Acta Biomaterialia 8 (2012) 4007–4019

Contents lists available at SciVerse ScienceDirect

Acta Biomaterialia

journal homepage: www.elsevier.com/locate/actabiomat

The use of layer by layer self-assembled coatings of hyaluronic acid and cationized gelatin to improve the biocompatibility of poly(ethylene terephthalate) artificial ligaments for reconstruction of the anterior cruciate ligament

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A R T I C L E I N F O

Article history:
Received 24 April 2012
Received in revised form 7 July 2012
Accepted 10 July 2012
Available online 17 July 2012

Keywords:
Artificial ligament
Cationized gelatin
Hyaluronic acid
Self-assembly
Biocompatibility

A B S T R A C T

In this study layer by layer (LBL) self-assembled coatings of hyaluronic acid (HA) and cationized gelatin (CG) were used to modify polyethylene terephthalate (PET) artificial ligament grafts. Changes in the surface properties were characterized by scanning electron microscopy, attenuated total reflection Fourier transform infrared spectroscopy, energy-dispersive X-ray spectroscopy, and contact angle and biomechanical measurements. The cell compatibility of this HA–CG coating was investigated in vitro on PET films seeded with human foreskin dermal fibroblasts over 7 days. The results of our in vitro studies demonstrated that the HA–CG coating significantly enhanced cell adhesion, facilitated cell growth, and suppressed the expression of inflammation-related genes relative to a pure PET graft. Furthermore, rabbit and porcine anterior cruciate ligament reconstruction models were used to evaluate the effect of this LBL coating in vivo. The animal experiment results proved that this LBL coating significantly inhibited inflammatory cell infiltration and promoted new ligament tissue regeneration among the graft fibers. In addition, the formation of type I collagen in the HA–CG coating group was much higher than in the control group. Based on these results we conclude that PET grafts coated with HA–CG have considerable potential as substitutes for ligament reconstruction.

1. Introduction

Damage to the anterior cruciate ligament (ACL) is one of the most common sports injuries. It has limited ability to heal itself after it is ruptured by trauma [1]. The main treatment for ACL injury has been to reconstruct the ACL using autograft or allograft tendon [2]. However, autograft harvest can result in pain, weakness and altered biomechanics and morbidity at the harvest site, while allograft implantation can result in disease transmission, infection, and allergic reactions [3]. Because of these drawbacks there is significant interest in the use of artificial ligaments in ACL reconstruction.

The Ligament Advanced Reinforcement System (LARS) is one such artificial ligament [4]. This type of artificial ligament is non-degradable and maintains good mechanical durability. Several investigations have reported that LARS artificial ligaments produce safe and satisfactory results in the reconstruction of knee ligaments [5–8]. However, some failure cases have been noted [9–11]. Guidoin et al. [9] analyzed 117 ACL prostheses excised after they had ruptured and developed synovitis after implantation. Chronic inflammatory reactions were observed, with macrophages and giant cells in the polyester ligaments. Poorly organized and unpredictably distributed collagen tissue, which resembled scar tissue, infiltrated between the fibers during healing, which may induce loss of integrity of the ligament textile structure and result in failure of the artificial ligament. Recently a rare case of serious synovitis was reported in a 26-year-old man with a LARS artificial ligament reconstruction. The 3-year post-operative observations revealed thick fibrous scar tissue around the graft and poorly organized fibrous scar tissue between the graft fibers, which might cause a loss of structural integrity of the ligament and eventual failure of the graft [10]. These failures indicated that the polyethylene terephthalate (PET) artificial ligament graft had poor "ligamentization" in the knee joint after implantation [12].

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http://dx.doi.org/10.1016/j.actbio.2012.07.008