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Socket location in total hip replacement

Preoperative computed tomography and computer simulation

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For choosing the size and location of the acetabular component, we have developed a three-dimensional simulation system based on computerized tomography and a microcomputer. In 34 cases of coxarthrosis secondary to congenital dysplasia or dislocation, the system provided valuable preoperative information.

In Japan most cases of coxarthrosis are secondary to congenital dysplasia or dislocation. In those cases requiring total hip replacement, it may be difficult to identify an optimal size and position for the acetabular component. For this purpose, we have developed a system using computerized tomography and computer simulation.

Patients and methods

Thirty-four arthrotic hips in 26 patients were analyzed. All the patients were females and were between 20 and 78 years of age. Dome sockets, including Charnley type and Bioceram type (Kyocera Coop.), were inserted into 30 hip joints, Bateman UPF prostheses into three hip joints, and a cylinder type ceramic socket (Kyocera Coop.) into one hip joint.

The equipment used for analysis consisted of a computerized tomography (CT) scanner CT 8600 (General Electric Company), a microcomputer FM-8 (Fujitsu Limited, Tokyo, Japan), a digitizer DT1000 (Graphtec Coop., Tokyo, Japan) and an XY-plotter DXY800 (Roland DG Coop., Hamamatsu, Japan). CT of hip joints was performed with a scan thickness of 2 mm and a slice interval of 5 mm. Ten to 18 slices, including the teardrop line and acetabular edge, were made. Hard copies were made in such a way that each slice had the same magnification and the same coordinates (Figure 1). Contours of the acetabulum on each slice were entered into the microcomputer with the digitizer, and they were displayed on the CRT screen.

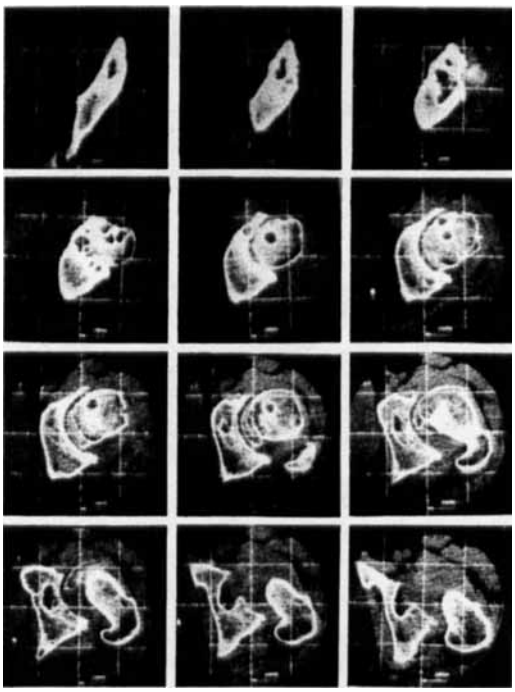

Figure 1. Hard copies of the CT image of Hip 3. Each slice has the same magnification and the same coordinates.

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The first step of the simulation was to decide at what level the component center should be located. We measured the distance between the teardrop line and the center of the femoral head in 127 normal Japanese females. The mean distance was 14.5 mm (SD 2.5 mm). We therefore located the probable center of the component as being 15 mm above the teardrop line. If, however, the lower part of the component protruded from the acetabulum, the component center was moved to a slightly higher position, at most 20 mm above the teardrop line. The diameter and the location of the component were chosen with relation to the anteroposterior diameter of the acetabulum and the thickness of its anterior and posterior lips. The location of the component center on the mediolateral axis was decided by using a cursor on the CRT screen.

The shape of the acetabular component on each slice was then computed from the location of the component center, the diameter of the component, and the angle of inclination to the long axis of the body, which was usually 45 degrees (Figure 2). The calculated section of the component were then drawn with the contours of the acetabulum on the CRT screen. If the floor or anteroposterior lips of the acetabulum at any level were too thin, the component was moved to a better location. If an adequate fit could not be achieved by adjusting the position of the component, another component size was selected. The final image was then drawn in actual size by an XY-plotter (Figure 3). Radiographs showing the results of this procedure can be seen in Figure 4. Another example (Case 14) is shown in Figures 5 and 6.

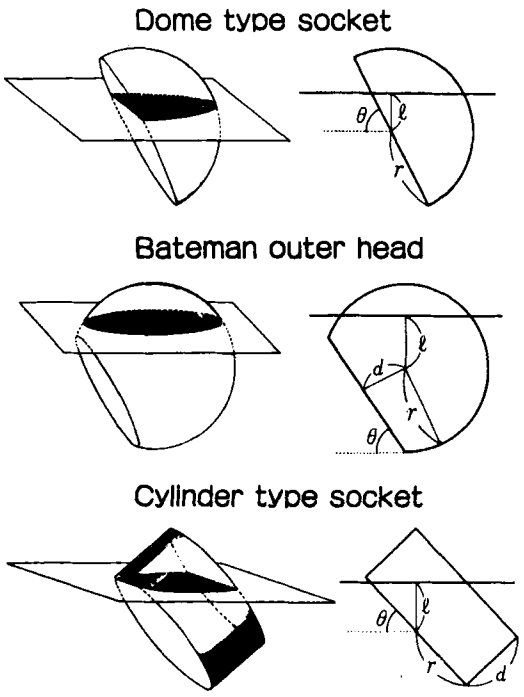

Figure 2. The shape of the section of the acetabular component on each slice can be computed by the input of the radius of acetabular component (r), the inclination angle of acetabular component (θ), the distance between component center and slice level (l), and other relevant data (d).

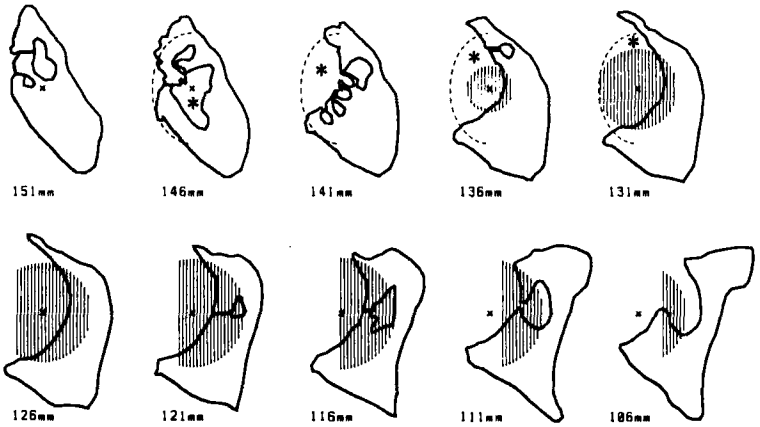

Figure 3. Graphic representation of the result by XY-plotter in Hip 3. The area in need of bone graft is represented by the spaces (indicated by asterisk), between the acetabulum and the dotted line which represents the lateral half contour of the projected image of the component on the horizontal plane.

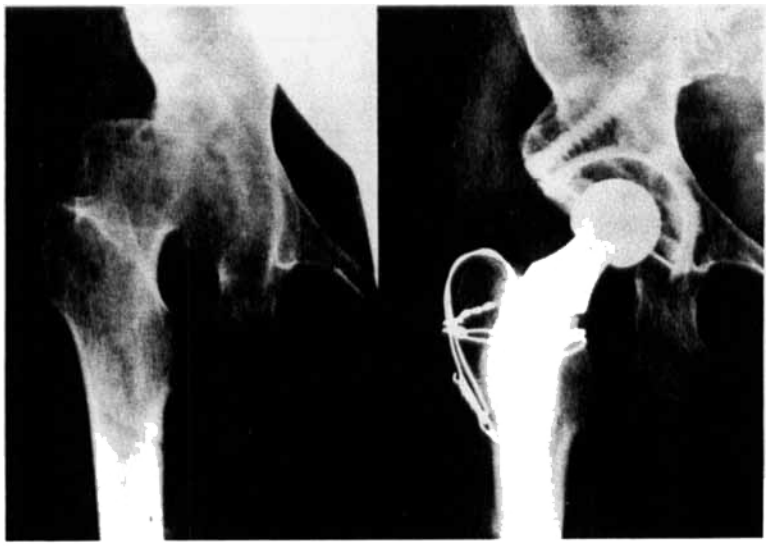

Figure 4. Preoperative and postoperative radiographs of the same hip (Hip 3) as shown in Figures 1 and 3. A bone graft was placed in the gap between the component and the cyst at the superior lip of the acetabulum.

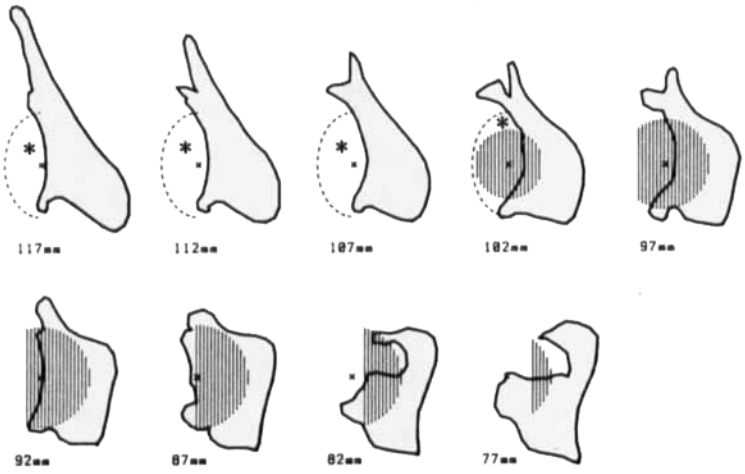

Figure 5. Graphic representation of the result in Hip 14 with a high dislocation. Both the anteroposterior and the maximal diameters at the original acetabulum were small. The maximal diameter of the component was estimated to be 40 mm, and a large bone graft to be necessary at the false acetabulum.

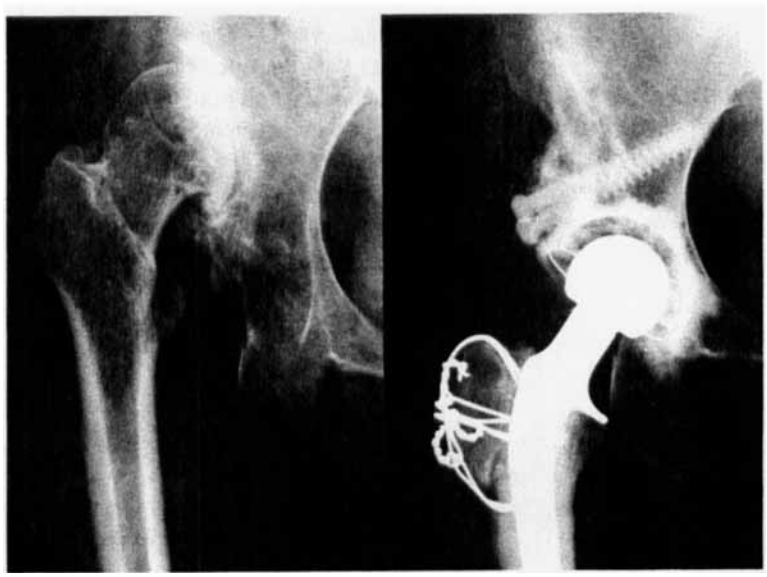

Figure 6. Preoperative and postoperative radiographs of Hip 14 with a large bone graft.

Table 1. Socket location in total hip replacement by preoperative computed tomography and computer simulation

Hip	Side	Component diameter (mm)		Location of component center[a]		Bone graft	
		E	A	E	A	E	A
1	L	44	46	15	20	+	+
2	L	44	42	20	17	+	+
3	R	44	44	15	19	+	+
4	R	42	42	15	17	+	+
5	R	44	44	15	11	+	+
6	R	42	42	20	24	−	−
7	L	46	46	20	25	+	+
8	R	42	44	20	17	+	+
9	L	43	44	15	15	+	+
10	L	48	44	15	17	+	+
11	L	42	44	20	29	+	+
12	L	44	40	20	19	+	+
13	R	44	44	15	12	+	+
14	R	40	40	20	18	+	+
15	L	44	42	20	29	+	+
16	L	46	46	20	15	+	+
17	L	46	44	15	16	+	+
18	R	44	42	20	22	+	+
19	L	44	46	15	21	+	+
20	R	42	44	15	15	+	+
21	L	44	46	15	19	+	+
22	R	46	44	20	22	+	+
23	L	43	43	15	18	+	+
24	L	43	43	20	24	+	+
25	R	43	43	15	19	+	+
26	R	43	40	15	20	+	+
27	R	43	43	15	19	−	−
28	L	43	43	20	30	+	+
29	L	43	43	15	20	−	−
30	R	43	43	15	11	+	+
31	L	46	49	20	23	+	+
32	L	46	48	20	22	+	+
33	L	48	46	15	22	+	+
34	L	48	48	20	24	−	−

E estimated, A actual.
[a] Distance from teardrop line (mm).
A dome socket was used in Hips 1–30, a Bateman in Hips 31–33, and a cylinder socket in Hip 34.

Results

The differences in the estimated and actual component sizes were within 2 mm in 30 cases (Table 1). The differences in the estimated and actual component locations were within 5 mm in 29 cases. Bone grafting was performed in 30 cases as indicated by the preoperative estimation.

Discussion

The preoperative morphologic evaluation of the hip joint and the surgeon's ability to judge visually during the operation are important for a successful operation. Charnley (1979) reported on principles and methods of preoperative measurement using plain radiographs. These principles are important, but of limited value because they only apply to two-dimensional evaluation, and not to the three-dimensional shape of the acetabulum, which varies greatly with the individual. Preoperative evaluations of the hip using CT have been reported by several authors (Lasda et al. 1978, Mendes 1981, Barmier et al. 1982, Vannier et al. 1985), but it has been difficult to decide the extent of acetabular reaming and the size and location of the component by using CT alone. However, the site and direction of the centering drill may be difficult to define in those cases where the true acetabulum is deformed and/or covered by osteophytes, and it is difficult to adjust the direction of the deepening reamer after the centering hole has been made. Further, the depth of reaming must

be frequently checked by observing the thickness of the acetabular floor through the pilot hole or by palpation. To make this easier and more accurate, we combined computer simulation with CT. Using this system, the three-dimensional relationship between the acetabulum and the component can be readily recognized. The final image, which shows reaming area, component diameter, and bone-graft area, supports the surgeon's visual judgement intraoperatively, contributing to a safer and more accurate operation.

Three types of acetabular components – dome type, cylinder type, and Bateman type – can be simulated with this system. The program for our system is short and simple. The program list is open and available on request, so it is easy to "transplant" to the user's microcomputer.

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