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How to avoid fracture of the locking screw in modular revision arthroplasty of the hip using the MRP Titan Revision System

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How to avoid fracture of the locking screw in modular revision arthroplasty of the hip using the MRP Titan Revision System

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Abstract

The use of modular femoral stems in primary and revision arthroplasty of the hip has become popular within the last decade. On the other hand modularity creates new potential problems like fretting, crevice and galvanic corrosion, component loosening, dissociation and fracture of modular prostheses. Recently a problem of fracture of a locking screw in revision arthroplasty of the hip using the MRP Titan Stem (Peter Brehm GmbH, Weisendorf, Germany) appeared. The aim of this study is to evaluate the meaning of surface contamination in respect to fracture mechanism. To avoid fracture of the screw M6 of the MRP Titan System we recommend cleaning the inner thread of the morse taper junction with saline solution before junction is fixed with the screw and the torque wrench.

1. Introduction

The use of modular femoral stems in primary and revision arthroplasty of the hip has become popular within the last decade because of the advantage of more flexibility and optimization of femoral anteversion, limb length, and femoral component offset. In several studies good mid- to long- term results have been published for the MRP Titan Revision Stem in revision arthroplasty of the hip [1, 2, 3, 4, 29]. Modularity also provides intraoperative flexibility when partial hip implant revision is required. On the other hand modularity creates new potential problems and complications which should be taken into account. Micromovement, component loosening, Fretting, crevice and galvanic corrosion, fracture and dissociation of modular prostheses in primary and revision hip arthroplasty have been published [5-17].

Recently a recurrent fracture of the cone of the morse taper junction of the MRP Stem in an Obese Patient has been published hip [15]. In this case intraoperatively a fractured locking screw could be found.

Grupp et al. [16] postulated surface contamination as a risk factor for modular titanium alloy neck adapter failures in hip replacement.

The aim of this study was to evaluate the meaning of surface contamination in respect to fracture of the locking screw of the MRP Titan Revision System (Peter Brehm GmbH, Weisendorf, Germany).

2. Material and Methods

The modular MRP Titan Revision Systembased on modular taper connections designed for cementless implantation with initial distal diaphyseal fixation. The implant components are made of a titanium alloy (Ti6Al4V) with a rough corundum-blasted surface with a roughness of 40-60 μm to facilitate osseous integration. The modular design essentially consists of three components:

– The distally tapered femoral stem with longitudinal parabolic ribs for fixation with rotational stability. The stem is available as a straight-stem model in 140 mm and 200 mm length, and curved-stem version to fit the physiologic anterior bow of the femur in 200 mm length. 260 mm and 320 mm curved stems with two distal transverse drill holes are also available, providing the possibility to use distal locking bolts for additional stability. Diameters are available in 1 mm increments between 13 and 22 mm.

– Three different neck models (length 50, 60, and 70 mm) with a standard taper (Euro taper 12/14). The neck components are available with different neck-stem angles of 130° (37 mm

offset) and 123° (47 mm offset).

– An optional extension sleeve, adding 30 mm to the neck length. The continuously adjustable taper connections are locked intraoperatively with a titanium-nitride coated locking screw using an implant-specific torque wrench 25 Nm.

Fig. 1: The MRP-TITAN System with the lockingscrew (gold)

The locking screw M6(Fig. 2) is made from Ti6Al4V alloy according to ASTM and DIN ISO [18-21]. The screw is 25 mm long, whereas the screw shaft measures 17 mm, thread length is 12 mm with 12 threads. The screw is titanium-nitride coated to reduce sliding friction [22]. During the fixation process titanium-nitride coating shows smooth abrasion.

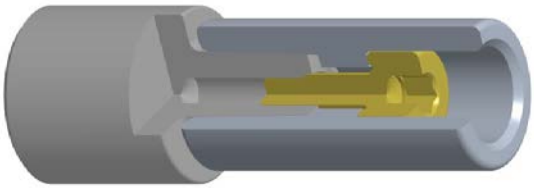

Fig. 2: Sectional view through the test specimen,

To evaluate the influence of contamination the inner tread of the morse taper junction in respect to fracture of the titanium nitrid coated locking screw M6 of the MRP Titan system was in vitro tested.

A MRP-stem model with the male component of the morse taper junction was fixed in a jaw

vice. The model stems and necks were assemblied and fixed with the elocking screw using the original implant devices. In sum 134 screws, model stems and model necks were tested.
To investigate the influence of NaCl solution on fixing the locking screw a preliminary study was conducted (series 0) (Table 1).

Table 1: Different trials with different sample sizes

Trial	Sample size	Contamination	Time of initial drying
0	40	sodium chloride solution	-
1	14	Contamination of the screw with blood	60-90 min
2	40	Contamination of the screw with blood and soft tissue (muscle and fat tissue)	60-90 min
3	20	Contamination of the female thread with blood and soft tissue (muscle and fat tissue)	60-90 min
4	20	Contamination of the female thread with blood and soft tissue (muscle and fat tissue) and cleaning after drying	60-90 min

Series 1:
The influence of contamination with dried blood was examined as the components of the MRP TITAN stem get in contact with patients blood intraoperatively. Therefore the screw M6 was put into pig's blood. After blood drying the morse taper junction was fixed with the torque wrench.
Series 2:
The influence of contamination with dried blood and biologic tissue was examined as the components of the MRP TITAN stem get in contact with patients blood and soft tissue (e.g. fat, muscle tissue) intraoperatively. Therefore the screw M6 was covered with a pulpous mixture of pig's blood, pig's muscle and pig's fat tissue. After the drying process the morse taper junction was fixed with the torque wrench.
Series 3:
The influence of contamination with dried blood and biologic tissue was examined as the components of the MRP TITAN stem get in contact with patients blood and soft tissue (e.g. fat, muscle tissue) intraoperatively. Therefore the female thread component was covered with a pulpous mixture of pig's blood, pig's muscle and pig's fat tissue. After the drying process of

the female thread component a new clean M6 screw was taken out of the sterile wrapping and fixed with the torque wrench.

Series 4:

The influence of cleaning of the contaminated female thread component was examined. Therefore the female thread component was covered with a pulpous mixture of pig's blood, pig's muscle and pig's fat tissue. After the drying process of the female thread component the contamination was cleaned with 50 ml saline solution. Afterwards a new clean M6 screw was taken out of the sterile wrapping and fixed with the torque wrench.

For our in vitro study we selected a long drying phase to be sure that the drying process at 20°C was complete, knowing that intraoperatively drying process is much more faster due to manipulation of the prosthesis devices and laminar air flow.

Aim is to analyse the differences of fracture of the screw M6 (Fig. 3) in different settings (series 1-4). Due to the small sample numbers we selected Fisher's exact test for statistical analysis [23, 24]. Since there is the reasonable assumption that cleaning the interface reduces the probability of screw cracks, we use the one-sided variant of the test.

Fig.3: Torsion fracture of screw M6

3. Results

In series 1 more power was necessary to fix screw M6 using the torque wrench.

After removal of the fractured screw blood could be found within the female thread component.

In series 2 more power was necessary to fix screw M6 using the torque wrench, too. After removal of the fractured screw dried coagulum could be found within the female tread. In some cases the complete screw could be removed. In these cases, all threads showed contamination.

In series 3 fixing of screw M6 was quite easy as contamination focussed on the female

component. After removal of the fractured screw dried coagulum could be found within the female thread.

In series 4 the female thread of the morse taper junction was cleaned after contamination. Due to the cleaning process with saline solution coagulum (up to 5 mm diameter) could be removed. Inspection revealed that no complete cleaning could be achieved.

Comparing series 1 with series 4, series 2 with series 4 and series 3 with series 4 statistical analysis showed a significant reduction of fractures of screw M6. For H_0: $p1 \leq p4$, H_0: $p2 \leq p4$ and H_0: $p3 \leq p4$ the p-values are 0.0072, 0.0001 and 0.0042 respectively.

Cleaning of contaminated female thread of the morse taper junction leads to a significant reduction of fractures of locking screw M6 of the MRP TITAN System. In cases of cleaned components no fracture of the screw could be detected.

In cases of fractured screws removal of the distal part of the broken screw was easy possible.

Analyzing surface of titanium-nitride coated screws surface of the screws showed no signs of abrasion of titanium-nitride coat.

Table 2: Tabular summary of the results.

Series	**1**	**2**	**3**	**4**
Sample size	14	40	20	20
Number of fractures	5	18	7	0
Location of fracture (No. of thread)	8-9	8-9	8-9	-
Fracture type	torsion fracture	torsion fracture	torsion fracture	-
Sound during fixing screw M6 using torque wrench	Creaking	Creaking	Creaking	Squeaking

4. Discussion

The use of modular MRP TITAN System in primary and revision arthroplasty of the hip offers a lot of advantages like optimization of femoral anteversion, limb length, and femoral component offset [1, 2, 3, 4]. Several authors discussed new problems and complications like fretting, crevice and galvanic corrosion, component loosening, fracture and dissociation of modular prostheses in primary and revision hip arthroplasty [5-17]. Grupp et al. [16] were the first who showed that surface contamination with blood or biologic tissue is a risk factor for breakage of modular components in total hip replacement. Failure of modular titanium alloy neck adapters can be initiated by surface micromotions due to surface contamination or highly

loaded implant components [16]. Another risk factor for implant failure is body weight over 100 kg which is postulated by Schuh et al., too [15]. Grupp et al. [16] recommended the use of modular cobalt chrome neck adapters which should provide higher safety compared to Titanium alloy material. Haschke H et al. [25] postulated that surgeons should carefully use assembly forces above 4 kN to decrease the amount of relative motion within the taper interface of neck adapters made of titanium (Ti6Al4V) and CoCr (CoCr29Mo).
In respect to published allergic reactions against cobalt chrome alloys [26-28] and the possible problem of local galvanic element mixing titanium and cobalt chrome alloys we don't follow this solution.
Our results clearly show that contamination of the inner tread of morse taper junction with blood or other biologic tissue leads to a significant reduction of resistance against fracture of the screw M6. Contamination can occur if the guiding rod has to be fixed several times and gets in contact with intraoperative situ. This leads to contamination of the guiding rod and the female component of the threads. Contamination leads to blocking of the screw. If fixation process of screw M6 is continued forcely using torque limiter the screw can be twisted off. In cases of fractured screws removal of the distal part of the broken screw was easy possible as blocking of the screw seems to occur in just one direction. Normally the fixation process of the titanium-nitride coated screw M6 leeds to smooth abrasion of the coating as a sign of complete contact of screw with the neck. In our study no or few signs of abrasion could be detected in contaminated screws. We conclude that in cases of contamination the head of the screw does not get in contact with the neck. In that way the torsional moment of 25 Nm concentrates on the body of the screw and leads to fracture of the screw. The screw is designed to resist tensile stress not torsional stress.

5. Conclusions

Modularity in THR provides intraoperative flexibility when partial hip implant revision is required. However, modularity creates new potential problems and complications like fretting, crevice and galvanic corrosion, component loosening and fracture. To avoid fracture of the screw M6 in revisionarthroplasty of the hip using the MRP Titan System we recommend cleaning the inner tread of the morse taper junction with saline solution.

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