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Original Article

Evaluation of the effect of custom burr holes on a surgeon's sense of screw fixation in revision porous metal cups

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ABSTRACT

Background/Aims: It is common practice to burr custom holes in revision porous metal cups for screw insertion. The objective of this study was to determine how different hole types affect a surgeon's sense of screw fixation.

Methods: Porous revision cups were prepared with pre-drilled and custom burred holes. Cups were held in place adjacent to synthetic bone material of varying density. Surgeons inserted screws through the different holes and materials. Surgeon subjective rating, compression, and torque was recorded.

Results: The torque achieved was greater ($p = 0.002$) for screws through custom holes than pre-fabricated holes in low and medium density material, with no difference for high density. Peak compression was greater ($p = 0.026$) through the pre-fabricated holes only in high density material.

Conclusion: Use of burred holes affects the torque generated, and may decrease the amount of cup-acetabulum compression achieved.

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1. Introduction

Trabecular metal (TM), a porous tantalum material, was developed by Zimmer, Inc. (Warsaw, IN, USA) in the late 1990s. Its design is intended to promote the ingrowth of

native bone due to its high (80%) porosity, low modulus of elasticity, and high frictional characteristics.¹ Due to these characteristics, TM revision cups have become a popular implant for use in complex acetabular revision surgery. Recent experience published by Skytta et al.² published their results on 827 acetabular revisions using TM revision shells

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and found a very low 3-year revision rate of 2% for aseptic loosening.

In revision total hip arthroplasty, there must be initial stability of the cup in the acetabulum for bony ingrowth to occur. Stability can be achieved by using a press-fit technique and augmenting this with acetabular screws. In certain cases, adequate fixation may not be achieved by using the prefabricated holes in the acetabular cup. Revision TM cups offer the opportunity for surgeons to burr custom holes in the TM to allow for screw placement wherever the surgeons feel there may be adequate native bone.³ Although it is not included in the technique guide provided by the manufacturer, it is described in the literature and is a common practice amongst revision surgeons.⁴ These custom holes frequently differ in size and geometry from the prefabricated holes. Although used routinely, the biomechanics of inserting screws through custom holes and its effect on cup fixation have not been evaluated. The objective of this study was to determine the surgeon's sense of screw purchase as well as quantify the change in biomechanics of screw insertion through pre-fabricated and custom-burred holes.

2. Materials and methods

Two Zimmer revision TM cups were obtained and used for the study protocol. Bone cement was cleared using an acetone solution. Custom burr holes were created in a standardized fashion using one pass of the 3.2 mm burr perpendicular to the cup surface at that point. This size was chosen to be similar to the use of a 4 mm by Siegmeth et al.⁴ previously reported in the literature. A recess was then created for the screw head using the same burr such that a minimum of 2.5 mm of TM remained (Fig. 1). This is the technique that is employed clinically in revision cases at our institution.

In order to standardize the density of the material for all screw insertions, synthetic bone blocks were used in our trials. Three varying densities of synthetic bone blocks were obtained to model varying quality of cancellous bone (Sawbones Open Cell Blocks, Pacific Research Laboratories, Vashon Island, WA).

Fig. 1 – Trabecular metal revision cup showing prefabricated and custom burr holes.

Fig. 2 – Testing apparatus used for screw insertion. The testing apparatus allowed the investigators to ensure that screw insertion occurred perpendicular to the face of the synthetic bone block.

The densities selected were 0.09 g/cm³, 0.24 g/cm³, and 0.48 g/cm³ to resemble low, medium, and high bone density, respectively.

A custom apparatus was designed to securely hold the revision TM cup and synthetic block in alignment for screw insertion (Fig. 2). The apparatus allowed for horizontal screw insertion, in order to better replicate the intra-operative experience. A load washer (LCMWD-2KN, Omega Engineering Inc., Stamford, CT) was placed between the TM cup and the bone block in order to measure cup-bone compressive forces. Three fellowship-trained arthroplasty surgeons participated in the testing. For each screw insertion, the surgeon was blindfolded and instructed not to apply any axial load. Each screw was inserted by the surgeon using a digital torque driver (DID-4, Sugisaki Meter Company, Japan), which was used to measure both the peak torque and end torque (at final screw-turn) from insertion. The surgeons were informed when the screw head had engaged the cup, since their sense of vision was removed for blinding purposes. A total of 24 screws were inserted in a randomized order that was unknown to the surgeon to represent clinically relevant scenarios.

The study protocol was divided into three phases. For the first phase, each surgeon inserted two 30 mm acetabular screws (Zimmer) into each of the three varying densities of Sawbone material. The peak torque, end torque, and the surgeon's subjective rating for how well the screw was fixed (using a 10-point scale) was recorded. The 30 mm screws are the most common length of screw used with the TM cups for enhanced fixation at our institution. However, the addition of the load washer for compression measurement required the use of a longer screw to ensure proper screw purchase. To ensure that the use of a longer screw did not modify the surgeon's perception or the magnitude of torque achieved, for the second phase of our testing, each surgeon inserted two 50 mm acetabular screws into each of the three varying densities of Sawbone material. The peak torque, end torque,

Table 1 – Comparison of 30 mm and 50 mm screws at varying densities of bone material.

	30 mm screw	50 mm screw	p-value
Low density			
Surgeon rating	2.00 (1.10)	1.00 (0.00)	0.049
Peak torque	0.55 (0.15)	0.78 (0.12)	0.015
End torque	0.25 (0.07)	0.18 (0.15)	0.29
Medium density			
Surgeon rating	3.17 (1.60)	2.67 (1.75)	0.62
Peak torque	1.63 (0.74)	2.21 (0.71)	0.20
End torque	0.66 (0.36)	0.52 (0.50)	0.59
High density			
Surgeon rating	8.83 (1.17)	7.83 (1.94)	0.31
Peak torque	14.20 (5.75)	16.18 (7.56)	0.62
End torque	10.53 (5.15)	11.18 (7.22)	0.86

peak compression, and end compression were measured and the surgeon's subjective rating was recorded.

In the third phase of the study, the revision TM cups were introduced. Each surgeon inserted two 50 mm acetabular screws through both the pre-fabricated holes and the burred holes, into each of the three varying densities of Sawbone material. Again, the peak torque, end torque, peak compression, and end compression were measured and the surgeon's subjective rating was recorded.

Statistical comparisons were performed with the independent samples t-test. Logarithmic transformations were performed when the distribution of data deemed it necessary. Correlational analysis was performed to assess the relation between surgeon's subjective ratings and achieved torque at each of the varying densities of Sawbone material. The level of significance for all statistical tests was set at 0.05 and was performed by the use of a statistical software package (SPSSv21, SPSS Inc., Chicago, IL).

Fig. 5 – Surgeon's subjective rating of the quality of the screw fixation into various density materials through prefabricated and burred holes.

3. Results

There was no difference in surgeon rating, peak torque, or end torque between the use of short screws (30 mm) and long screws (50 mm) in the medium and high density synthetic bone materials (Table 1). Using the low density synthetic bone, surgeon rating ($p = 0.049$) and peak torque ($p = 0.015$) were greater with the longer screw. There was no difference in end torque.

The peak torque (Fig. 3A) created when inserting screws through burred holes was greater than through the pre-fabricated holes in the low density ($p = 0.002$) and medium density ($p = 0.002$) bone materials. End torque (Fig. 3B) was also greater through the burred holes than the pre-fabricated holes for both the low density ($p = 0.002$) and medium density ($p = 0.002$) bone materials. There was no difference in peak or end torque between the burred and pre-fabricated holes for the high density material. For screws inserted through the burred holes, peak torque ($p = 0.008$) and end torque ($p = 0.008$) were

Fig. 3 – Peak torque (A) and end torque (B) with screw insertion into various density materials through prefabricated and burred holes. **Fig. 4 – Peak compression (A) and end compression (B) with screw insertion into various density materials through prefabricated and burred holes.**

greater in the high density material than either the low or medium density bone material. There was no difference in peak torque or end torque between the low and medium density bone materials.

Peak compression (Fig. 4A) was greater ($p = 0.026$) using screws inserted into the high density bone material through the pre-fabricated holes than the burred holes. There was no difference in compression between pre-fabricated holes and custom burred holes when the screws were inserted into either the low or medium density material.

Surgeon's subjective rating of the quality of the screw fixation (Fig. 5) was found to be higher with screw insertion through burred holes vs pre-fabricated holes in both the low density ($p = 0.002$) and medium density ($p = 0.009$) bone materials. There was no difference with the high density bone material. The correlation between surgeon ratings and torque across all screw insertions was $r^2 = 0.759$.

4. Discussion

In revision acetabular surgery, the practice of using custom burr holes in TM is common. It is not known, however, how these holes affect both the fixation of our shell or how they affect the surgeon's ability to distinguish good fixation. Previous studies have looked at screw insertion for acetabular shell fixation using Sawbones material^{5–7}; however, in our study, we set out to examine the biomechanics of screw insertion through custom burr holes in revision TM shells.

There have been no previous studies analyzing these custom burr holes. Our findings are novel and show that when inserting screws through custom burred holes, the surgeon is no longer able to accurately distinguish between good bone and moderate or poor quality bone. With the smaller custom burr holes, there is more friction created between the cup and the screw, which is likely to influence the surgeon's sense of the quality of screw fixation.

There is also less compression achieved when inserting screws through custom burred holes in higher quality bone. We hypothesize that this may be due to a locking effect that occurred between the screw and the cup similar to the engagement that occurs with locking plates. A study by Heller et al.⁵ using Sawbone substitute showed that there was no superiority for locked screws as compared with standard screw fixation for primary cup fixation. This study was performed with normal density bone, however, and may not be transferrable to osteoporotic bone. A locking screw in more osteoporotic may be advantageous in conferring cup stability but this has not been studied.

This study has its limitations. We acknowledge that our study was limited by the use of Sawbones as a substitute for acetabular cancellous bone. There have, however, been studies performed to validate the use of this material as a substitute for cancellous bone,^{8–11} and many studies have used Sawbones as a substitute for biomechanical testing.^{5–7,12,13} Its reproducibility during testing is favored for more accurate results. Our study was also limited by the blindfolding of the test subjects. This was done to prevent the surgeon from knowing the material and screw hole type for a screw insertion. However, blindfolding the surgeon does eliminate their ability to use visual cues when

inserting the screws. They were informed when the screw had contacted the cup, but blindfolding could have influenced their screw insertion. Furthermore, our technique of creating these custom holes may not be universal. At our institution, the surgeons create these holes with one pass of the metal 3.2 mm burr followed by recession for flush fit of the screw head. Our results may not be transferrable to those who create larger custom burr holes similar to the pre-fabricated holes. However, these results may suggest that these custom holes should more closely resemble the pre-fabricated holes.

In conclusion, inserting screws through burred holes affects a surgeon's ability to sense the quality of screw fixation in osteoporotic bone found in revision hip surgery as well as the biomechanics of the screw-cup construct. Further studies are needed to determine the best methods of creating custom burr holes in these popular TM revision shells.

Conflicts of interest

The authors have none to declare.

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