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An Experimental Technique for Measurement of Heat Generated During Bone Sawing

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Introduction:

Orthopaedic bone cutting processes such as osteotomy and hip arthroplasty involve the cutting of bone with the aid of various manual and powered cutting instruments including manual and powered bone saws.

The extent of surgically induced bone necrosis at the point of the cutting tool and the bone is mainly due to the frictional heat generated by bone cutting. Bone necrosis has an impact on bone regeneration, and the rate of healing of the bone post operation. The threshold temperature for impaired regeneration of bone is in the range of 44˚C to 47˚C [1]. Overheating also affects the sharpness life of the blade.

A review of the literature indicates that work has been completed on temperature in the immediate cutting zone. This current research focuses on the size of the overheated zone relative to the cutting position and effect of blade sharpness and cutting parameters such as cutting forces and rate of cutting on the size of the affected zone.

Materials and Methods:

Experiments were conducted on portions of the mid diaphysis of bovine tibia. The temperature measurements were made with type **T** Copper-Constantan thermocouples (TC Direct Ltd., UK). Thermocouples, 0.8 mm in diameter, were inserted and glued into 1-mm-diameter holes prepared by a twist drill at a depth of 5 mm and positioned on a 3 mm grid in bands as shown in Figure 1. Temperature recording was achieved by means of a data logger (Grant Instruments, Cambridge, UK). The mean rise in temperature, the total time of sawing, and the time for specimen to return to the baseline temperature (22˚C to 25˚C) were monitored.

The bone specimens were fixed in a holding device in order to avoid any undesirable vibration during the sawing procedure. Transverse cuts across the tibia specimens were completed until the saw blade had cut more than half way through the bone section. Sawing procedures were carried out with a 3M Maxi Driver and Reciprocating Blade (P512) without the application of any physiologic solution or lubricant.

The experiments were carried out and repeated 5 times with the same blade and the temperatures in each band relating to each test were compared. The blade was allowed to cool to room temperature after each test.

Results and Discussion:

Table 1 shows the temperatures measured during sawing for each band relative to each test. It was found that the temperatures were greatest in the first measurement band where average maximum temperatures of 51˚C to 71˚C were recorded for the 1st to 5th tests respectively. Lower peak temperatures for other bands were recorded with an associated time lag due to heat transfer in the bone and it can be observed that the temperatures in the second band are also approaching the lower critical temperature for necrosis of 44˚C.

As it is shown in table 1, the temperatures in band 1 increase sequentially. The thickness of the bone section beneath the cutting zone was measured post test and it indicated that the specimen used in experiment 2 had a thinner cortex than those used in other experiments which could explain the lower temperature recorded for this specimen.

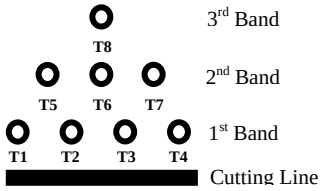

Figure 1: *Thermocouple positions relative to the cutting zone*

Test No.	Band 1	Band 2	Band 3
1	51˚C	37˚C	30˚C
2	45˚C	35˚C	31˚C
3	61˚C	42˚C	33˚C
4	62˚C	44˚C	35˚C
5	71˚C	44˚C	35˚C

Table 1: *Average maximum temperatures in each band relative to each test*

Conclusion:

These results illustrate that the zone affected by temperatures likely to cause thermal necrosis extends outwards from the cutting zone to a distance of 6 mm either side of the blade. We have also observed an increase in the temperature in each zone for each specimen in the sequence. We assume that this increase is most likely due to blade wear as no other parameters of the cutting process were altered for the experiment sequence and we permitted the blade to be cooled adequately between each test.

References:

[1] Eriksson R. A., et al, J. Oral Maxillofac Surg, 42, 705-711, 1984

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