### THE ABRASIVE WATER-JET AS A NEW TOOL FOR THE RESECTION OF CANCELLOUS BONE

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# INTRODUCTION

In orthopaedic surgery the quality of bone cuts is evaluated by means of two factors. *Accuracy* is important for meeting manufacturing tolerances. *Biological potency* of the bone at the cut surface is important for bony in-growth into an implant. The frictional heat generated by conventional cutting tools may have a negative influence on the biological potency. Water jet cutting has the advantage that there is no heat generation. This study investigates the quality of abrasive water jet (AWJ) cuts in cancellous bone in comparison to a pneumatic oscillating saw.

#### **METHODS**

Cancellous bone blocks were obtained from porcine femoral condyles. The AWJ was generated using the injection technique. A metal carbide focus was used for the acceleration of biocompatible abrasive particles ( $\alpha$ -lactose-monohydrate, Mesh#45). In the AWJ group the specimens were moved past the focus orthogonal to the jet direction at 10mm/min (Fig.1). The water pressure ( $p_W$ =35, 70MPa) and abrasive feed rate (n&=0.5, 1.0, 2.0g/s) were varied.



Figure 1: Cutting of a cancellous bone block with an AWJ.

In the saw group an oscillating saw with a 1mm thick saw blade was used. For every group and parameter combination 10 cancellous bone specimens were separated. On every cut surface three contours in jet direction and in feed direction were scanned using a coordinate measuring machine. For each contour a regression line was computed. To quantify the accuracy, the cutting gap angle  $\delta$  between two

corresponding regression lines in jet direction and the roughness average  $R_a$  for each contour were computed.

#### **RESULTS AND DISCUSSION**

In the AWJ group  $\delta$  was positive for every  $p_W$  and n k, the cut getting wider with cut depth (Tab.1). However, in tests on cortical bone Honl et al (2000) report negative cutting gap angles. As cancellous bone has a high porosity the jet is obviously bent by the numerous material transitions. The jet spread results in a positive cutting gap angle. n k had a significant influence on  $\delta$  (p<0.001).  $\delta$  of the saw group showed no significant difference to the AWJ group at abrasive feed rates of n k = 0.5 g/s and n k = 2g/s. The large variation of the cutting gap angle is unfavourable as the jet direction can not be adjusted by a predefined value to achieve a desired cut surface orientation.

At  $m_{w}=0.5g/s$  and  $p_{W}=35MPa R_{a}$  was significantly larger than at  $p_{W}=70MPa$  (jet direction: p=0.006, feed direction: p=0.049). The roughness in the saw group was significantly less than the lowest values in the AWJ group (p<0.001).

Adjacent to the cut surface the inter-trabecular spaces of the cancellous bone were washed out by the AWJ up to a depth of 4mm. It has to be assumed that this is a negative aspect for the biological potency of bone.

#### SUMMARY

Although the saw group was superior to the AWJ group in terms of roughness, this study reveals that with a variation of the abrasive feed rate the accuracy can be improved. While the accuracy may be sufficient for osteotomy the jet parameters have to be optimised if it is intended to use an AWJ as a tool for the implantation of endoprostheses.

## REFERENCES

Honl, M. et al (2000). J. Biomed. Mater. Res.; 53:781-790.

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	AWJ							
nox	[g/s]	0.5		1.0		2.0		Saw
$p_W$	[MPa]	35	70	35	70	35	70	
δ	[deg]	$1.63 \pm 3.89$	$0.36 \pm 1.70$	$2.40 \pm 4.67$	$4.13 \pm 4.65$	*	$0.06 \pm 2.40$	$0.88\pm0.98$
Ra (jd)	[mm]	$59 \pm 26$	$48 \pm 17$	$71 \pm 38$	$68 \pm 29$	*	$39 \pm 16$	$28 \pm 12$
Ra (ad)	[mm]	$74 \pm 38$	$62 \pm 28$	$94 \pm 42$	$86 \pm 35$	*	$54 \pm 22$	$36 \pm 19$

\* Pressure in the mixing chamber was not sufficient to achieve a constant abrasive feed rate.