Acetabular augmentation using a glass-ceramic block

3 patients followed 3–4 years

Satoru Yoshii[1], Masanori Oka[2], Takao Yamamuro[3], Kiyoshi Ikeda[1] and Hitoshi Murakami[1]

Departments of [1]Orthopedics, Kansai Denryoku Hospital, Osaka 553 Japan, [2]Tissue Regeneration, Field of Clinical Application, Institute for Frontier Medical Sciences, Kyoto University, Kyoto 606 Japan, and [3]Orthopaedics, Faculty of Medicine, Kyoto University, Kyoto, 606 Japan. Correspondence: Dr. Satoru Yoshii, 2-7-14 Imaichi, Asahi-ku, Osaka, 535-0011 Japan. Tel +81 6 6956 2729. E-mail: K-20433@kepco.co.jp
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ABSTRACT – We have developed a block of glass-ceramic to augment the dysplastic acetabulum. 3 patients with acetabular dysplasia underwent implantation of a block of glass-ceramic on the lateral surface of the ilium just above the hip joint. The patients did not require immobilization and returned to their daily lives, walking without a cane 4 weeks after the operation. The mean Harris hip score was 47 points preoperatively and 94 points 3 years postoperatively.

Shelf procedures are useful for patients with acetabular dysplasia in whom no other osteotomy will establish a congruous joint. However, after these operations, weight bearing must be avoided until the graft has become stable. Moreover, a thick augmentation requires an abundant bone graft. We have developed a block of bioactive glass-ceramic to solve these problems.

Patients and methods

Patients

Between June 1996 and November 1998, 4 patients with acetabular dysplasia had acetabular augmentation, using a glass-ceramic block. We report 3 women (ages 21, 41, 54 years) followed for 3–4 years. The 4th case has been followed for 2 years with good outcome, but because of the short follow-up period is not included. The study was carried out in accordance with the World Medical Association Declaration of Helsinki. Patients gave informed consent and the study was approved by the institution's review board. The criteria used for the diagnosis of acetabular dysplasia were: 1) an acetabular angle of at least 40 degrees and 2) a center-edge angle of no more than 20 degrees. The patients were treated with rest, cane and medication (indomethacin 50 mg per day) for 3–10 years. However, the hip pain gradually intensified and serial radiographs showed progressive subluxation of the femoral head. All 3 patients had severe pain at times and pain at rest. They had marked limitation of activities, but they were ambulatory with a cane. Range of motion was moderately restricted in all 3 cases (Table). A femoral osteotomy was not indicated because the neck-shaft angle and anteversion of the femoral neck were not so large (Table).

Characteristics of the implant

The chemical composition of the glass-ceramic was MgO 4.6, CaO 44.9, SiO_2 34.2, P_2O_5 16.3, CaF_2 0.5, in terms of weight ratio. We made the glass-ceramic by compacting a glass powder of the above composition under a pressure of 400 kgw/cm^2 and heating it to 1050 °C for sintering and crystallization. The resulting glass-ceramic had high bending strength and a compressive strength of 196 MPa and 1,076 MPa, respectively. Young's modulus was 117,600 MPa, and the porosity was 0.7%. Some animal studies were done

Patient data preoperatively and 3 years postoperatively.

A	B		C	D	E	F	G	H	I	J	K	L	M	N
1	41	preop.	125°/0°	35°/15°	25°/25°	3°	42°	60%	142°	19°	2.9/2.9	51	10	20
		3-yr p.o.	125°/15°	42°/25°	35°/55°	44°	31°	100%	–	–	4.1/4.1	93	40	30
2	54	preop.	95°/0°	45°/30°	30°/30°	0°	52°	57%	144°	18°	2.2/2.2	54	10	17
		3-yr p.o	125°/20°	45°/35°	60°/45°	20°	48°	86%	–	–	3.0/3.0	93	40	30
3	21	preop	130°/15°	40°/30°	25°/25°	11°	50°	77%	129°	12°	4.0/3.0	37	10	10
		3-yr p.o.	140°/15°	50°/30°	45°/55°	56°	34°	100%	–	–	4.5/4.5	96	44	33
Mean		preop	117°/5°	40°/25°	27°/27°	4.7°	48°	65%	–	–	3.0/2.7	47	10	16
(SD)						(5.7°)	(5.3°)	(11%)			(0.9)/(0.4)	(9.1)	(0)	(5.1)
		3-yr p.o.	130°/17°	47°/30°	47°/52°	40°	38°	95%	–	–	3.9/3.9	94	41	31
						(18°)	(9.1°)	(8.1%)			(0.8)/(0.8)	(1.7)	(2.3)	(1.7)

A Patient
B Age
C Flexion/extension
D Abduction/adduction
E Internal rotation/external rotation
F CE angle
G Acetabular angle of Sharp
H Coverage of the femoral head
I Neck-shaft angle
J Anteversion
K Joint space
Weight bearing/minimum, mm
L Harris hip score
M Pain score
N Gait score

using this material and method before proceeding with human studies. We used 60 rabbits and 35 dogs (Yoshii et al. 1988, 1992). We found that the glass-ceramic had good bone-bonding (33 kgw/cm^2 in dog 1 year postoperatively) and suggested that it might be used in block to reconstruct an acetabular defect.

We made a block of the glass-ceramic that measured 30 × 27.5 × 20 mm (Figure 1). It had two holes, one 6.5 mm in diameter and one 2.8 mm in diameter.

Operation

The operation was performed, using Hardinge's (1982) lateral approach. The lateral iliac surface was exposed subperiosteally over an area of 3 × 3 cm just above the hip joint. The recurrent head of the musculus rectus femoris was detached and sutured to the joint capsule 2 cm lateral to the original insertion. The hip joint capsule was partly opened anteriorly to inspect the joint and labrum, no enlargement or tear of the labrum was found. The joint capsule was closed. The correct position of the implant was confirmed, using a trial jig under radiographic control. The lateral surface of the ilium was planed with an ilium plane 30 mm in diameter. The glass-ceramic block was placed on the hip joint capsule above the center of the femoral head with a 5 degree anterior tilt to improve anterior acetabular coverage and fixed to the lateral surface of the ilium with two titanium screws. Active and passive range-of-motion exercises of the hip joint were started the day after the operation. Walking with the aid of crutches was permitted with partial weight bearing on the affected side 3 days after the operation. The patients were allowed to walk with the aid of a single cane 2 weeks after the operation. 4 weeks after the operation, the cane was discarded and the patients returned to their daily living habits.

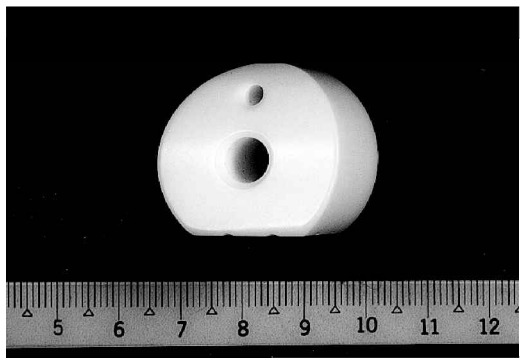

Figure 1. A block of the glass-ceramic measuring 30 × 27.5 × 20 mm. It has two holes, one 6.5 mm in diameter and one 2.8 mm in diameter.

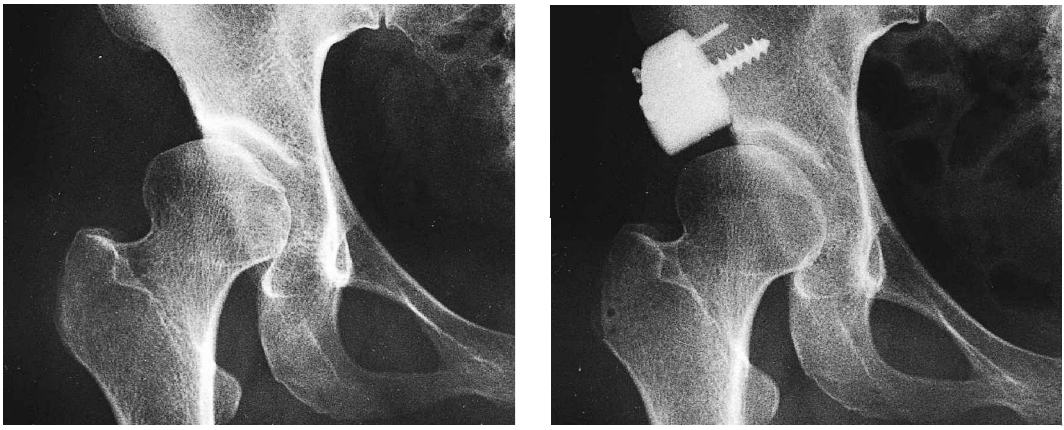

Figure 2. Case 1. Preoperatively and 3 years after the operation. The acetabular angle of Sharp has decreased by 11 degrees, the center-edge angle has increased by 31 degrees and the coverage of the femoral head has increased by 40%. The weight-bearing and minimum joint spaces have increased by 1.2 mm and 1.2 mm, respectively. A step between the glass-ceramic block and the acetabular roof came from the joint capsule.

Results

The mean intraoperative blood loss was 156 (140–167) g and the mean operating time 89 (85–102) minutes. No complications occurred. During the follow-up, the patients had no pain in the operated hip joints. These joints had full range of motion (Table). The manual muscle test showed all muscles around the joints had grade 5 strength in all 3 patients. The patients could walk without any support for more than 2 hours without pain in the operated hip joints. The Harris (1969) hip score was determined in all patients at 1, 2 and 3 years postoperatively. No change in score had occurred since the first examination. The mean score improved by 47 points. In particular, the pain score improved markedly (Table).

Radiographs showed no translucent zone between the implant and iliac surface, nor migration of the implant at the 3–4-year follow-up (Figure 2). Pelvic radiographs were taken during weight bearing preoperatively and at 3 years postoperatively. The mean center-edge angle of Wiberg (Wiberg 1939) had increased by 35 degrees, the mean acetabular angle of Sharp (Sharp 1961) had decreased by 10 degrees and the mean coverage of the femoral head had increased by 31%, compared with the preoperative measurements (Table). The mean weight-bearing joint space (measured at the superior aspect of the dome of the acetabulum, as determined by a vertical line through the center of the femoral head) (McCarthy et al. 1996), and minimum joint space (measured at the point of greatest narrowing of the joint space perpendicular to the articular surface (McCarthy et al. 1996) had increased (Table).

Discussion

Operations to increase the coverage of the femoral head are useful in patients with congenital dysplasia of the hip (Bosworth et al. 1961, Wainwright 1976). By increasing the coverage of the femoral head, adequate support for the subluxated femoral head is obtained and this may provide lasting symptomatic relief (König 1891, Colton 1972, Wilson 1974, White and Sherman 1980). The shelf operation was first described by König (1891). Many other techniques have been developed since then and the shelf operation became the main procedure used in acetabular reconstruction (Albee 1915, Dickson 1924, Gill 1924, Ghormley 1931). Pelvic redirectional and displacement osteotomies have largely replaced this type of operation (Chiari 1955, Salter 1961, Pemberton 1965). However, some types of acetabular deformities are difficult to correct by pelvic osteotomy and the need for the shelf operation remains. This need has resulted in renewed interest in the shelf operation (Heyman 1963, Staheli 1981, Saito et al. 1986, van der Ham and van der

Heyden 1986, Courtois et al. 1987). The shelf procedures have been performed by enlarging the volume of the acetabulum. In a classic shelf operation, the acetabular roof is extended laterally by a bone graft or the lateral cortex of the ilium. After these operations, weight bearing must be avoided until the graft has become stable. Moreover, a thick augmentation requires an abundant bone graft. We have developed a block of bioactive glass-ceramic to solve these problems. It was easy to position the implant correctly, using a trial jig and radiographic control. The fixation of the implant was simple and solid, using 2 screws and postoperative immobilization was not necessary. The patients could walk without a cane 4 weeks after the operation.

The advantages of our surgical procedure are: 1) correct and solid fixation of the implant, 2) shorter surgical procedure, 3) less blood loss since an autogenous graft is not used, 4) customized sizing of glass-ceramic block for coverage, 5) improved stability of the joint, 6) rapid clinical recovery with no need for cast or a brace, 7) major improvement in pain and Harris hip scores. We believe this procedure can also be used for unsatisfactory coverage of the femoral head in incongruous hip after Perthes' disease or septic arthritis.

The bonding that occurs between bone and the bioactive glass-ceramic implant is thought to be chemical and biological (Yoshii et al. 1988). In the early postoperative period, the screws kept the block on the surface of the ilium. According to a previous study, the bonding between bone and the glass-ceramic implant progresses between 2 weeks and 2 months after the implantation (Yoshii et al. 1992). Our patients were suitable also for a periacetabular osteotomy as described by Ganz et al. (1988). In cases of severe dysplasia, that is an excellent, but a more technically demanding surgical procedure.

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