INTRODUCTION:
The advantage of a modular system is that the surgeon is able to choose the metal cup and insert to adapt the implant system to the individual needs of a patient. During preoperative planning an appropriate and approved combination is chosen. During surgery facing deviant conditions it is possible to change decision choosing another insert size or material. Beside the benefits, disadvantages of the modular connection system exist. The ceramic insert is recommended as being manually assembled during surgery into a dry and clean metal cup by pushing it in along the metal taper. Furthermore, a slight axial tap using a plastic impactor should be applied onto the insert to assure a secure connection. According to investigations related to current surgical practice, it has been found that during the intraoperative assembly of insert and metal cup, the forces applied by the surgeon show a large variation. In some cases, surgeons are even avoiding the impaction. Under in-vivo conditions, adhesion forces generated between ball head and insert due to the synovial fluid transfer tension forces between ball head and inserts. Hence, microseparation between the head and the insert are causing tensile forces on the insert. This study shows the importance of a slight axial tap on the insert for a secure connection by examining the effects of adhesion between ball head and insert.

METHODS:
Metal cups, embedded in a cast resin, have been used in an appropriate adhesion test setup. Ceramic inserts made of BIOLOX® delta were assembled with the cups by applying three different methods:

a. three inserts pressed-in manually
b. three inserts statically pressed-in by use of a 10 kg weight (100 N)
c. three inserts impacted manually with a slight axial tap (mean peak force measured during impaction: 2800 N)

To apply the loading, a ball head (diameter 36 mm, BIOLOX® delta) is set into the insert calotte which is wetted with 3 ml of a 25% Di-H2O-nue born calf serum solution. For the test a 20 kg falling weight (equivalent to a swinging leg) is accelerated to a velocity of 3 m*s-1 and is pulling the ball head out of the insert. The adhesion forces acting at the instant of separation of head and insert have been recorded by a load cell fixed between embedding pot and supporting frame.

RESULTS:
The taper connection of each insert pressed-in manually or pressed-in statically by a mass of 10 kg failed, the inserts were pulled out of their appropriate metal cups, see figure 2 a-b. The adhesion forces caused a strong attachment between ceramic insert and ball head. Nevertheless, the impaction forces generated by a slight tap have been evaluated as being sufficient so that the ceramic inserts remained in their metal cups, see figure 2 c.

DISCUSSION:
The results show that manual pressing-in of inserts does not lead to sufficient connection strength. Not even pressing-in with 100 N (comparable to a mass of 10 kg) assures a secure connection. Only a slight axial tap using a plastic impactor after inserting the ceramic insert yields sufficient locking strength of the parts. In conclusion it is necessary that every implanted insert should be impacted.

REFERENCES:
1. Beaver, McCormick, Kop; Fractures in Misaligned Ceramic Acetabular Liners: A Laboratory Study; 7th International Biolox Symposium 2002; Thieme Verlag

Figure 1: Experimental set-up for pulling the ceramic ball head out of a ceramic insert

Figure 2 a-c High speed pictures made in the moment of separation: insert pressed-in manually; b: insert pressed-in with 100 N; c: insert impacted: insert remains in the metal cup!

Figure 3: Maximum tension forces measured during separation of ball head and insert

The parts pressed-in manually or with 100 N force failed at low tension forces of appr. 80 N, see figure 3. The tests with the impacted inserts show maximum adhesion forces of 150..200 N.