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Case study

A failure study of a locking compression plate implant

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ABSTRACT

In this case study a failed locking compression plate was investigated. Such plating systems are used to provide the stability to fractured bone and fixation. The locking compression plate had been separated in two pieces. One of the fracture surfaces from the failed component was investigated for surface topographical features. The visual, optical and scanning electron microscopy results indicated the presence of beach marks, intermetallic inclusions, corrosion pits and striations indicating fatigue crack propagation and overload failure. Some corrosion damage also was documented on the fractography. This case study shows that corrosion may have initiated fatigue crack which grew by the activities of daily living causing the failure.

1. Introduction

Locking compression plates are extensively used to treat the factures of the bones [1–3]. Annual use of such devices is expected to be over 4.5 million in the United States alone. The plate submitted for this investigation is a 10 hole, plate. Each hole was prepared such a way to allow either a non-locking screw or a locked screw placement. In the case of a locked screw, the screw head contains threads and meshes with the screw threads within the plate-hole. Such meshing allows the transfer of forces from the bone to the plate without compressing the bone, thus enhancing the vascular supply to the fracture site [3,4]. Therefore, these devices are very popular and used for fracture fixation, osteotomies, nonunion and fusion of smaller bone fragments [1–4]. Hybrid plating technique [2] combines the use of both locking and non-locking screws in different holes within the same construct depending upon the bone quality to reduce the costs of operation.

The locking compression plate stabilizes the bone fragments by the virtue of the attachment of screws to the plate in a very rigid manner that allows only fixed angle coupling [4]. Non locking screws apply frictional force, see the mechanics of force development in plated constructs in Fig. 1, between the plate and the bone to achieve stabilization of the bone fragments that are generated by the screws which compress the plate and bone together [1–4].

2. Materials and method

The retrieved device is shown in Fig. 2. The device consisted of plate, separated in two pieces from the mid-section. There were 8 screws of the different sizes. Among them two were locking screws and others non-locking screws. Total length of the

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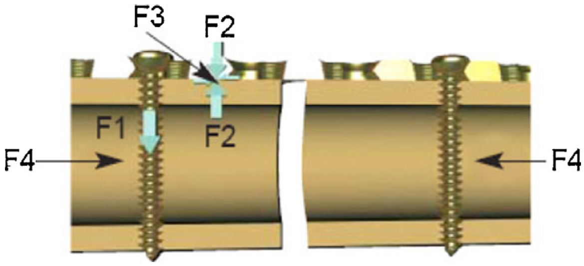

Fig. 1. Mechanics of the locking compression plate technology and forces generated as a result [12] where, F1 = force to tighten the screw into a bone, F2 = reaction force developed because of force F1, F3 = friction force between the plate and bone due to F2, and F4 = axial load [2].

plate was 137.5 mm. The length of the screws were; 16.5, 20.5, 24.5, 28.5, and 30.5 mm, respectively. The plate was 3.5 mm thick, Fig. 2.

2.1. Hardness tests

The average hardness of the plate was 279 HB which was similar to [4]. For this material the tensile strength, empirically converted from hardness value, was 965 MPa and consistent with the specifications for Stainless Steel plate [5]. The chemical composition, microstructure and other properties can be found in ASTM F138-03 [5].

2.2. Visual inspection

Visual inspections revealed scratches on the surface of the plate. Some rusting also was visible.

2.3. Optical microscope analysis

Surface topography of the plate was undertaken using an optical microscope. The fracture surface was removed by making a cut close to the fracture surface. The cut piece was cleaned using ultrasonic cleaning process and air blowing [6]. The eight different locking and non-locking screws were also clamped under the optical microscope to investigate the documentable features. Apart from some scratches, which may have formed after the device removal, the screws did not reveal any quantifiable damage to them. Site from where the crack started was documented in Fig. 3.

2.4. Fractography

After cleaning the surface, the sample was observed under the scanning electron microscope (SEM). The features from the site of crack initiation and propagation were documented at low and high magnifications.

3. Results and discussion

The fatigue crack was initiated from the surface of plate. The plate had undergone some corrosion damage as rust was visible on the plate surface. The corrosion and intermetallic inclusion may have started the crack and it propagated from the

Fig. 2. Locking compression plate and Screws submitted for this study.