主論文

Evaluation of joint thickness in the hip joint before and after Bombelli's osteotomy using three-dimensional modelling techniques

三次元モデルを用いたボンベリー骨切り術前後の股関節裂隙の評価

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[Abstract]

Before and after Bombelli's osteotomy (intertrochanteric valgus-extension osteotomy), the joint thickness was evaluated using three-dimensional modelling techniques. Preoperatively, the average joint thickness of the entire hemispheric surface was 2.3 mm (n=12), which was significantly thinner than that of the controls ($p < 0.001$). After the operation, 11 out of the 12 patients exhibited an increase in the thickness. The average of the joint thickness increased to 3.0 mm postoperatively ($p < 0.001$). The joint thickness of the patients who underwent surgery (n=12) was nearly to that of the controls. The joint thickness expanded in whole area of the hip. This was accompanied by clinical improvement of the Harris score.

[Résumé]

L'épaisseur du joint a été évaluée par les techniques de modelage tridimensionnel avant et après l'ostéotomie de Bombelli (ostéotomie intertrochantérique à extension de valgas). Préopératoirement, l'épaisseur moyenne du joint de la surface hémisphérique entière était de 2.3 mm (n=12), ce qui est significativement inférieure à celle des témoins ($p<0.001$). Après l'opération, 11 cas sur 12 ont montré une augmentation d'épaisseur. L'épaisseur moyenne a augmenté et a atteint à 3.0

mm postopératoirement ($p<0.001$). L'épaisseur du joint des patients ayant subi une chirurgie (n=12) était pratiquement égale à celle des témoins. L'épaisseur du joint s'est accure sur toute la partie de la hanche. Ceci s'est accompagné d'une amélioration clinique du score Harris.

[Introduction]

Bombelli[2] first described a valgus extension osteotomy for the treatment of osteoarthritis of the hip in 1976. Since then, this operation has been followed for osteoarthritic hip with excellent results in many countries . We have performed this operation on 50 osteoarthritic hips in 48 patients since 1984. Twelve of the 50 hips were examined with computed tomography (CT) both pre- and post-operatively.

[Materials and Methods]

From January 1984 to September 1989, we performed Bombelli's operation for 50 osteoarthritic hips in 48 patients at the Aichiken Saiseikai Hospital. There were 47 females, and one male. The average age was 46.9 years (range 34 to 66 years).

Osteoarthritis of the hip was classified using plain radiography based on a scheme proposed by the Japanese Orthopaedic Association[4,9]: Stage 1 (pre arthrosis) on no arthritic changes; Stage 2 (early degenerative), slight narrowing of the joint space associated with sclerosis of the subchondral bone; Stage 3 (progressive), marked joint space narrowing with many cystic lucencies and small osteophytes in the femoral head and acetabulum; and Stage 4 (end-stage), with disappearance of the joint space marked osteophyte formation at

the joint margin. None of the hips were Stage 1, while three were Stage 2, 32 were Stage 3, and 15 were Stage 4.

Clinical evaluation

The clinical outcome was evaluated using the Harris hip-scoring system[3]. The follow-up period ranged from 2 to 6 years (mean 4.4 years).

Radiographic evaluation

Plain anteroposterior radiography of the hip was performed on all 48 patients. The size of the articular cavity, the degree of osteosclerosis, and the presence and size of bone cysts and osteophytes were evaluated before and after the operation.

The size of the articular cavity was estimated with the aid of a computer using the following method[6]. The acetabular joint surface was approximated with 20 to 30 points on the bone surface. The femoral head surface was approximated in the same fashion. The size of the articular cavity was estimated from the difference of the surface of the acetabulum and the femoral head.

Measurement of joint thickness

In 12 patients, CT of the hip was used to estimate the joint

thickness using three-dimensional modelling. The postoperative examination was performed after one to 4 years (mean 3.3 years).

The control group consisted of 29 patients who underwent CT examination of the hip for injuries or osteoarthritis involving one side, without deformity of the pelvis. Average age of the control group was 55.6 years. About the nature of injuries to the orther hip, 11 cases were femoral neck fracture, 4 cases were pelvis fracture, and one case was contusion of the hip. And, 12 cases were the orther sides of osteoarthritis of the hip, and one case was the orther side of avascular necrosis of the femoral head. The CT of the uninvolved hip was examined for the calculation of joint thickness.

Using the three-dimensional modelling technique of Kawabe and Konishi[4], it is possible to calculate joint thickness of a spherical surface from axial CT images. The joint thickness was estimated in seven areas: the whole joint, the anterior aspect, the posterior aspect, the anterior equatorial zone, the anterior apical zone, the posterior apical zone, and the posterior equatorial zone.

The significance of resulted data was analyzed using Student's t-test .

[Results]

Clinical evaluation

The clinical outcome was judged according to the Harris hip-scoring system (Table 1). Pain was improve from a preoperative score of 17.6 points to a postoperative score of 42.3 points. Function improved from a preoperative score of 31.1 points to a postoperative score of 38.2 points. The absence of deformity and the range of motion scores were not significantly different after the operation. The sum score improved from a preoperative average of 55.7 points to a postoperative average of 87.5 points. Twenty five patients (50%) had an excellent result, and 18 patients (36%) had a good result.

Radiographic evaluation

Preoperative plain radiography revealed that 49 hips had osteosclerosis. After the operation, 34 hips (68%) showed a reduction of the osteosclerosis.

Forty seven hips had osteocysts. After the operation, 27 hips (54%) showed a reduction in the size of the osteocysts.

Osteophytes were found in 15 hips. In 17 hips (34%) newly formed or larger osteophytes were found.

The mean articular cavities had expanded postoperatively

in 36 hips (72%) from 2.2 mm to 3.1 mm ($p < 0.001$).

Measurement of joint thickness

Joint thickness was compared before and after operation (Table 2). Eleven patients had an increase in the joint thickness. The average of the joint thickness increased from 2.3 mm to 3.0 mm ($p < 0.001$) (average increment 0.7 mm). The anterior thickness increased from 2.2 mm to 3.0 mm ($p < 0.001$) (average increment 0.8 mm). The posterior thickness increased from 2.4 mm to 3.0 mm ($p < 0.05$) (average increment 0.6 mm). An increase in the joint thickness was observed in all four zones (Table 3).

The joint thickness of the patients was compared to that of the normal controls (Tables 4 and 5). Preoperatively the joint was thinner over the entire joint and its anterior aspect in the patients (n=12) who underwent surgery ($p < 0.001$). No significant difference was observed postoperatively in the joint thickness over the entire joint or its posterior aspect in the patients and in the controls. However, the joint thickness was thinner on the anterior aspect in the patients who underwent surgery ($p < 0.05$).

[Case presentations]

Plain radiographs of the hip of a 61-year-old female before and after Bombelli's operation are shown in Figure 1. Four years postoperatively, the Harris score was noted to improve from 42 to 91 points. The joint thickness increased from 2.5 mm to 3.2 mm.

Plain radiography of the hip of a 46-year-old female before and after Bombelli's operation are shown in Figure 2. Five years postoperatively, the Harris score was noted to improve from 48 to 84 points. The joint thickness increased from 2.1 mm to 3.2 mm.

[Discussion]

In the treatment of osteoarthritis of the hip in the young patient, femoral osteotomy is an alternative to total hip arthroplasty[7,10,11,13]

Bombelli[2] described a modification of the Pauwel's procedure, the intertrochanteric valgus-extension osteotomy. This creates a valgus angulation of 25 to 35 degrees, 15 to 20 degrees of extension, and a lateral shift of the greater trochanter. The advantage of this osteotomy is reported in hips with advanced osteoarthritis. It is not clear, however, that this procedure is more effective than Pauwel's valgus osteotomy[8].

Santore and Bombelli[11], in 1983, reported excellent or good results in 75% of their patients after valgus osteotomy, varus osteotomy and Bombelli's osteotomy.

Maistrelli, et al.[7], in 1990 reported that, over 11 years of follow-up, 67% of the patients who underwent Bombelli's operation had an excellent or good result.

We have performed Bombelli's osteotomy for advanced osteoarthritis since 1984. Excellent or good results have been obtained in 86% of patients.

Radiographic evaluation after trochanteric osteotomy has been described by Santor and Bombelli[11]. Reduction of the acetabulum and femoral head cysts was noted in 54%, and a decrease in the severity of osteosclerosis was noted in 54%. We also noted a reduction in 54% of the osteocysts, and a decrease in the severity of osteosclerosis in 68% of hips. Although 17 of our cases (34%) developed new osteophytes, or exhibited an increase in the size of old osteophytes, they were usually small. In seven cases, roof osteophytes were large enough to compensate for a dysplastic acetabulum.

Santors and Bombelli[11] reported that 56% of cases had an increase in the size of the articular cavity postoperatively. Weisl[13] reported similar results (67%) after intertrochanteric osteotomy. We observed an expansion of the articular cavity in

72 % of hips in plain radiography.

Recently, computed tomography has been employed in the evaluation of osteotomy on the hip. Klaue, et al.[5] have examined the congruency of the hip joint using CT, simulating the operative correction to aid in the design of osteotomies.

Ferdinando-Vigliani, et al.[12] have also employed three-dimensional CT to visualize the changes in pelvic morphology in congenital hip dysplasia.

Azuma, et al.[1] have evaluated the three-dimensional relationship between the acetabulum and femoral head using CT reconstructions before and after rotational acetabular osteotomies.

Kawabe and Konishi[4] have examined the thickness of the cartilage in both normal hips and coxarthrosis using a computer model based on CT. They have reported that the anterior cartilage is thicker than the posterior cartilage. In patients with advanced coxarthrosis, the anterior cartilage was found to be significantly thinner than the posterior cartilage.

We noted an increase in the joint thickness after Bombelli's osteotomy. This was confirmed by plain radiography (two-dimensional assessment), and CT reconstruction (three-dimensional assessment). In our study by means of CT scan and plain radiography, we could not make clear that the thickness

of the joint is really the thickness of articular cartilage, because the joint thickness measured by our method was a sum of the acetabular cartilage, the femoral cartilage, and the interspace filled with joint fluid. So, we could not make clear which area of the articular cartilage become thicker, is it femoral, or acetabular, or both. However, we assume thickening occurrence is both area. These favorable joint change was accompanied by clinical improvement of the Harris score. And the joint thickness measured postoperatively was comparable to that of the normal controls.

[References]

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[Legends]

FIGURES 1A-1D. (A) Preoperative anteroposterior roentgenogram of the left hip of a 61-year-old woman, (B) preoperative distribution of joint thickness, (C) Postoperative anteroposterior roentgenogram of the same hip, (D) Postoperative distribution of joint thickness, The postoperative thickness (3.2mm) is thicker than the preoperative thickness (2.5mm).

FIGURES 2A-2D. (A) Preoperative anteroposterior roentgenogram of the left hip of a 46-year-old woman, (B) preoperative distribution of joint thickness, (C) Postoperative anteroposterior roentgenogram of the same hip, (D) Postoperative distribution of joint thickness, The postoperative thickness (3.2mm) is thicker than the preoperative thickness (2.1mm).

TABLE 1. Harris score

	Pain	Function	Absence of deformity	Range of motion	Total
Pre Op.	17.6	31.1	3.5	3.5	55.7
Post Op.	42.3	38.2	3.5	3.4	87.5

TABLE 2. Change of the Joint Thickness

	Total	Anterior	Posterior
Pre Op.	2.3±0.5	2.2±0.7	2.4±0.6
Post Op.	3.0±0.5	3.0±0.5	3.0±0.7
Significance	$p<0.001$	$p<0.001$	$p<0.05$

Values are means ± SD (mm). (n=12)

TABLE 3. Change of the Joint Thickness

	Anterior Equatorial	Anterior Apical	Posterior Apical	Posterior Equatorial
Pre Op.	2.5±0.6	1.8±1.2	1.9±0.8	2.6±0.6
Post Op.	3.3±0.6	2.6±0.7	2.7±0.8	3.1±0.7
Significance	$p<0.01$	$p<0.05$	$p<0.01$	$p<0.05$

Values are means ± SD (mm). (n=12)

TABLE 4. Normal V.S. Pre Op.

	Total	Anterior	Posterior
Normal (n=29)	3.0±0.3	3.4±0.5	2.7±0.4
Pre Op. (n=12)	2.3±0.5	2.2±0.7	2.4±0.6
Significance	$p<0.001$	$p<0.001$	N.S.

Values are means ± SD (mm).

TABLE 5. Normal V.S. Post Op.

	Total	Anterior	Posterior
Normal (n=29)	3.0±0.3	3.4±0.5	2.7±0.4
Post Op. (n=12)	3.0±0.5	3.0±0.5	3.0±0.7
Significance	N.S.	$p<0.05$	N.S.

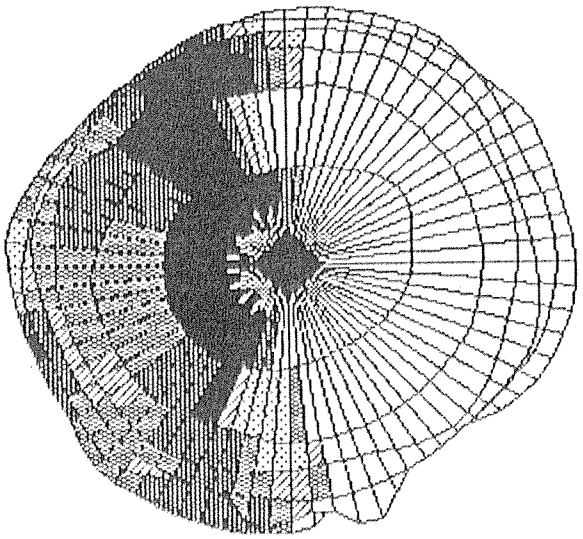
Values are means ± SD (mm).

1 (A)

Cartilage Thickness in the Segment of

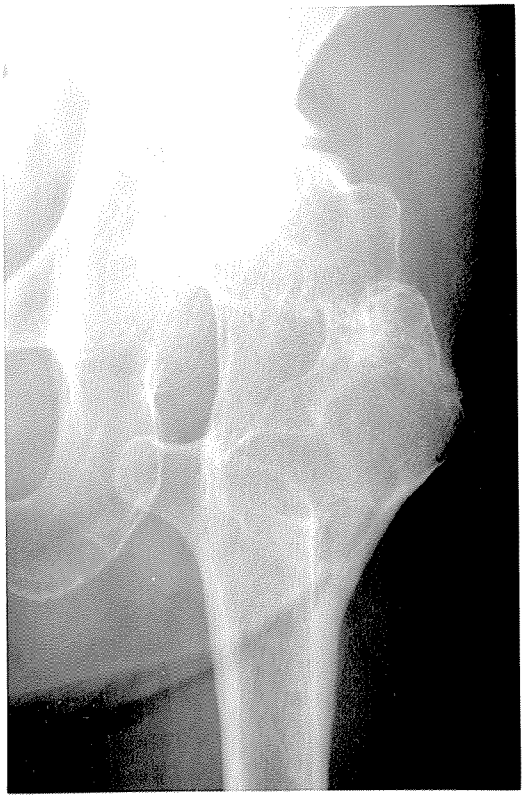
Total	=	2.54
Anterior	=	2.21
Posterior	=	2.83
Anterior Apical	=	1.31
Posterior Apical	=	2.28
Anterior Equatorial	=	2.56
Posterior Equatorial	=	3.04

Values are averages (mm)



0.0 <=..< 1.2
1.2 <=..< 2.4
2.4 <=..< 3.6
3.6 <=..< 4.8
4.8 <=..< 6.0
6.0 <=..<(uncovered)

1 (B)

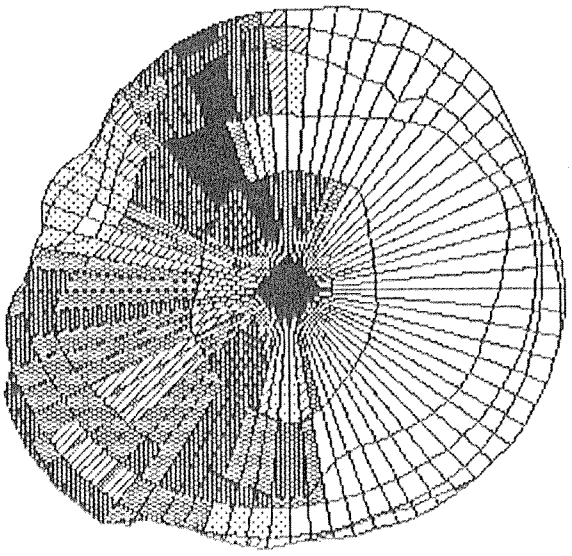


1 (C)

Cartilage Thickness in the Segment of

Total	=	3.22
Anterior	=	3.44
Posterior	=	3.02
Anterior Apical	=	2.45
Posterior Apical	=	3.06
Anterior Equatorial	=	3.88
Posterior Equatorial	=	3.00

Values are averages (mm)



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- 6.0 <=..<(uncovered)

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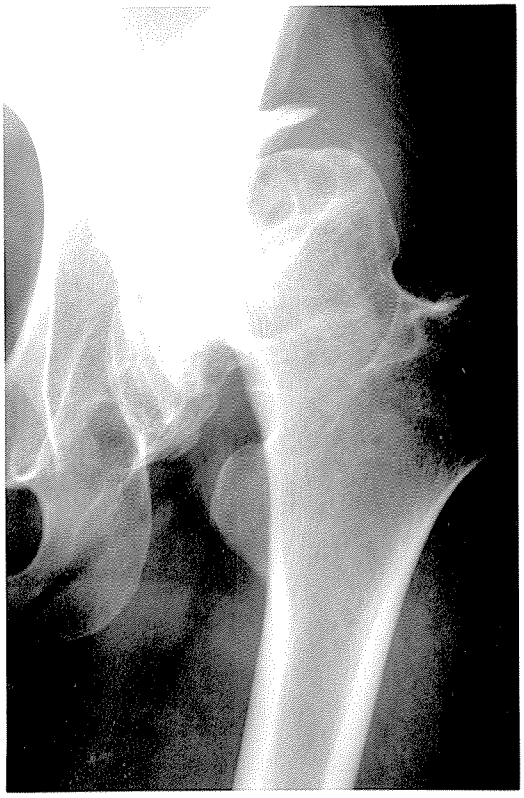
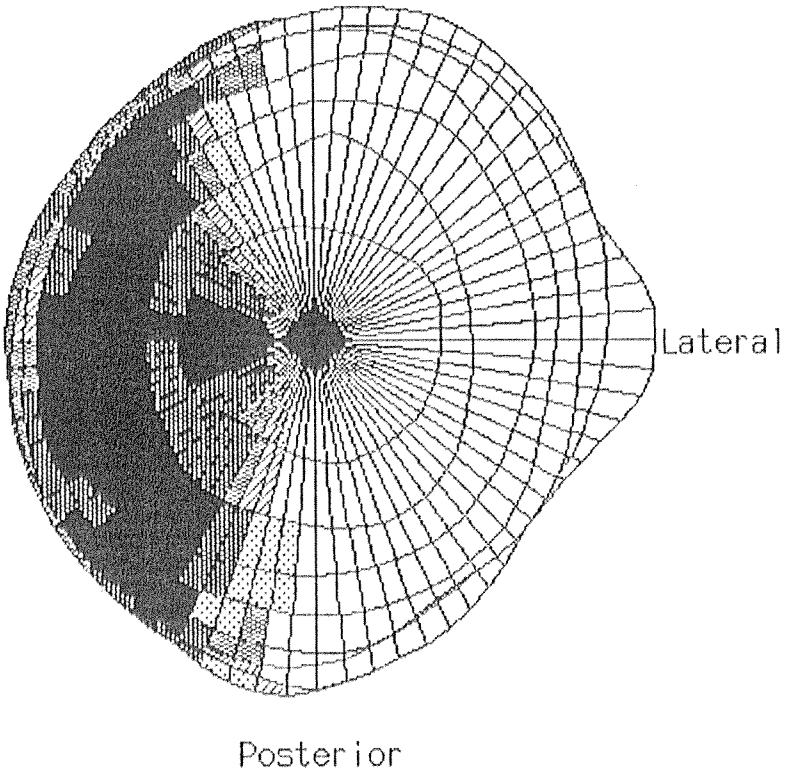


2(A)

Cartilage Thickness in the Segment of

Total	=	2.12
Anterior	=	2.22
Posterior	=	2.04
Anterior Apical	=	2.44
Posterior Apical	=	2.09
Anterior Equatorial	=	2.17
Posterior Equatorial	=	2.03

Values are averages (mm)



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- 4.8 <=..< 6.0
- 6.0 <=..<(uncovered)

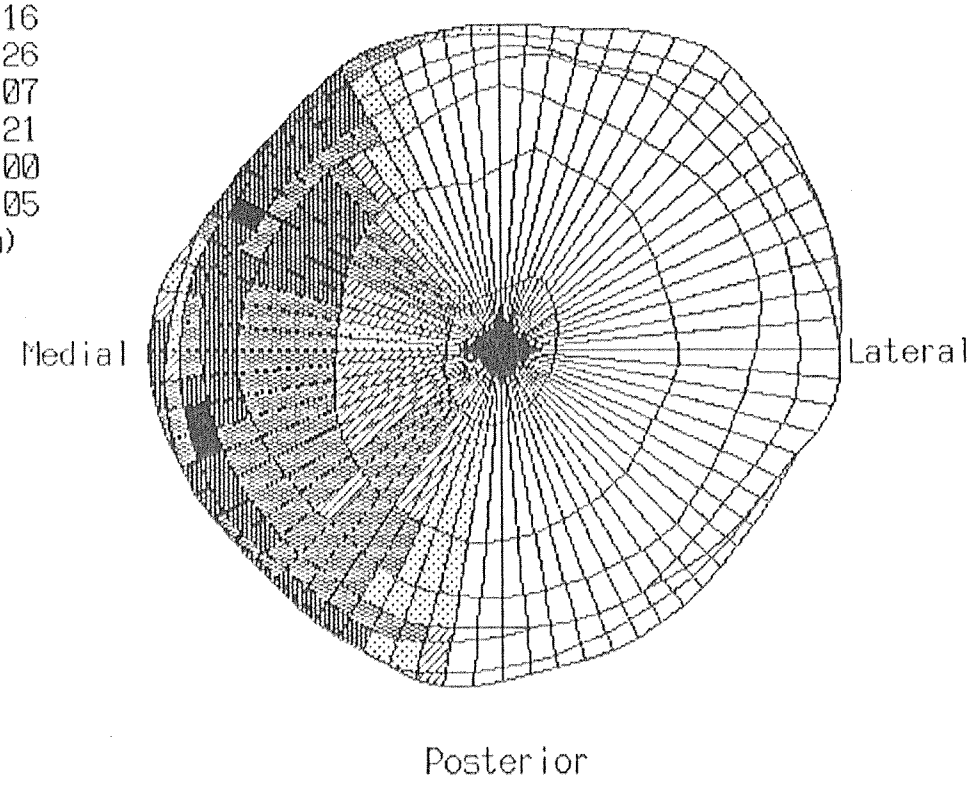
2 (B)

2 (C)

Cartilage Thickness in the Segment of

Total	=	3.22
Anterior	=	3.16
Posterior	=	3.26
Anterior Apical	=	4.07
Posterior Apical	=	4.21
Anterior Equatorial	=	3.00
Posterior Equatorial	=	3.05

Values are averages (mm)



- 0.0 <=..< 1.2
- 1.2 <=..< 2.4
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2 (D)