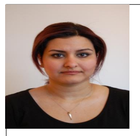
Thermal Effect of Bone Reaming

Acetabular reaming in Total Hip Arthroplasty measured with the aid of an Infrared Thermal Camera



Behrokh Eskandari
MEng Mechanical Engineering with Bioengineering
behrokh.eskandari@newcastle.ac.uk
School of Mechanical and Systems Engineering

Supervisor: Professor Tom Joyce
thomas.joyce@ncl.ac.uk

Introduction

Total hip replacement surgery is common in modern medicine and it provides patients with pain free gait. During surgery, high speed mechanical tools such as reamers (Figure 1) are used to prepare bone to receive the implant. Acetabular reamers are used to create the required part-spherical cavity in the acetabulum for the artificial cup or shell of a total hip replacement.

Figure 1 – Typical reamer and handle

During acetabular reaming, some surgeons note occasional smoke, blackening of tissue and a smell of burning, especially with reamers which have been used many times. These high temperatures may result in potential thermal damage to the bone, as above 56˚C osteonecrosis may occur. This bone death could result in failure of cementless fixation which relies on bone growing in to the artificial joint.

One of the factors effecting temperature increase amy be the reamer's bluntness. There is no accepted definition of bluntness and surgeons would prefer to have a quick indicator of reamer condition. For this reason, use of an infrared laser camera has been proposed. The project objectives were to undertake in vivo tests of acetabular reaming using cow (bovine) bone. Using a FLIR E45 infra-red video temperature recording system the temperature before, during and immediately after reaming was recorded.

Reaming process was performed on 8 bovine acetabula (hemi-pelvis) using various reamers while the temperature was recorded. All reamers were used and several different sizes were tested.

Figure 2 - Hemi-pelvis and FLIR E45 camera position during testing. Note reamer on the end of the drill and some debris from reaming process

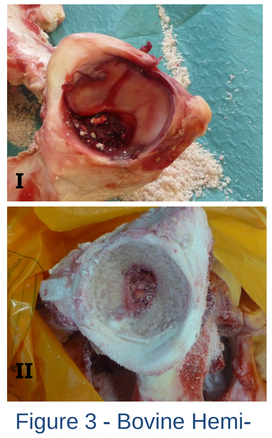


Figure 3 - Bovine Hemi-pelvis Before (I) and after (II) reaming

Results and Discussion

All used reamers were weighted before and after the reaming to examine any gravimetric wear. Reamers 52A, 56A and 58A were not used during the test but were still weighed repeatedly to check accuracy of results (Table 1).

Reamers Weight before and after reaming test (g)				
Diameter	Before use	After use	Weight Loss	Weight Loss %
Φ48	35.49179	35.48201	-0.00978	-0.028%
Φ50	46.44673	46.44545	-0.00128	-0.003%
Φ52 A	56.70506	56.70507	0.00001	0.000%
Φ52 B	56.69313	56.68836	-0.00477	-0.008%
Φ54	67.14827	67.13035	-0.01792	-0.027%
Φ56 A	75.89013	75.89005	-0.00008	0.000%
Φ56 B	75.69143	75.68826	-0.00317	-0.004%
Φ58 A	86.37530	86.37560	0.00030	0.000%
Φ58 B	85.99230	85.96710	-0.02520	-0.029%
Φ60	98.33580	98.33350	-0.00230	-0.002%
Φ62	109.99130	109.98460	-0.00670	-0.006%

Table 1 - Reamers weight before and after reaming test, note grey rows refer to unused reamers

Table 2 shows maximum temperatures and observations made during the reaming tests on the bovine hips.

Case	Bone initial T (˚C)	Highest T at the reamer (˚C)	Highest T at the reamed surface (˚C)	Note
A	5.7	55.8	63.7	Bone reaming started at ϕ58mm reamer
B	5.7	42.9	47.4	Bone reaming started at ϕ62mm reamer
C	1.4	50.9	80.1	Bone reaming started at ϕ58mm reamer and smoke was seen at ϕ58mm reamer
D	4.2	36.5	46.3	Bone reaming was not reached with available reamer sizes. Bovine hemi-pelvis was too large
E	5.8	48.5	60.9	Bone reaming started at ϕ58mm reamer
F	4.1	33.7	31	Bone reaming was not reached with available reamer sizes. Bovine hemi-pelvis was too large
G	6.9	39.6	48.6	Bone reaming started at ϕ58mm reamer
H	7.2	86.9	101.1	Bone reaming started at ϕ56mm reamer and Smoke and burn smell was observed ϕ58mm reamer

Table 2- Reaming test observations

Result obtained from FLIR E45 thermal camera showed higher temperature in smaller acetabula (cases C and H - Table 2, Figure 4 and 5).

It could be related to the effectiveness of reaming using available sizes of reamers. In cases D and F as the hemi-pelvis was too large, bone reaming was not reached fully and observed temperature was significantly lower (Table 2).

As shown in table 3 and figure 6, a direct relationship was found between bone size and observed maximum temperature.

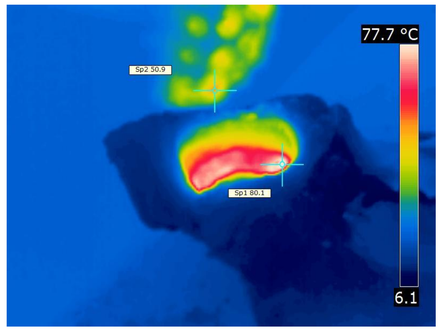


Figure 4 - Highest temperature recorded in case 3 - Green and yellow shape at the top shows temperature variation in reamer (T= 50.9˚C) and red and white shows highest temperature at the acetabulum cavity. White colour represents highest temperature at the reamed surface (Highest T= 80.1˚C)

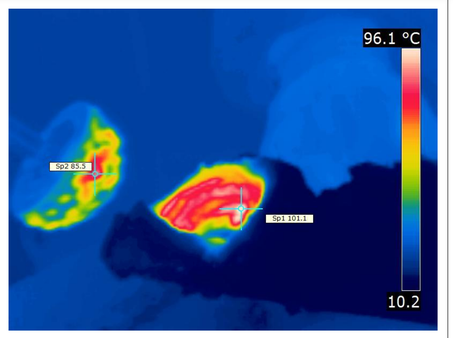


Figure 5 - Highest temperature recorded in case 8 - Yellow, white and red shows temperature on the surface of the reamer (Highest T= 86.9˚C) and yellow, red and white shows temperature variation at the reamed surface of bovine acetabular cavity (Highest T= 101.1˚C)

Case	Highest Temperature (˚C)	Rank
H	101.1	1
C	80.1	2
A	69.7	3
E	60.9	4
G	48.6	5
B	47.4	6
D	46.6	7
F	31	8

Table 3 - Ranking the cases based on the size of hemi-pelvis from smallest to the largest

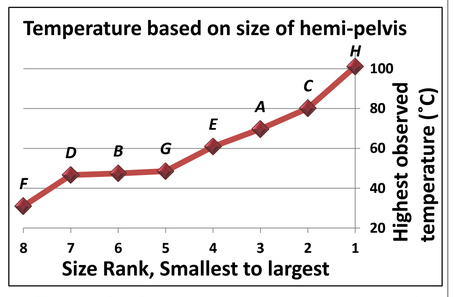


Figure 6 - Relationship between size of the hemi-pelvis and highest observed temperature

Conclusion

- In 4 out of 8 cases bone was subject to higher temperature than 56˚C which is said to be the critical temperature for thermal injury and potential necrosis (death) of bone.
  - •A decrease in hip size increased the observed temperature which may indicate that in humans, with their smaller hip sizes, higher temperatures could be expected.
  - •Loss of material observed from the reamers suggests that wear has taken place during the reaming tests.
  - •The highest temperature and weight loss was found with reamer 58. This shows a potential link between intensity of use, wear and temperature at contact points.