CHAPTER 1

INTRODUCTION

1.1 GENERAL

Sutures play an important role in wound healing after surgical interventions or accidental tissue ruptures. Surgical wounds are generally acute and mostly heal naturally without creating complications such as surgical site infection (SSI) and wound dehiscence. Wounds with surgical site infections contain devitalised tissues and the removal of this tissue enhances the wound healing (Baxter 2003). Devitalised tissue may vary from dry, hard, black to a wet, soft fibrous, yellow or green and may lead to the production of wound exudates with odour (O’Brien 2003). It has been reported by the Health Protection Agency that in UK, 4 - 5% of patients undergoing surgery suffer from SSI (Smyth 2008). Additional days of hospitalisation and cost have to be spent in treating SSI. It is necessary to develop sutures which can prevent the formation of infections and re-approximating the tissues perfectly. An ideal suture should provide a friendly environment and specific functions depending on the type of wound and patient factor.

1.2 SUTURE AND ITS CHOICE

Surgical sutures are sterile filaments which act as a self-supporting element to hold the tissues until they heal. It also helps to connect the tissues with prosthetic devices (Gurumoorthy et al. 2013). Sutures are made up of
natural or synthetic biomaterials with a metallic needle attached to it at one of the fibrous ends (Saxena et al. 2011). A good suture material should be made up of fibres with desirable properties like inertness, adequate tensile strength and strength retention in the body’s environment, good healing characteristics and compatible with body tissues (Rajendran & Anand 2002). Sutures are classified according to three major criterions. Depending on the origin, sutures are classified as natural and synthetic; depending on the structure, they are classified as monofilament and multifilament and based on their durability, they are classified as absorbable and nonabsorbable.

In the past, there were only a few choices for wound closure, however it has changed now. Starting from catgut, silk, linen and cotton, there has been a tremendous development in sutures; approximately 5269 sutures have been developed from various natural and synthetic materials comprising antibiotic loaded sutures and knotless sutures. Very recently, the use of adhesives, glues, staples and tapes in wound closure also became popularised. Wound closing in an infant differs from wound closing in an elderly person and also vary with the presence of heart disease, diabetes, steroids use and type of skin. In a body, skin varies based on its thickness, elasticity, speed of healing and scar formation. Apart from selecting a suture based on its properties, other factors like surgeon’s experience, patient’s age, comfort, health condition, weight, and incidence of infection comfort are very important. Performance and quality of sutures produced by different companies vary, though manufactured with similar chemical components. It is paramount to any surgeon to choose a method and material that is technically easy with secure closure with minimal pain and scar to avoid infections and to enhance healing (Hochberg et al. 2009).
1.3 SILK - A BIOMATERIAL FOR SUTURE

Silk fibres from Bombyx mori silkworm are the primary material used in biomedical applications, particularly as sutures. Silk has been effective in many clinical applications for decades. Sericin glue like protein covering the outer surface of the silk fibre has been a problem in creating adverse effects in biocompatibility and hypersensitivity in using silk and after its removal; core fibroin fibres are comparable with other biomaterials. According to the US Pharmacopeia’s definition silk is classified as non-degradable but through literature, it has been categorised as slowly degradable material for longer times. Degradation behaviour of biomaterial is important in the in vivo medical applications. Silk fibroins are degraded by enzymes, especially by proteolytic enzymes (Altman et al. 2003).

1.4 PLASMA TREATMENT

Plasma is considered to be the fourth state of matter after solid, liquid and water. It is a mixture of free radicals, electrons and heavy particles which make it unique for surface modification (Morent et al. 2008b). Many properties like adhesion, hydrophilicity, antibacterial, electrical and mechanical properties of textile materials are enhanced by nano-scaled modification of the surface (Shahidi et al. 2010). Though many gases are being used, oxygen is the most commonly used gas for modification of polymers by plasma as it improves the wettability of the surface by incorporating the polar groups on the polymer surface and degradation is hindered even though the degree of crosslinking is low (Morra et al. 1993).

1.5 FOCUS ON TRADITIONAL PLANTS IN HEALTH CARE

Healthcare costs and treatment failures have increased due to the resistance of pathogens to antimicrobial agents. Usage of suitable antimicrobial drug gives conclusive benefit, but these drugs are used
offensively by many physicians and public. Recent research has concentrated on pathogens that affect the skin, digestive and respiratory systems. It was concluded that the pathogens develop resistance to first-line antibiotics and again when new antibiotics were developed, the pathogens extend their resistance to the new class of drug also. So in order to overcome, this many researchers focused on the development of extracting drugs from the valuable source of traditional plants (Saad et al. 2014).

1.6 Cynodon dactylon IN WOUND HEALING

Cynodon dactylon occupies a major place in ethnomedicinal use and traditional practices. It possesses enormous medicinal values, including antimicrobial, antiviral, anti-inflammatory, anti-diabetic, antioxidant, wound healing properties and it is used in the treatment of urinary tract infections, prostatitis, syphilis and dysentery (Asthana et al. 2012). Phytochemical constituents present in Cynodon dactylon encompass more activity against Escherichia coli and Staphylococcus aureus which are common bacteria responsible for nosocomial infections (Annabelcarz et al. 2009).

1.7 CHITOSAN IN WOUND HEALING

Chitosan is a biopolymer obtained by deacetylation of chitin, a major component of crustacean shells. Chitosan has activity against gram negative, gram positive, algae, yeast and fungi. Though the antibacterial activity of chitosan is not clear, it is accepted that positive charges provided by primary amine groups interacts with negatively charged cell membranes of the microbes (Ueno et al. 2001). It has excellent blood and cell compatibility, and so it has been used internally to promote surgical hemostasis and diffuse bleeding. Chitosan possesses high durability, good biocompatibility, low toxicity, liquid absorption and antibacterial activity which makes it effective for wound healing applications (Yogeshkumar et al. 2013).
1.8 OBJECTIVES OF THE PRESENT STUDY

The research study is focused on the development of suture with desirable mechanical, handling and wound healing properties using plasma treated braided silk thread, chitosan, and *Cynodon dactylon*. The objectives of the research work are summarized below based on the above discussion.

- To develop and analyze the effect of structural parameters on the mechanical and handling properties of different braided silk sutures by varying the core, sheath and number of filaments.

- To prepare and analyze the extract of *Cynodon dactylon* for its active components against wound healing and anti-diabetic property. To find the Minimum Inhibitory Concentration (MIC) required against *Staphylococcus aureus* and *Escherichia coli*.

- To optimize the process parameters for the preparation of chitosan-*Cynodon dactylon* coated suture and to evaluate the properties.

- To treat the suture constructed with 12 filaments, 3 ply sheath and cable core with oxygen plasma. To coat the plasma treated and untreated suture with solution prepared under optimized process conditions and to cure the suture under optimised temperature. To characterize and evaluate the suture properties.

- To compare the developed silk suture with commercial suture on the basis of their mechanical, handling, *in vitro* antibacterial and *in vivo* wound healing studies.
1.9 ORGANISATION OF THESIS

Chapter 1 introduces the background information and objectives of the research work along with the organizational structure of the thesis.

Chapter 2 provides the detailed information and data obtained from the literature survey including suture types and their characteristics, surgical site infections, developments in the suture, plasma and its effects, chitosan and its properties, Cynodon dactylon and its properties.

Chapter 3 outlines the materials and methods used in the research work with the experimental plan.

Chapter 4 studies the effect of different structural parameters on the essential properties of the braided silk suture.

Chapter 5 deals with the component analysis of Cynodon dactylon and Minimum Inhibitory Concentration (MIC) against gram positive Staphylococcus aureus and gram negative Escherichia coli.

Chapter 6 presents the optimization of process parameters for the preparation of chitosan-Cynodon dactylon loaded silk sutures.

Chapter 7 deals with the oxygen plasma treatment and their effects on mechanical, handling and antibacterial properties of silk sutures. This chapter also deals with the preparation, evaluation and characterisation of plasma treated and untreated silk sutures coated with optimized process parameters and are compared with commercial silk suture.

Chapter 8 deals in comparing the developed suture with commercial suture on the basis of in vitro antibacterial and in vivo wound
healing studies using two wound models namely, incision wound model in normal groups and diabetic groups.

Chapter 9 summarizes the results and findings of the present research work and draws the conclusions. The scope of the future work is also discussed.