Total Hip Arthroplasty Through a Minimally Invasive Anterior Surgical Approach

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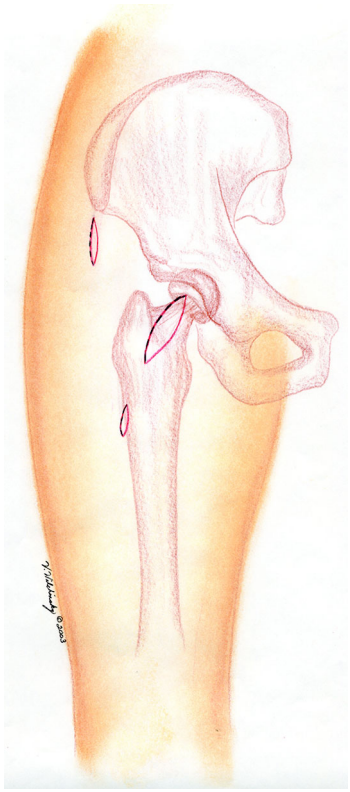

Fig. 1
Performance of an anterior approach for total hip arthroplasty with a one, two, or three-mini-incision technique depends on the surgical profile of the patient.

Total hip arthroplasty has become one of the most frequently performed and successful reconstructive procedures in orthopaedic surgery since its introduction more than forty years ago[1]. While there have been many changes in implant designs and biomaterials, surgical approaches have remained relatively unchanged over the years. Recently, in response to the evolution of minimally invasive procedures such as angioplasty, laparoscopic abdominal surgery, and arthroscopy, orthopaedic surgeons have expressed an increased interest in minimally invasive surgical approaches to total hip arthroplasty.

A variety of surgical approaches have been utilized for the performance of total hip arthroplasty; these include anterior, anterolateral, direct lateral, transtrochanteric, and posterior techniques[2-11]. The modified anterior approach developed by one of us (K.J.K.) provides effective access to the hip through a small incision and the use of secondary incisions for acetabular and/or femoral instrumentation (Fig. 1)[12,13]. This surgical approach has been utilized by the three senior authors (K.J.K., J.M.K., and R.S.W.) in more than 6000 total hip arthroplasties over the past thirty years. The purpose of this report is to present the perioperative clinical parameters and short-term clinical outcomes documented in our extensive patient database established twenty years ago.

Minimally Invasive Surgical Approach

Patient Positioning

The operating table is oriented at right angles to the walls to provide the surgeon with accurate references for ana-

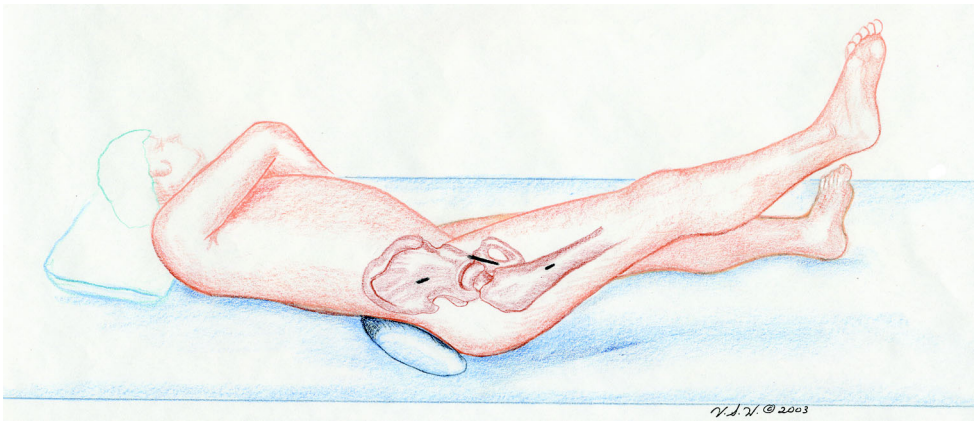

Fig. 2
The patient is positioned supine, with a sandbag or intravenous fluid bag under the sacrum to facilitate femoral access. Bilateral hip arthroplasty can be performed through this approach without repositioning or redraping.

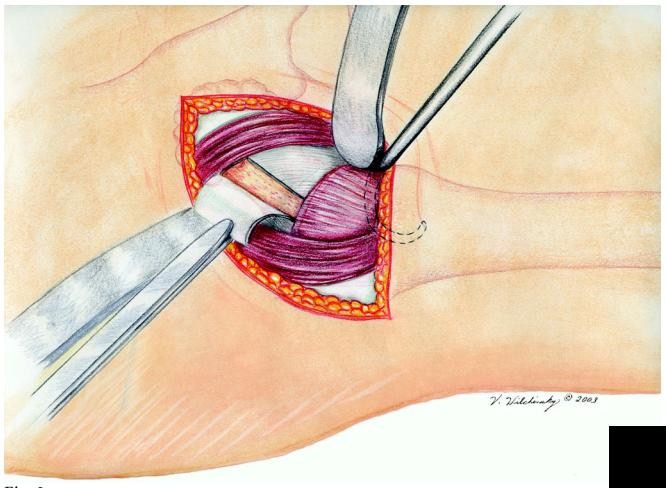

Fig. 3

Fig. 3 Acetabular reaming can be performed through a single incision in a thin patient. Reaming and cup positioning are facilitated by the anatomical supine position of the patient. Anterior small-single-incision approach. Splitting the anterior fibers of the tensor fasciae latae easily exposes the anterior hip joint capsule.
Fig. 4 The femoral head is removed with use of a hip skid and/or a corkscrew after osteotomy of the femoral neck. **Fig. 5** Acetabular reaming can be performed through a single incision in a thin patient. Reaming and cup positioning are facilitated by the anatomical supine position of the patient.

tomical orientation. The patient is positioned supine with the axis of the pelvis at a right angle to the long axis of the table (Fig. 2). The uninvolved lower limb is abducted and is placed on an arm board extending beyond the edge of the operating table in order to allow for adduction of the lower limb that is to be operated on. A small sandbag is placed under the sacrum and lumbar spine to tilt the pelvis forward. This facilitates draping and improves access to the femoral canal by placing the lower limb in extension. Extension of the lower limb and femoral exposure can be further increased by lowering the foot of the operating table. The hip and lower limb are draped free. An elastic compression bandage is wrapped from the foot up to the proximal part of the thigh, compressing the superficial veins and minimizing venous pooling. A distinct advantage of this method of positioning and draping is that it allows the performance of bilateral total hip arthroplasty without redraping or repositioning of the patient.

Surgical Exposure

Various anterior approaches to the hip joint have been reported[3,4,12,13]. Our anterior approach employs a curved transverse or short straight skin incision with or without a small proximal incision, or stab wound, to allow for the precise passage of femoral reamers and prosthetic components, and occasionally an additional small distal incision for the passage of acetabular instruments. The

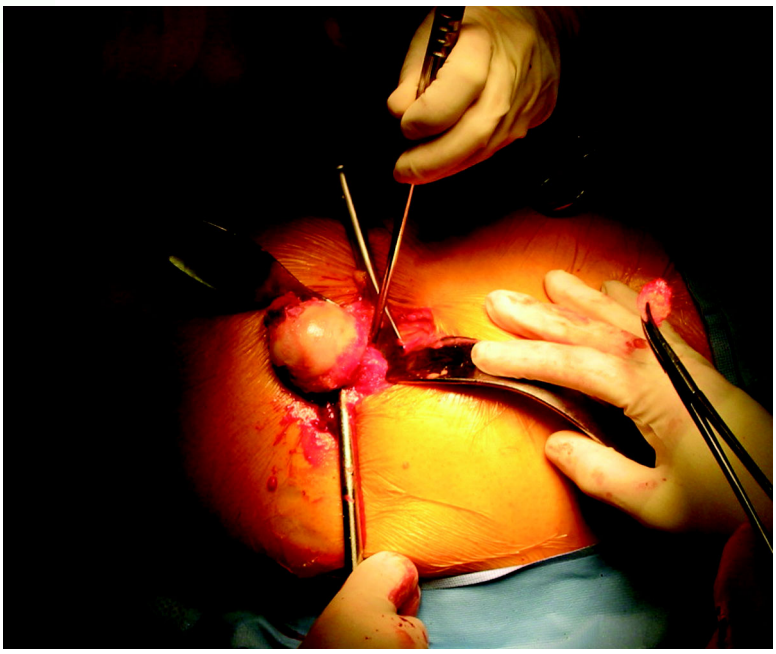

Fig. 4

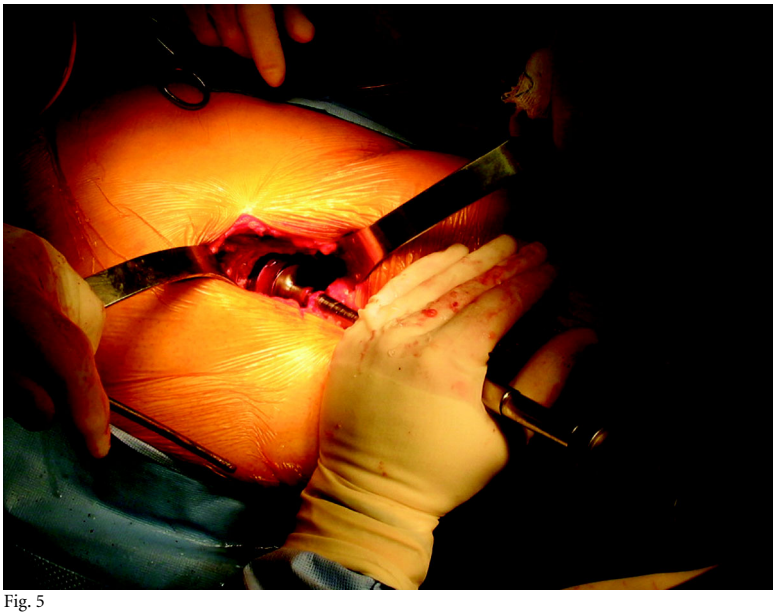

Fig. 5

primary skin incision is similar to the proximal portion of a Watson-Jones approach or the distal portion of a Smith-Petersen incision and allows exposure of the underlying tensor fasciae latae muscle[3,7]. Splitting the anterior fibers of the tensor fasciae latae easily exposes the anterior hip joint capsule (Fig. 3). This approach utilizes the anatomic interval between the tensor fasciae latae, innervated by the superior gluteal nerve, and the sartorius, innervated by the femoral nerve.

Retractors are placed on the superior and inferior aspects of the capsule and the underlying femoral neck. The anterior femoral circumflex vessels are exposed and, if possible, preserved. If these vessels are transected to achieve better exposure, they are controlled with suture ligatures or electrocoagulation to minimize blood loss. The anterior hip capsule is then excised to expose the femoral neck. Excision of the anterior hip capsule does not increase the risk of dislocation as does the posterior capsular resection in the posterior approach. It is also our impression that excision of a contracted, thick anterior capsule decreases the risk of posterior dislocation by reducing the impingement and tethering effect of this tight structure. The femoral neck is osteotomized in situ with an oscillating saw at an angle and level determined by preoperative templating. The femoral head is removed with a hip skid or a corkscrew device following the osteotomy (Fig. 4).

Acetabular Exposure and Preparation

The remaining anterior hip capsule and labrum are then excised. Cobra retractors are placed: one on the lateral aspect of the ilium to allow lateral retraction of the tensor fasciae latae and the abductor muscles, and another on the medial rim of the acetabulum to retract the medial structures. The ligamentum teres is removed with curets and rongeurs. The artery of the ligamentum teres requires cauterization if it is patent. The transverse acetabular ligament can also be excised if it inter-

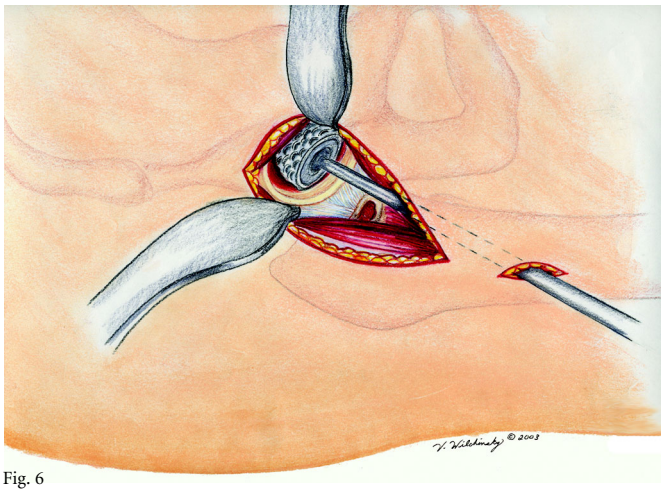

Fig. 6

Fig. 6 For large and obese patients, a distal stab wound can be used for the percutaneous passage of the acetabular reamer and impactor. **Fig. 7** The distal stab wound allows percutaneous passage of the standard acetabular reamer, which can then be used to ream the acetabulum under direct visualization. **Fig. 8** The practical limit to the surgeon's ability to minimize the size of the wound without damaging the surrounding tissue is the size of the acetabular component.

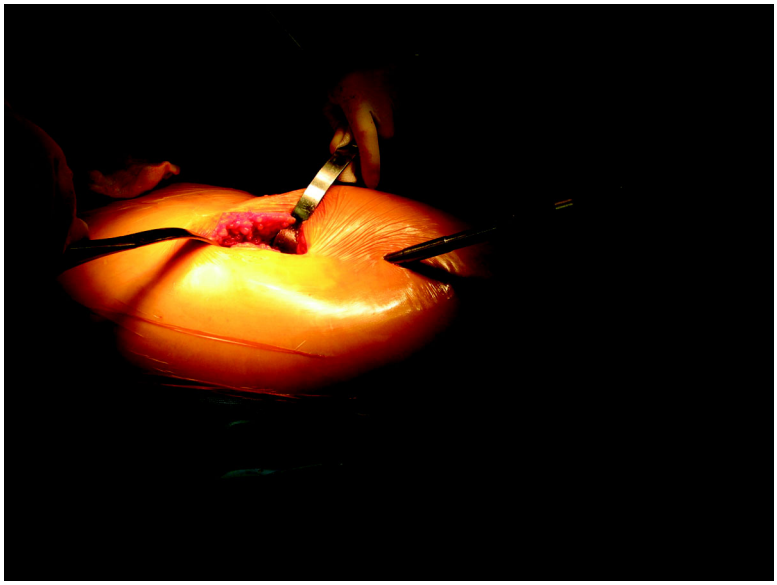

Fig. 7

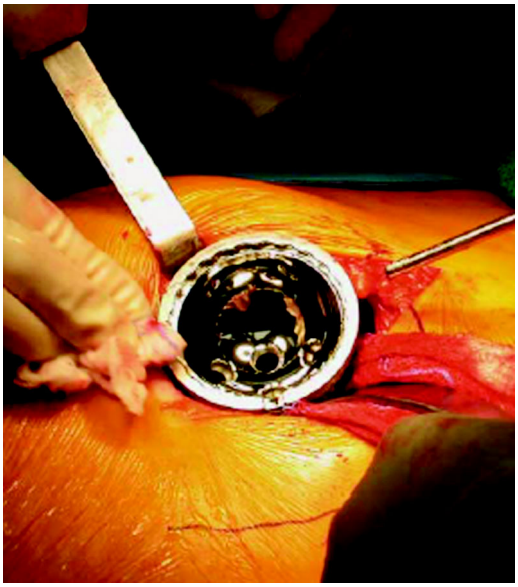

Fig. 8

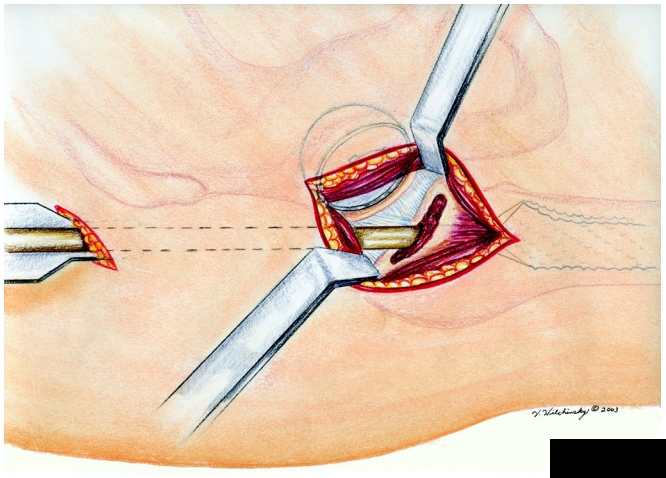

Fig. 9
A separate proximal incision or stab wound can be made to facilitate passage of the reamers and rasps in line with the longitudinal axis of the femoral canal.

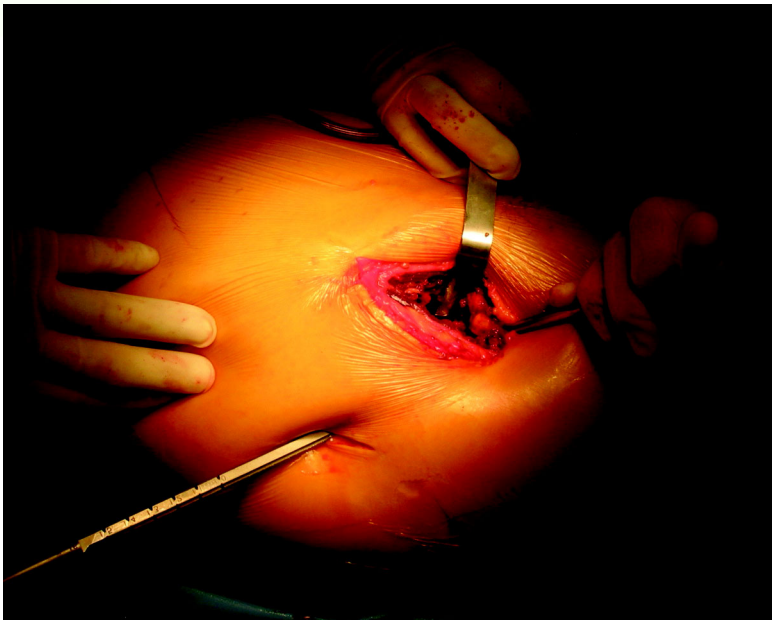

Fig. 10
We have been utilizing this secondary incision technique for approximately twenty years, since we first began performing cementless total hip arthroplasties that required more precise reaming of the femoral canal.

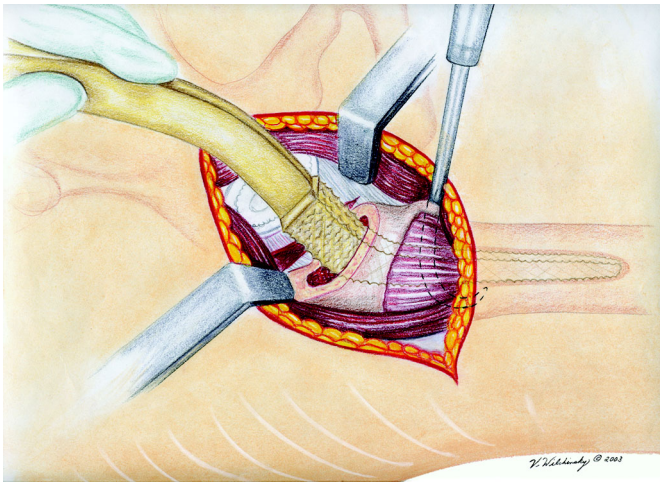

Fig. 11
Curved-handle rasps facilitate femoral preparation when the single-incision technique is used. They are not necessary when a proximal stab wound and long, straight reamers and rasps are employed.

feres with medial placement of the acetabular reamers and prosthesis. Acetabular osteophytes should be removed to minimize impingement. The acetabulum is reamed sequentially. Medialization with use of smaller-diameter reamers is performed first. The direction of reaming is in approximately 40° of abduction and 15° to 20° of anteversion. Reaming of the ac-

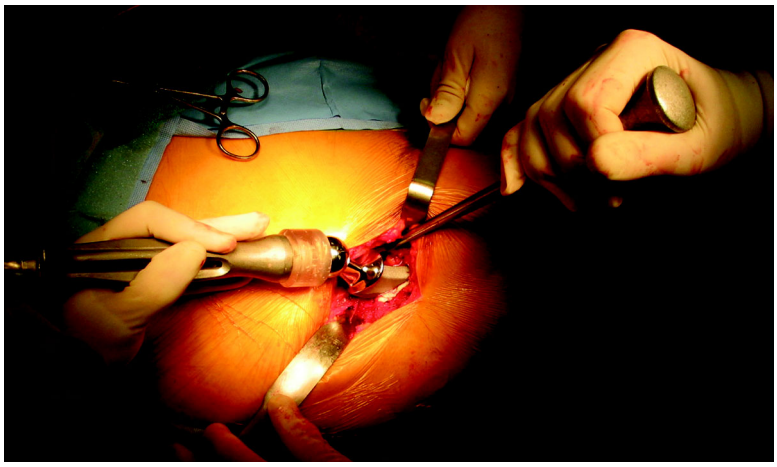

Fig. 12
Insertion of a cemented primary femoral component requires only a single incision in a thin patient.

Fig. 13
The Apex Modular Cementless Stem.

Fig. 14
The OTI R-120 Cemented Modular Neck.

Fig. 15
The Cremascoli-Wright Medical Modular System.

etabulum and positioning of the cup are facilitated by the anatomical supine position of the patient, the surgeon's ability to palpate the iliac spines, and the direct view of the acetabular fossa (Fig. 5). In obese and muscular patients, a small accessory incision may be made distal to the main incision to allow for retrograde passage of the shaft of the reamers and anatomical reaming of the acetabulum without extending the main skin incision or requiring extensive muscle retraction (Figs. 6 and 7). The acetabular cup is inserted after proper reaming. It should be noted that the diameter of the hemispherical acetabular component now becomes the primary factor limiting the surgeon's ability to minimize the size of the incision (Fig. 8). We have used noncemented porous press-fit, cemented, threaded hemispherical, and truncated-cone acetabular designs, all with equal success.

Femoral Exposure and Preparation

The femur can be accessed by elevating it with a bone hook placed posterior to the lesser trochanter. Potential dangers of this method of retraction include femoral fracture, trochanteric avulsion, or a tear of the iliopsoas tendon. However, we have only rarely encountered these complications. Care must be taken to avoid perforating the medullary canal with the bone hook. Such perforation can result in improper rasping and reaming of the femoral canal, leading to a suboptimal fit and position of the stem.

TABLE I Total Hip Arthroplasty Systems Employed by the Authors Over the Past Twenty Years

Mittelmeier Ceramic System
Collared Optifix System
Collarless Optifix System
S-ROM System
Whiteside System
Zweymueller System
Triwedge System
Biofit System
Anatomic System
Gemini System
Harris-Galante System
Synergy System
Spectron System
Perfecta Total Hip System
Echelon System
Cremascoli-Wright Medical Modular System
Apex Modular Cementless System
OTI R-120 Cemented Modular System

Femoral exposure can be improved with additional techniques, including (1) placing a rigid retractor (such as a Hohmann retractor) posterior to the greater trochanter to elevate the proximal part of the femur, (2) lowering the foot of the table to allow for more extension at the hip, (3) releasing the tensor fasciae latae from the anterior iliac crest, (4) releasing the medial joint capsule, and (5) releasing the posterior joint capsule and the short external rotator tendons. This posterior capsular release is accomplished by placing the lower limb in maximal external rotation while bringing the femur anteriorly with the bone hook. The capsule and tendons are released at their insertion on the greater trochanter. The posterior circumflex vessels must be identified and cauterized. Note that the use of the newer, modular total hip systems discussed later obviate the need for this step.

Once the femur has been adequately exposed, it is prepared for insertion of the femoral component. Curets or osteotomes are used to remove the remaining lateral aspect of the femoral neck and the cancellous bone in the greater trochanter to ensure proper placement of the reamers and rasps. A separate proximal incision or stab wound can be made to facilitate passage of the reamers and rasps in line with the longitudinal axis of the femoral canal (Fig. 9). This technique was initially developed by one of us (K.J.K.) to facilitate precise preparation of the femoral canal for noncemented devices, as it allows the insertion of cylindrical reamers and rasps of all types (Fig. 10). We have had success with the second incision for approximately twenty years, and we have also inserted the femoral component through this accessory skin portal.

The underlying fascia lata is split along its fibers, and reamers can be passed as far distally as necessary with a technique similar to that utilized for closed femoral nailing. Rasping can be done with use of either rasps with a handle with an anterior curve (Fig. 11) or by inserting rasps with a straight handle through the separate proximal incision. While standard, nonmodular cemented femoral stems are still frequently inserted with use of only a single incision in thin patients who do not require precise femoral preparation (Fig. 12), use of this separate incision to gain access to the femur reduces the need for extensive posterior release, thus minimizing the risk of bleeding from the circumflex vessels.

Over the years, we have utilized a multitude of stem designs (Table I). Currently, we use several modular stem designs that allow insertion of the medullary stem portion first. These include the Apex Modular Cementless Stem (Fig. 13), the OTI R-120 Cemented Modular Neck (Fig. 14), and the Cremascoli-Wright Medical Modular System (Fig. 15). Each of these modular systems allows for more accurate reproduction of the biomechanics of the hip and minimizes the need for posterior capsular and external rotator releases.

Insertion of the modular stem is followed by insertion of the metaphyseal body and neck portion separately (Fig. 16). This greatly reduces the need for extensive soft-tissue dissection and retraction since modularity reduces the overall dimensions of the femoral component. A modular design also offers precise orientation of the proximal part of the neck to best reconstruct the desired offset and anteversion. We believe that this reduces the risk of dislocation by allowing better soft-tissue balancing without limb-lengthening. These modular prostheses also allow adjustment of femoral neck anteversion or retroversion after the femoral component has been inserted. This feature is valuable in complex cases involving congenital hip problems, old fractures, or a malpositioned femoral stem. Moreover, separate preparation of the diaphysis and metaphysis allows maximization of the fit and fill of the canal.

Although we have not used surgical navigation techniques or fluoroscopy to insert rasps and modular components,

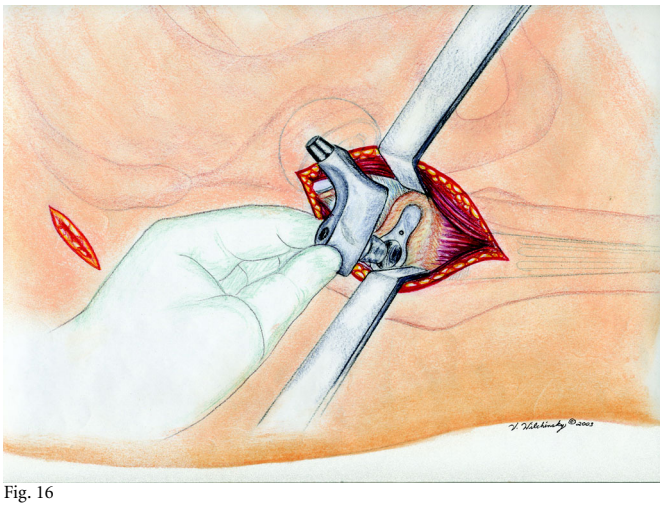

Fig. 16

Modular components allow improved offset, sizing, anteversion, and limb-length adjustment by assembling the components in situ.

TABLE II Demographic Data

	Cemented Stem		Noncemented Stem	
	Noncomplex Procedure	Complex Procedure	Noncomplex Procedure	Complex Procedure
No. of procedures				
Total	1177	104	672	179
In patients with bilateral arthroplasty	338	18	221	30
Age *(yr)*				
Average	73.7	72	54.8	50.8
Range	44-94	51-91	17-78	16-72
Standard deviation	7.1	8.6	9.5	10.9
Male *(no.)*	440	27	445	104
Female *(no.)*	737	77	227	75
Average height *(in [cm])*	65 (165)	65 (165)	68.6 (174.2)	68.3 (173.5)
Weight *(lb [kg])*				
Average	163.2 (74)	179.5 (81.4)	185.2 (84)	219.2 (99.4)
Range	90-284 (41-129)	80-305 (36-138)	96-290 (44-132)	98-450 (45-204)
Standard deviation	32.97 (15)	48.8 (22.1)	37.6 (17.1)	61.2 (27.8)

an advantage of the anterior approach is that fluoroscopy is easily applied with the patient in the supine position if the surgeon has any doubts about the placement of the rasps or prosthesis (Fig. 17).

Limb lengths and soft-tissue tension are determined by using trial components. The supine position of the patient allows direct palpation of anatomical landmarks, such as the iliac crest, patella, and malleoli, for precise assessment of the limb lengths. We have been pleased with our clinical results and are currently analyzing the prevalence of limb-length discrepancy in our patient population.

Wound Closure

The wound is irrigated and débrided. All sites of bleeding are once more inspected and are cauterized if necessary. A suction drain is placed in the posterior aspect of the hip. If a distal stab wound was utilized for the passage of acetabular reamers, it often can be used for passage of a suction drain with tonsil forceps. A single continuous absorbable suture is used to approximate the tensor fasciae latae. The subdermal layers and the skin are closed in a standard fashion. This simple closure technique greatly reduces the operating time.

Postoperative Care

We have used the same rehabilitation protocol after total hip arthroplasties performed with and without cement. Walking is started on the first postoperative day. Weight-bearing is typically allowed as tolerated, and most of our patients have left the hospital walking with a cane on the third or fourth postoperative day. We emphasize immediate hip and knee flexion, rapid foot pumps, and deep breathing exercises to minimize thromboembolic and pulmonary complications. Approximately half of the patients choose to continue their rehabilitation at an in-patient facility, whereas the others are discharged home with home care services. We emphasize early discharge to the home setting and encourage self-care and exercises. Even though a substantial portion of our patients could be discharged in the first twenty-four hours after the operation,

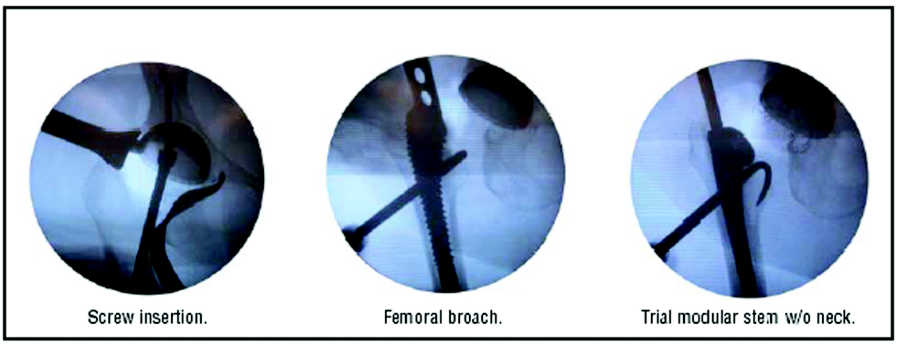

Fig. 17

Although we typically do not use surgical navigation or fluoroscopy, either is easily used with the patient in the supine position if there is any doubt about placement of the rasps or prosthesis, as is shown here with a modular total hip prosthesis for teaching purposes.

TABLE III Diagnoses*

	Cemented Stem		Noncemented Stem	
	Noncomplex Procedure	Complex Procedure	Noncomplex Procedure	Complex Procedure
No. of procedures				
Total	1177	104	672	179
In patients with bilateral arthroplasty	338	18	221	30
Osteoarthritis	1092	46	544	95
Osteonecrosis	45	28	74	25
Rheumatoid arthritis	29	0	14	0
Congenital hip dislocation	1	2	23	21
Other	10	28	17	38

*The diagnoses were varied, and no patient with a primary total hip arthroplasty was excluded from this consecutive series.

TABLE IV Intraoperative Parameters

	Cemented Stem		Noncemented Stem	
	Noncomplex Procedure	Complex Procedure	Noncomplex Procedure	Complex Procedure
No. of procedures	1177	104	672	179
Op. time *(min)*				
Average	51.8	76	60.4	82.9
Range	20-134	33-180	27-150	34-250
Standard deviation	13.2	27.5	15	29.6
Intraop. est. blood loss *(units)*				
Average	0.35	0.61	0.51	0.72
Range	0-3	0-5	0-3	0-3
Standard deviation	0.51	0.86	0.58	0.7
Postop. est. blood loss *(units)*				
Average	0.93	0.94	0.89	1.12
Range	0-11	0-6	0-19	0-13
Standard deviation	1.17	1.13	1.41	1.6

as has been advocated by some other proponents of minimally invasive total hip arthroplasty, it is our strong belief that patients should stay in the hospital for at least three or four days because of the still present, if reduced, risk of thromboembolic events, bleeding, and other complications.

We use aspirin for thromboembolic prophylaxis. Low-molecular-weight heparin, adjusted-dose warfarin, and adjusted-dose unfractionated heparin have been used in high-risk patients.

Results

The senior authors (K.J.K., J.M.K., and R.S.W.) have performed a total of more than 6000 total hip arthroplasties with the described anterior approach over the past thirty years. A computerized database was instituted in 1983 to follow the patients who had been treated with arthroplasty by the senior surgeon (K.J.K.); to date, that database includes more than 3000 total hip replacements. Many different prosthetic systems have been used over the thirty-year interval (Table I), with the spectrum ranging from simple mechanical designs without biologic fixation to prostheses with surfaces designed to achieve biologic fixation by osseous ingrowth. A retrospective review of the consecutive primary total hip replacements performed by the senior author during the last ten years was conducted to identify the operative times, blood loss, and complications. This review included 1281 cemented femoral stems and 851 noncemented stems used in a total of 2132 consecutive primary total hip arthroplasties.

One thousand five hundred and twenty-five (71.5%) of the primary total hip arthroplasties were unilateral, and 607 (28.5%) were performed in patients with a bilateral total hip arthroplasty. All of the operations were done with the described minimally invasive anterior approach.

It was useful to group the cemented and noncemented femoral stems according to whether they had been used for a complex or noncomplex procedure, as determined by the de-

TABLE V Complications

	Cemented Stem		Noncemented Stem	
	Noncomplex Procedure	Complex Procedure	Noncomplex Procedure	Complex Procedure
No. of procedures	1177	104	672	179
Dislocation				
Total	14	1	9	4
Early (within 72 hr)	3	0	6	3
Late (at 72 hr-6 mo)	11	1	3	1
Requiring open reduction	0	0	1	0
Infection				
During hospital stay	1	1	0	0
At 1 wk-6 mo	5	0	0	0
Hematoma	21	1	6	3
Fracture				
Total	19	7	46	15
Shaft, requiring cerclage wire	4	3	10	4
Greater troch. fracture/fissure	9	3	9	3
Requiring additional fixation	2	2	1	0
Lesser troch. fracture/fissure	0	0	1	1
Requiring additional fixation	0	0	0	1
Calcar fracture/fissure	5	1	24	7
Requiring additional fixation	0	0	1	0
Acetabular fracture	1 ramus	0	1 medial wall, 1 posterior rim	0
Femoral cutaneous nerve injury	3	0	0	2
Transient postop. footdrop	2	1	0	1
Sciatic nerve injury (residual)	0	0	0	0
Thromboembolic disease				
Total	8	1	7	1
Pulmonary embolus	6	1	3	1
Deep vein thrombosis	2	0	4	0
Nonfatal myocardial infarction or cerebrovascular accident	7	3	2	0
Death (myocardial infarction)	0	0	1	0
Lost to follow-up before 6 mo	18	1	11	0

gree of technical difficulty and the patient's anatomy. Complex procedures included those performed in patients with congenital hip dysplasia, old fractures, or other deformities such as those caused by prior osteotomies. Overall, 1177 cemented stems (55.2%) were used in noncomplex procedures, 104 cemented stems (4.9%) were used in complex procedures, 672 noncemented stems (31.5%) were used in noncomplex procedures, and 179 noncemented stems (8.4%) were used in complex procedures.

Table II summarizes the demographic data, Table III summarizes the diagnoses by category of arthroplasty, and Table IV summarizes the important intraoperative parameters measured during the procedures.

Complications occurring within the first six months after surgery included dislocations, fractures, damage to the lateral femoral cutaneous nerve, clinically relevant hematomas, infections, thromboembolic events, cerebral vascular injuries, myocardial infarctions, and a single death (Table V). There were no injuries to the femoral or sciatic nerve in this series. Thirty (1.4%) of the 2132 hips were lost to follow-up before six months postoperatively.

Discussion

A number of surgical approaches for total hip arthroplasty have been advocated over the past forty years. Charnley originally advocated the transtrochanteric approach, which is rarely used today. At present, the posterolateral and anterolateral approaches are the most frequently used techniques. Recently, there has been new interest in minimally invasive hip arthroplasty to decrease the size of the incision and blood

loss. The modified anterior approach described here has a number of advantages: the abductor mechanism is not released or distorted in any way, bilateral arthroplasty is easily performed without changing the position of the patient or redraping, anatomical visualization of the femur and acetabulum is excellent, and only a small anterior incision, with or without accessory stab wound incisions, is required, which reduces soft-tissue dissection, operative time, and blood loss. This in turn leads to a low prevalence of intraoperative and perioperative complications.

In this large series, clinically relevant thromboembolic disease occurred following only seventeen (0.8%) of the 2132 arthroplasties. The prevalence of deep venous thrombosis was reported to be between 5% and 60% in several large series of patients treated with a variety of prophylactic regimens[14-16]. A major contributory factor in the pathogenesis of thromboembolic disease during hip arthroplasty is intraoperative distortion of the femoral vein due to retraction and limb positioning, which has been shown to be particularly pronounced with positioning for the posterior approach[17-19]. Patients in this series routinely received low-dose aspirin (650 mg per day) for prophylaxis. We believe that the low prevalence of thromboembolic disease in our series was due primarily to the short operative times and the intraoperative positioning afforded by the anterior approach.

In conclusion, the modified anterior approach to the hip described by the senior author (K.J.K.) has been utilized by the three senior authors for nearly thirty years with quite satisfactory results. The technique was first presented in a scientific exhibit at the 1977 Annual Meeting of the American Academy of Orthopaedic Surgeons in Las Vegas, Nevada[20]. Our analysis of 2132 consecutive primary total hip replacements revealed low recorded rates of intraoperative and perioperative complications, short operative times, and low blood loss. A typical incision is only 6 to 10 cm long, and proximal and distal accessory incisions may be utilized to allow preparation of the femur and acetabulum for optimal positioning of the prosthetic components.

We believe that the low blood loss and low complication rate are at least in part due to the minimally invasive nature of this approach, which keeps soft-tissue trauma to a minimum and leads to faster postoperative mobilization and rehabilitation. In addition, as greater interest in smaller incisions is generated by cosmetic concerns, it should be noted that this approach offers a substantially shorter incision. We continue to use this adaptable anterior approach and have found it to be advantageous. ■

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In support of their research or preparation of this manuscript, one or more of the authors received grants or outside funding from the Keggi Orthopaedic Foundation. None of the authors received payments or other benefits or a commitment or agreement to provide such benefits from a commercial entity. A commercial entity paid or directed, or agreed to pay or direct, benefits to a research fund, foundation, educational institution, or other charitable or nonprofit organization with which the authors are affiliated or associated. (Keggi Orthopaedic Foundation has received benefits from Smith-Nephew Richards, Apex Surgical, Osteoimplant Technology Incorporated, and Wright Medical.)

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