a part of the lower limb distal to the ankle joint, which helps in locomotion as walking, running or jumping. *(**Gosling** et al., 2008)*

The strong and complex mechanical structure of human foot contains more than 26 bones, 33 joints, and more than a hundred muscles, tendons, and ligaments that can withstand sheer stress of the whole body weight. *(**Gosling** et al., 2008)*

The foot is divided into the hindfoot, the midfoot, and the forefoot, each consists of bones, joints, aponeurosis, and muscles:

Bones of the foot

The hindfoot has the talus (Latin for ankle bone) and the calcaneus (Latin for heel bone). The two long bones of the lower limb, the tibia and fibula, are connected the largest bone of the foot called the calcaneus, and is cushioned inferiorly by a layer of fat. *(**Gosling** et al., 2008)*

The talus is the most superior bone of the foot and sits on top of and is supported by the calcaneus, it articulates above with the tibia and fibula to form the ankle joint and also projects forward to

articulate with the intermediate tarsal bone (navicular) on the medial side of the foot ***(Gray**, 2014)*

The calcaneus is the largest of the tarsal bones posteriorly it forms the bony framework of the heel and anteriorly projects forward to articulate with one of the distal group of tarsal bones (cuboid) on the lateral side of the foot. ***(Gray**, 2014)*

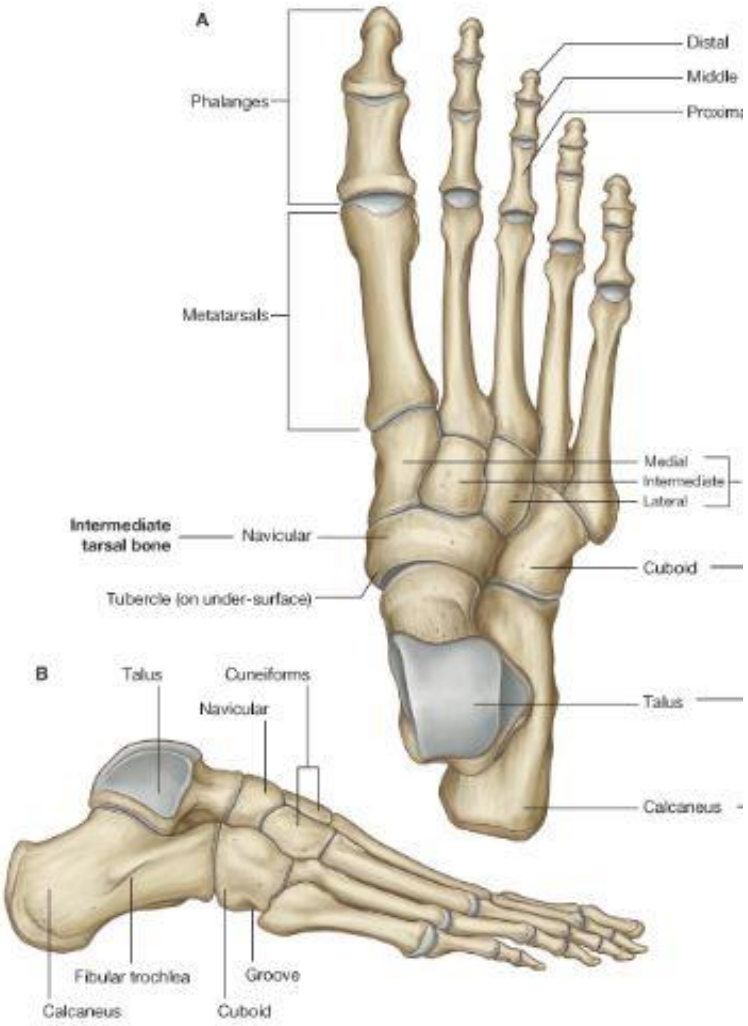

Figure 1 – bones of the foot (Gosling et al., 2008)