Effect of impalnt type on periprosthetic bone remodeling after cementless hip arthroplasty using the ROBODOC system

Kohei Yabuno[1], Nobuhiko Sugano[1], Takashi Nishii[1], Nobuo Nakamura[2], Akihiro Kakimoto[2], Mituyoshi Yamamura[2], Takehiko Hananouchi[1], Hideki Yoshikawa[1]

[1]orhopeadic surgery, Osaka University Graduate School of Medicine, osaka, Japan; [2]Center of Arthroplasty, Kyowakai Hospital, osaka, Japan

k-yabuno@umin.ac.jp

Introduction: Periprosthetic bone loss is one of major concerns in patients after total hip arthroplasty (THA). It can occur as a result of reduction in load transfer from the implant to bone around the proximal femur, the so-called stress shielding phenomenon. The variable patterns of stress shielding may reflect degree and distribution of load transfer around the entire length of the implant, in association with implant types. In the present study, we monitored the periprosthetic bone mineral density (BMD) of two different types of uncemented femoral implants as a function of time over a 2-year period, in order to evaluate the influence of implant design.

Materials and Methods: 37 patients (42hips) with non-inflammatory arthritis entered the study. There were 35 female and 2 male patients, with a mean age of 57 years (range, 39-74). Patients received either a straight stem (Versys FiberMetal Taper, Zimmer, IN) or an anatomical stem (Centpillar, Stryker, NJ). Both the straight and the anatomical stems were made of titanium alloy (Ti-6Al-4V). The straight stem had proximal titanium fiber mesh structure, plasma-sprayed with coating layer consisting of 70% hydroxyapatite (HA) and 30% tricalcium phosphate (TCP). The anatomical stem had proximal surface of fish scale texture, plasma-sprayed with HA. The available stem lengths ranged 110-145cm for the straight stem and 88-110cm for the anatomical stem. There were 19 patients (21hips) with the straight stem (Straight group) and 16 patients (19hips) with the anatomical stem (Anatomical group). Surgery was performed using the posterolateral approach with the ROBODOC femoral milling system (Integrated Surgical Systems, CA). Full weight bearing commenced the second postoperative day. Dual energy X-ray absorptiometry (DXA) scans was conducted at 3 week, 6,12 and 24 months after surgery, using a Lunar DPX-NT (GE Lunar, WI). The scans were analyzed using the manufacturer's metal exclusion software,and the seventeen periprosthetic zones were defined according to modified Gruen zones . (Fig1)

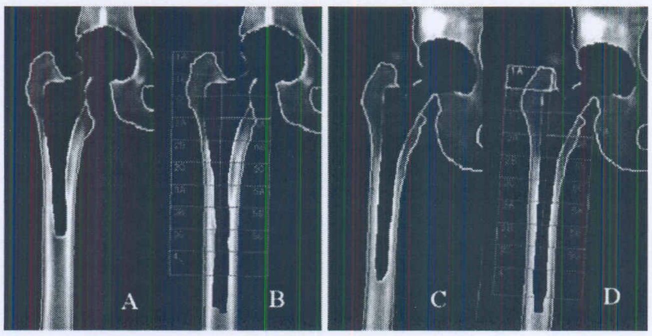

Fig.1.simulated stem transfer method in DEXA analysis. The scans were analyzed using the manufacture's metal exclusion software,and the seventeen periprothetic zones were defined according to the modefied Gruen zones.(B)(D):original anatomical stem (A),simulaed anatomical stem(B),original straight stem(C),simulated straight stem(D)

Each Gruen zone was devided into three zones,criteria as followed periprosthetic zones (zone 1A,1B,1C: greater trochanter; 2A,2B,2C,3A,3B,3C: lateral stem of the prosthesis; 4: tip of the prosthesis; 5A,5B,5C: medial stem of the prosthesis; 6A,6B,6C: lesser trochanter;7A:calcar) the average stem length differed between the two stems, the zones in the anatomical stem were defined by estimating the optical size of the straight stem. The aim of the model was to investigate the pattern and grade of remodelling of proximal femur caused by either the straight stem and the anatomical stem in detail.

Results: Two patients (1straight stem,1anatomical stem) had incomplete DXA follow-up after THA. The demographic data for the remaining 35 patient (40 hips) was given in Table 1.

	Straight stem	Anatomical stem	Statistical significance*
Number of hips	21	19	
Gender(male/female)	0/19	2/15	NS
Age	58.2(10.9)	58.1(5.7)	NS
Height(cm)	154.1(5.2)	154.4(7.2)	NS
Weight(kg)	53.6(7.6)	57.5(9.9)	NS

*NS not statistically significant

Table 1.Demographic characteristics of subjects in straight and anatomical stem groups

We did not find significant differences in the initial postoperative BMD at 3weeks at any zone(data not shown).The BMD relative to time after operation at each zone in all groups in table2. In both groups, loss of BMD was noted in all zones after 6 months, which was most pronounced in Zone 7A(calcar resion).However, there was substantial recovery of BMD 1 year postoperatively. The BMD loss after 2year postoperatively was significantly smaller at zone2A and 6B, and significantly larger at zone 3C and 4 in the Anatomical group than the Straight group .

Discussion: The design of the anatomical stem used in this study was determined based on the femoral shape of patients with CDH and normal hips in order to fit the metaphyseal area of femur1) and facilitate load transfer proximally. Because the ROBODOC system allows determination of optimal size and position of the femoral components preoperatively and assists the placement of the component accurately during operation, bias due to surgical skill and procedure was minimized in this study. Previous studies of uncemented femoral implants showing bone loss (10-40%) in the calcar region after 1-4 years2-4), are in agreement with the present finding. Our findings confirmed that the anatomical design with high fitting to the metaphysical femoral shape is advantageous in proximal load transfer and preservation of bone stock in the proximal femoral area.

References: 1) Noble PC, Kamiric E, Sugano N,et al. Clin Orthop 2003(417):27-40

2)Karrholm J,Anderber C, Snorrason F, et al. J Bone Joint Surg Am 2002;84-A(2):1651-8

3)Venesmaa PK, Kroger HP, Miettinen HJ. et al. J Bone Miner Res 16:1056-1061

Table2.Comaprision of Postoperative BMD Ratios (Average±SD) between the Two Groups

	Straight group				Anatomical group			
	3weeks	6months	12months	24months	3weeks	6months	12months	24months
Zone1A	100±0	101± 15	114± 20	121± 22	100±0	104± 17	104± 18	111± 18
Zone1B	100±0	91 ± 22	98± 22	104±25	100±0	101± 05	100± 16	100± 17
Zone1C	100±0	82 ± 21	88± 22	92± 26	100±0	85± 18	84± 21	82± 17
Zone2A	100±0	82± 18	83± 19	83± 19	100±0	90±14	92± 21	99± 22 *
Zone2B	100±0	89±16	90±18	91±19	100±0	99± 10 *	100± 13	101± 18
Zone2C	100±0	91 ±8	93± 10	97±14	100±0	98±9 **	97± 10	96± 9
Zone3A	100±0	93± 8	97± 7	101± 8	100±0	101±8 **	98± 6	98± 10
Zone3B	100±0	94 ±8	99± 8	101± 9	100±0	99± 6 *	98± 6	100± 8
Zone3C	100±0	97± 13	101± 12	104± 12	100±0	98± 5	98± 6	98± 7 *
Zone 4	100±0	98 ± 12	102± 9	103±10	100±0	97± 3	96± 4 *	94± 5 **
Zone5A	100±0	97 ± 12	98± 8	103± 12	100±0	101± 6	101± 8	102± 10
Zone5B	100±0	96± 13	99± 11	96± 13	100±0	101± 7	100± 8	101± 9
Zone5C	100±0	109± 44	110± 45	112± 43	100±0	97± 14	98± 7	97± 14
Zone6A	100±0	88 ± 21	91± 23	86± 26	100±0	90±13	91± 18	95± 28
Zone6B	100±0	95± 14	97± 16	94± 18	100±0	97± 13	99± 10	105± 14 *
Zone6C	100±0	98 ± 15	100± 10	100±13	100±0	100± 8	106± 10	103± 10
Zone7A	100±0	79± 19	80± 27	78± 26	100±0	82± 18	78±22	83± 28

As determined by the Mann-Whitney U test

* $P<0.05$ vesus straight group

** $P<0.01$ vesus straight group