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Improved bone cutting using a semirotating saw

A cadaver study of the cut surface on tibial condyles

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Cut surfaces on cadaver tibial bones prepared to receive an endoprosthetic tibial component, using an oscillating and a semirotating saw, were studied. Dental imprint material was used. The imprints were measured by a Zeiss UMC 850 to define the characteristics of the cut surface. The surface was smoother using the semirotating saw than the oscillating saw, with a mean maximum roughness of 1.46 mm and 2.36 mm, respectively. The corresponding flatnesses were 0.26 mm and 0.49 mm. The primary cut surface could not be improved during second cutting trials, which showed the importance of first correctly sawing in joint replacement surgery.

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Uneven prosthetic beds may create gaps between the prosthesis and bone large enough to prevent bony ingrowth, as shown both in cadavers and in vivo, using the same technique as in this study (Toksvig-Larsen and Ryd 1991, Toksvig-Larsen 1992). The gap between bone and implant should not exceed 0.3–0.5 mm (Sandborn et al. 1987, Carlsson et al. 1988).

The objective of this study was to investigate the possible benefical use of a semirotating saw regarding the smoothness of the cut and also to investigate if the primary cut surface could be improved during secondary cutting trials.

Methods

Operations were performed on cadaver knees, using a 3M Maxi Driver™ oscillating saw and a 3M Maxi Driver™ oscillating saw blade L124 (Orthopedic Products Division 3M, St. Paul, U.S.A.) in 8 cases and the Tuke Bone Saw (Protek AG, Berne, Switzerland) with a large cancellous bone blade (No. 76.55.15) in 9 cases. The cuts were made so that both saws were tested in the same cadaver. We used the Freeman-Samuelson Tibia Cutting Guide (No. 76.89.05-01, Protek AG, Berne, Switzerland). The cuts were first made as well as possible, the proximal bone was removed and an impression of the surface was made. After these procedures the cut surface was trimmed until an optimally flat surface, judged subjectively by the use of flat guides and visual inspection. A second imprint was subsequently made.

The saw used was an ordinary oscillating saw (Figure 1) with a maximum speed of 17000 rpm. The Tuke saw works in a circle of a nominal 1.5 mm diameter. This, together with the Tuke saw teeth, give a more efficient cutting, followed by a return stroke around the 1.5 mm circle with a speed of 17000 rpm. The imprint technique was the same as described earlier (Toksvig-Larsen and Ryd 1991).

Measurements of the surface smoothness were done by a Zeiss Universal Measuring Centers UMC 850 (Carl Zeiss, Industrielle Messtechnik, D-7082 Oberkochen, Germany). The outermost 2 mm rim was not included in the measured area to avoid the influence of marginal osteophytes and soft tissues. In 2 cases a central defect was excluded from the measurements. Thus, only the area covered by the planned prosthesis was measured.

Figures were obtained denoting the maximum difference between the lowest and highest points, the maximum roughness, and the standard deviation of all measured points, i.e., the flatness. The accumulat-

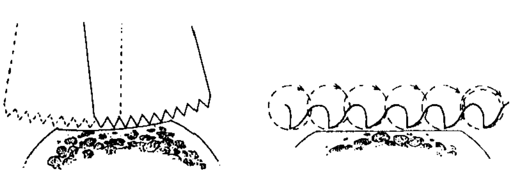

Figure 1. The oscillating saw mechanism (left) and the semirotating saw mechanism (right).

Table 1. Measurements of cut bone surfaces (mm)

	Primary cut		Smoothening cut	
	Maximum roughness	Flatness	Maximum roughness	Flatness
Oscillating saw				
	2.17	0.42	2.34	0.50
	2.91	0.68	2.34	0.57
	2.16	0.50	2.16	0.50
	2.68	0.55	2.55	0.52
	2.63	0.47	2.22	0.45
	2.34	0.57	1.45	0.31
	2.42	0.40	1.80	0.40
	1.56	0.30	2.32	0.43
Mean	2.36	0.49	2.15	0.46
Semirotating saw				
	1.19	0.23	2.13	0.37
	1.42	0.29	1.33	0.21
	2.03	0.44	1.73	0.32
	1.27	0.21	1.75	0.29
	1.94	0.31	1.99	0.36
	1.21	0.22	1.12	0.17
	1.27	0.24	1.22	0.23
	1.16	0.15	1.75	0.30
	1.69	0.28	1.01	0.20
Mean	1.46	0.26	1.56	0.27

$P < 0.01$ in comparing mean values

ed percentage of points within each 0.3 mm interval was plotted against the distance from the lowermost point on the surface to estimate the bone area that could theoretically achieve bone fixation (Toksvig-Larsen and Ryd 1991), accepting a 0.3 mm gap as critical (Carlsson et al. 1988).

The Anova test was used for statistical analysis, the level of significance was set at $P < 0.01$.

Results

The mean *SD* maximum roughness of the cuts was 2.36 *0.41* mm for the oscillating saw and 1.46 *0.34* mm for the Tuke Bone Saw (Table 1). The corresponding value of the second (smoothing) cut was 2.15 *0.36* mm and 1.56 *0.40* mm.

The mean flatness was 0.49 *0.12* mm for the oscillating saw and 0.26 *0.08* mm for the Tuke Bone Saw. The corresponding value for the second (smoothing) cut was 0.46 *0.08* mm and 0.27 *0.07* mm (Table 1). There were no differences between the first and second cuts for any saw regarding the maximum roughness or the flatness (Figure 2).

A theoretical 0.5 mm subsidence of a prosthetic component would introduce a mean 36 *15* percent of the bone bed within a 0.3 mm gap using the oscillating saw and 61 *22* percent using the Tuke Bone Saw (*P* 0.02).

Discussion

The surfaces created in this study showed an improved smoothness using the semirotating saw in comparison to the oscillating saw. However, in a previous cadaver study using the Maxi Driver oscillating saw (Toksvig-Larsen and Ryd 1991), the smoothness achieved was better than that created in this study using the oscillating saw. One explanation could be a difference in the cadaver bone quality, and a direct comparison between the oscillating saws in the two studies cannot be done. In the present study this has been addressed so that the oscillating and the semirotating saws were tested in bone in the same cadaver with a minimum of difference in bone quality.

The Tuke saw has teeth which have a top rake angle and therefore will bite into bone in one direction of motion only. As with a hand saw, cutting takes place in one direction with a passive return stroke. The Tuke-blades are traversed in a circle of nominal diameter of 1.5 mm and thus a more efficient one-

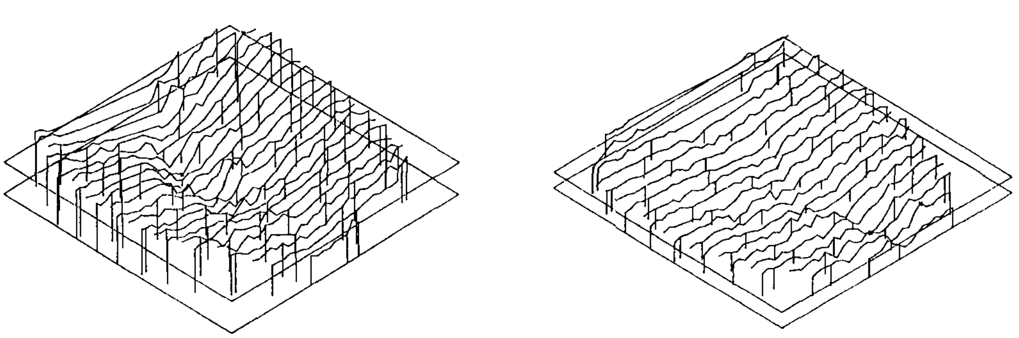

Figure 2. Plot showing the surface after the oscillating saw cut (left) and the semirotating saw cut in the same bone (right).

direction cut with a bite is achieved, followed by a return stroke around the 1.5 mm circle. The orbital motion at 17000 rpm results in a surface speed of less than 2 m/sec. The cutting surface speed of an oscillating saw can be as much as 22 m/sec.

With the orbital/semirotating motion there is a self-cleaning action of the blade which makes debris climb out of a slot, side clearance can aggregate jamming, and allow blades to wander off track. Bone has a good lubrication mechanism, especially cancellous bone. This could be the reason for the superiority of the surfaces created, and the Tuke saw could theoretically even reduce the cutting temperature. It is doubtful if subcritical values will be reached, since the saw blade partly resembles the Hall saw blade (Toksvig-Larsen 1992).

The area described as flat is not, however, equal to an area of perfect fit between bone and prosthesis, which instead will ride on a few weight-bearing points. To assess the smoothness from a biological point of view, the results were arranged according to the data on the significant gap size, i.e., 0.3 mm (Carlsson et al. 1988). Thus all points, except the ones within the first 0.3 mm interval, will be outside this critical gap, i.e., no ingrowth will occur. By determining the accumulated percentage of points in increments of 0.3 mm, the percentage within reach of the prosthesis because of subsidence, the surface available for ingrowth can be determined. After insertion, the primary weight-bearing points will be first crushed and subsequently even larger areas of high points will be remodeled, leading probably to further subsidence. Non-cemented prostheses consistently subside between 0.5 and 1.0 mm (Ryd et al. 1988, 1990). In the present series, the prostheses would rest on 1–2 percent of the surface before subsidence. A 0.5 mm subsidence will bring 36 percent of the bone bed within 0.3 mm from the prosthesis using the oscillating saw and 61 percent using the Tuke Bone Saw.

The primary cut surface could not be improved during secondary cutting trials, which emphasizes the importance of a correct first sawing. Our measurements revealed smoother cutting surfaces with the use of a semi-rotating saw.

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References

Carlsson L, Röstlund T, Albrektsson B, Albrektsson T. Implant fixation improved by close fit. Cylindrical implant-bone interface studied in rabbits. Acta Orthop Scand 1988; 59 (3): 272–5.

Ryd L, Albrektsson B E, Herberts P, Lindstrand A, Selvik G. Micromotion of noncemented Freeman-Samuelson knee prostheses in gonarthrosis. A roentgen-stereophotogrammetric analysis of eight successful cases. Clin Orthop 1988; 229: 205–12.

Ryd L, Lindstrand A, Stenström A, Selvik G. Porous-coated anatomic tricompartmental tibial components. The relationship between prosthetic position and micromotion. Clin Orthop 1990; 251: 189–97.

Sandborn P M, Cook S D, Anderson R C, Spires W P, Kester M A. The effect of surgical fit on bone ingrowth into porous-coated implants. 33rd Annual ORS 1987; 122: 217.

Toksvig-Larsen S. On bone cutting. Thesis, University of Lund, Lund, Sweden 1992.

Toksvig-Larsen S, Ryd L. Surface flatness after bone cutting. A cadaver study of tibial condyles. Acta Orthop Scand 1991; 62 (1): 15–8.