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Case study

Pedicle screw rupture: A case study

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ABSTRACT

In this work we present a technical description related to the rupture of a titanium alloy pedicle screw and connecting bar implanted in dorsal vertebras of a patient. Only metallurgical facts are described, with no attempt to identify any imperfections in the clinical aspects related to the rupture. The results described here are based on extensive analysis of the broken materials in a material sciences specialized laboratory. Excluding an incorrect prosthesis implantation in the surgical procedure and a possible low bone density, an information not available to the research team, with high probability the rupture of metallic pieces used in the prosthetic implant, was produced by the low fatigue resistance resulting by an improper machining process and excessive bending of the connecting bar prior to implant.

1. Introduction

The person involved in this clinical case, named here simply as the "patient", was suffering with intense pains in the lumbar region of his dorsal spine. Clinical treatments were used with no results, resulting in the surgical action in order to insert a prosthetics linking two adjacent vertebras, so as to eliminate the effect of a broken connection between these vertebras. After about six months from the surgical intervention, the patient was suffering again by intense pains in the region where the prosthetic was implanted. X-rays and Tomography revealed the rupture of a screw and attached connecting bar. A new surgical intervention was done to substitute the prosthetic. The patient sued the company responsible for the prosthetic material, claiming a certain amount for both physical and psychological discomfort.

Some articles have related features of surgeries and instrumentation used.

Intravertebral and intrapedicular pedicle screw bending moments were studied by [1] as a function of sagittal insertion angle. The influence of various parameters on the failure of fixation systems due to the pull-out phenomenon of the fixation screws was explored by [2] through a finite element model of the human lumbar vertebral bone and of the transpedicular fixation screw with the design simulation based on the main characteristics of commercial fixation pedicle screws.

The goal of the De Marco et al.'s study [3] was to evaluate thoracic and lumbar pedicle screws placement to treat a variety of spinal disorders, where these screws were inserted using intra operative anatomical and fluoroscopic parameters.

Daher et al. [4] investigated if the number of pedicular screw (screw density) within the major curve correlates with the curve correction in the surgical treatment of neuromuscular scoliosis and also compared the correction of the major curve

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and pelvic obliquity using Luque–Galveston instrumentation and pedicle screw constructs in the treatment of neuromuscular scoliosis [5].

Masson et al. [6] had analyzed experimentally the early alterations of the bone-screw interface with tapping techniques in the cancellous bone of the cervical vertebrae.

Vendrame et al. [7] had accessed microscopically bone tissue changes between vertebral bone and implant interface, whose pilot hole was prepared using probe, drill and drill followed by tapping.

A prospective, randomized clinical study was performed by [8] to determine whether unilateral pedicle screw fixation was comparable with bilateral fixation in 1- or 2-segment lumbar interbody fusion.

Other literatures have described typical analysis methods adopted to evaluate materials and failures on pedicle screw.

Chen et al. [9] had investigated the pedicle screw breakage by conducting retrieval analyses of broken pedicle screws from 16 patients clinically and by performing stress analyses in the posterolateral fusion computationally using finite element (FE) models, when fracture surface of screws was studied by scanning electron microscope (SEM).

La Torre et al. [10] had estimated inner forces acting on lumbar spine during activity of lifting objects. After that, using inverse dynamics method the resulting joint between L5/S1 and resulting muscle forces were calculated.

The three basic concepts that are important to the biomechanics of pedicle screw based instrumentation were described by [11], where they are: first, the outer diameter of the screw determines pullout strength, while the inner diameter determines fatigue strength; secondly, when inserting a pedicle screw, the dorsal cortex of the spine should not be violated and the screws on each side should converge and be of good length; and thirdly, fixation can be augmented in cases of severe osteoporosis or revision.

A research done to determine the cause of a broken titanium pedicle screw supporting a prosthesis inserted to repair a broken spinal vertebra in a 38 year old patient was reported by [12].

Siskey et al. [13] had been performed mechanical tests based on the standard ASTM-F1717 protocol, with the exception that displacement control (as opposed to load control) to evaluate the fatigue performance of PEEK spinal fusion rod systems.

Yust [14] had compared a clinically applicable method of testing pedicle screw failure in human cadaver osteoporotic vertebrae to previously studied synthetic bone.

Chang [15] presented a short description about stages of a mechanical failure analysis of a broken bolt, highlighting these stages: (1) character; (2) setting; (3) plot; and (4) conflict.

Fakhouri et al. [16] had compared, using photoelasticity, internal stress produced by USS II type screw with 5.2 and 6.2 mm external diameters, when submitted to three different pullout strengths.

Kueny et al. [17] had determined the fixation strength of three current osteoporotic fixation techniques and had investigated whether or not pullout testing results can directly relate to those of the more physiologic fatigue testing.

In Williams and Chawla [18], fractography of a failed Profemur Z implant showed that a life limiting fatigue crack was nucleated on the anterolateral surface of the implant(tm)s neck.

In Cetin et al. [19], effects of the pedicle screws angled fixation to the rod on the mechanical properties of fixation were investigated.

2. Case history

In what follows the real facts occurred are given a short description:

1. The patient was interned in a local hospital in June 4th, 2009, going through a clinical and physiotherapeutic treatment, being discharged (with no complains) on June 6th, 2009.
2. Returning to the hospital with increasing pains in lumbar spine and taking into account X-rays in the region of L4 and L5 vertebra, a decision was made to proceed to implant a prosthetics to stabilize that region. Standard surgical procedure was performed fixing Titanium Ti6Al4V alloy screws supporting a Titanium connecting bar in two adjacent vertebra. Material was provided by a local vendor, utilizing screws and other necessary parts produced by an international company in June 17th, 2009.
3. A post-surgical radiography, in August 1st, 2009, indicated a correct positioning of screws and connecting bars.
4. After about six months from surgical procedure, in view of new complains by the patient, a new radiography in the lumbar region, showed two fractured screws and a connecting bar, as shown in the following case study report.
5. After this finding, a new radiographic analysis showed the presence of degenerative spondylopathy: degeneration of lumbar vertebra, commonly known as "parrot's beak" in local non-technical language.
6. In March 1st, 2010, a new radiography showed the evidence of Laminectomy, a surgical procedure for the extraction of one or two vertebral lamina, a procedure, we believe, necessary in case of long time exposure of bone marrow.
7. In March 17th, 2010, a new radiography revealed the presence of Retrolistesis, that is, a back dislocation of L4 vertebra over L5 vertebra, a phenomenon affecting seriously the quality of life of the patient.
8. Afterwards, a new analysis showed a Motion Limitation of Lumbar Extension, accelerating the necessity of new surgery to introduce a new prosthetics, which was done in September 9th, 2010, that is, a little over seven months after the first surgery. Radiographies indicated the correct positioning and stability of the new prosthetics.
9. Following a suite of the patient against the vendor of the implant material, the international company responsible for the production of screws and connecting bars, informed very clearly that "the rupture of screws in spinal implants are very