Functional Problems and Treatment Solutions After Total Hip and Knee Joint Arthroplasty

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FUNCTIONAL PROBLEMS AND TREATMENT SOLUTIONS AFTER TOTAL HIP AND KNEE JOINT ARTHROPLASTY

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Introduction

Although most patients who undergo total hip or knee joint arthroplasty have an excellent clinical result with routine postoperative interventions, substantial dysfunction develops in 15% to 20% of patients for various reasons[1]. These patients do not respond to standard physical therapy modalities and need a very aggressive regimen of management that may include both invasive and noninvasive therapeutic options. The purpose of this study was to identify these patients with functional limitations and to assess the results of treatment with a customized regimen. We defined soft-tissue problems as those not directly related to the implant. Implant-related problems due to malalignment or loosening were ruled out radiographically or by specialized testing by two of the authors (M.M. and G.E.). We identified several functional problems following total hip arthroplasty and total knee arthroplasty that were related to muscle weakness, muscle tightness, limb-length differences, and nerve problems (Table I).

After identification of the problems, management was initiated with either noninvasive treatment such as physical therapy, customized bracing, electrical stimulation, or iontophoresis or with invasive treatment such as injections of Botox (botulinum toxin type A; Allergan, Irvine, California), intra-articular injections, nerve blocks, or muscle-lengthening procedures. For patients exhibiting joint stiffness, a lack of extension, or a lack of flexion (<90°) following total knee arthroplasty, we developed a special customized protocol utilizing a customized hinged cast and adjunctive physical therapy. We identified problems with the soft-tissue envelope that were directly related to the joint in the majority of patients. In addition, some patients had problems affecting an adjacent joint that resulted in poor gait and function, such as malalignment of the knee joint in a patient who had had a total hip arthroplasty or malalignment of the foot in a patient who had had a total knee arthroplasty.

Materials and Methods

Our study group consisted of 118 patients who had been treated with a unilateral arthroplasty. Rehabilitation was difficult in this group, and in most cases a standard postoperative regimen of physical therapy had failed. Sixty-seven patients had undergone a total hip arthroplasty and fifty-one, a total knee arthroplasty. Seventeen of the sixty-seven total hip arthroplasties were revisions performed because of either component loosening or a previous infection at the hip. Thirteen of the fifty-one total knee arthroplasties were revisions secondary to loosening, infection, or joint stiffness. The study group repre-

TABLE I Problems Following Total Hip and Knee Arthroplasty

	No. of Patients
Hip problems	
Hip abductor weakness	36
Iliopsoas contracture	17
Rectus femoris contracture	16
Tensor fasciae latae contracture	15
Adductor contracture	4
Ipsilateral shortening of 0 to 2.5 cm	2
Ipsilateral apparent lengthening due to tight tensor fasciae latae	4
Ipsilateral lengthening	2
Ipsilateral knee malalignment	6
Ipsilateral foot malalignment	2
Contralateral knee malalignment	2
Knee problems	
Quadriceps weakness	21
Flexion contracture	23
Knee flexion deficit (<90° of flexion)	9
Peroneal nerve entrapment	3
Sciatica	2
Superficial neuroma	2
Limb-length difference: surgically treated side 1 to 2.5 cm longer	4
Ipsilateral foot malalignment	3
Severe ligamentous laxity	1

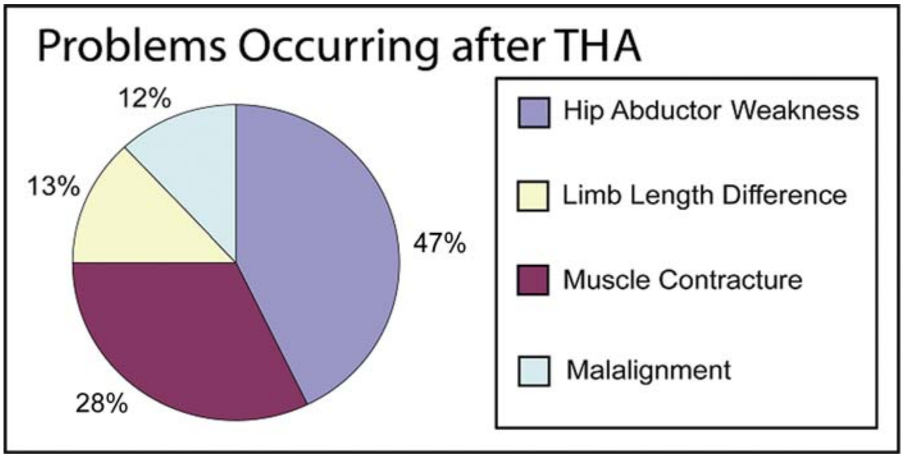

Fig. 1
The percentages of the total number of functional problems (n = 76) after total hip arthroplasty (THA).

sents about 5% of the patient population at our center. There were fifty men and sixty-eight women, and the age range was forty-seven to seventy-two years (mean age, 65.3 years).

Patients were screened carefully for radiographic evidence of loosening. Additional assessment included a detailed physical examination, isokinetic strength testing, videotaped gait analysis, assessment of balance, and, for the few patients with malalignment, a three-dimensional gait study. Patients with neuropathic pain underwent sensory nerve testing and electromyography, and superficial nerve blocks were used to identify specific etiologies in some patients. On the basis of these detailed examinations, we identified certain functional problems associated with total hip arthroplasty and total knee arthroplasty. Functional limitations due to range-of-motion deficits in the patients who had had a total hip arthroplasty were most commonly identified around two to 2.5 months after the surgery, usually during the second or third follow-up visit. Problems related to joint stiffness in the patients who had had a total knee arthroplasty were typically detected at six to nine weeks postoperatively and also coincided with the second or third follow-up visit. All of the other functional limitations were detected late in the follow-up period. Problems related to malalignment were usually discovered much later than the other functional deficits (approximately one year after the surgery).

We questioned all patients regarding their ability to participate in light recreational sports and whether they had been active prior to the surgery. We also posed specific questions regarding their activities of daily living, including stair-climbing, showering, dressing and undressing, and walking various distances, as well as other relevant activities, including sexual relations.

Hip Functional Deficits

On the basis of a thorough examination as outlined above, we identified hip functional deficits and classified them into four major categories (Fig. 1): muscle weakness, muscle contracture, limb-length difference, and malalignment. We analyzed hip abductor strength with the patient both in the side-lying position and standing, and we assessed walking for the presence of a Trendelenburg gait. Of the patients treated with a total hip arthroplasty, thirty-six had abductor weakness: the gluteus medius was weak in all thirty-six patients[2,3], the gluteus minimus was weak in twenty-eight (78%) of the thirty-six, and the tensor fasciae latae were weak in four (11%).

A muscle contracture was present in twenty-one of the sixty-seven patients who had had a total hip arthroplasty. A hip flexion contracture resulting from iliopsoas tightness was identified in seventeen patients, who walked with a lack of hip extension in terminal stance, with increased lordosis of the lumbar spine, and with trunk rotation. Some of these patients also had deep groin pain on active flexion of the hip joint. We found a rectus femoris contracture in sixteen patients. The rectus femoris contracture reduced swing-phase knee flexion in two of these patients, and the remaining patients reported stiffness of the hip joint.

Fifteen patients with a total hip replacement had tightness of the tensor fasciae latae. In four of them, the contracture was >10°, which resulted in apparent lengthening of the affected limb (Fig. 2). All of these patients felt that the surgically treated side was longer. A careful evaluation of the radiographs in this group determined that none of the cases of lengthening were caused by the implant.

We identified four patients with a hip adductor contracture. Three of them lacked full abduction, and one had a substantial adduction contracture that resulted in apparent shortening of the ipsilateral limb.

Nine of the sixty-seven patients treated with a total hip arthroplasty had a limb-length discrepancy. The discrepancy was caused by true ipsilateral lengthening from the prosthetic fit in two of these patients, apparent ipsilateral lengthening due to tightness of the tensor fasciae latae in four, apparent ipsilateral shortening due to hip adductor tightness in one, and ipsilateral shortening of 1.5 and 2.5 cm due to multiple total hip arthroplasty revisions in two.

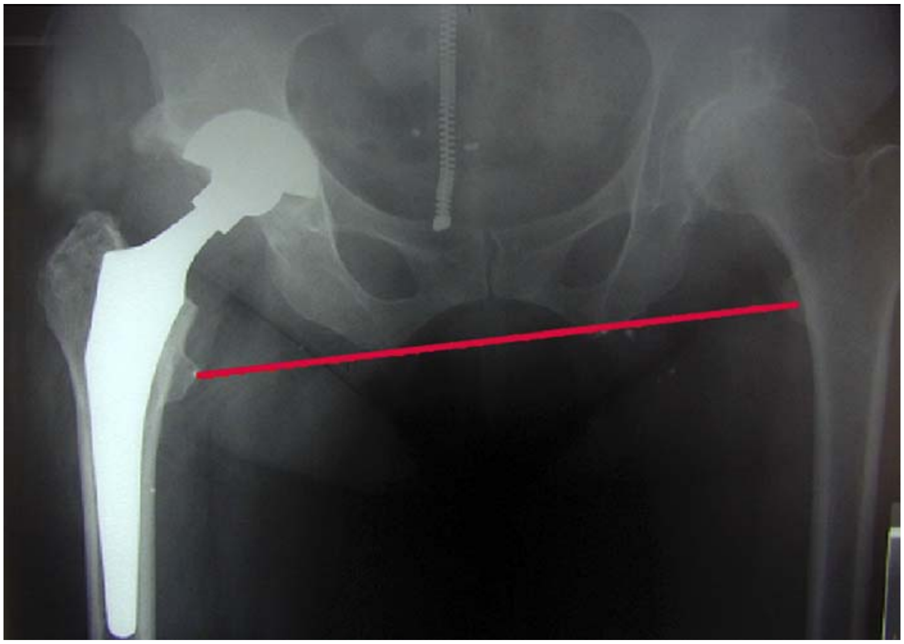

Fig. 2

Anteroposterior standing radiograph showing an apparent limb-length difference caused by an abduction contracture. Note that the line drawn from the ischial tuberosity passes close to the lesser trochanter on both sides, indicating that there is no true difference caused by the implant.

Ten of the sixty-seven patients had malalignment, not of the prosthesis but of a more distal joint. Five patients had malalignment of the ipsilateral knee joint due to a genu valgus deformity, and one had ipsilateral genu varum with a flexion contracture that resulted in gait and functional abnormalities. Four patients in this group did not have symptoms in the knee until after they underwent the total hip arthroplasty, even though the knee deformity had been long-standing. Thus, the biomechanical abnormality may have been unmasked by the total hip arthroplasty. Two patients had malalignment of the contralateral knee; both had a substantial genu varum deformity that resulted in increased knee pain with walking. Two patients had an ipsilateral planovalgus abnormality of the foot. These two patients had constant foot pain and a gait disturbance related to the collapsed longitudinal arch.

Knee Functional Deficits

The knee functional deficits were broadly divided into six

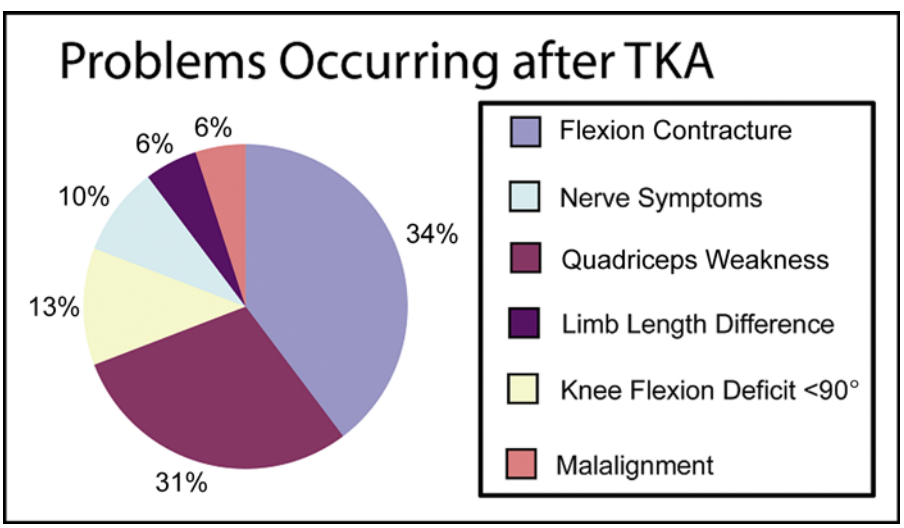

Fig. 3

The percentages of the total number of functional problems (n = 68) after total knee arthroplasty (TKA).

categories: weakness, peroneal nerve symptoms, flexion contracture, limb-length difference, knee flexion deficit, and malalignment (Fig. 3). Twenty-one of the fifty-one patients who had had a total knee arthroplasty had a clinically relevant quadriceps strength deficit as demonstrated by an isokinetic test with a Biodex dynamometer (Biodex Medical Systems, Shirley, New York). Quadriceps weakness was defined as an active extension lag exceeding 15° in the early postoperative phase or <50% of the strength of the contralateral limb as shown by isokinetic testing in the later stages of recovery.

There was a high rate of knee flexion contracture (defined as a lack of extension of ≥10°), which was identified in twenty-three of the fifty-one patients who had had a total knee arthroplasty (Fig. 4). The common causes of the knee flexion contractures were adaptive muscle-shortening, exuberant scar-tissue adhesions, quadriceps inhibition and hamstring overactivity, unrecognized tightness of the gastrocnemius, limb-length difference, and peroneal nerve entrapment. A knee flexion deficit (defined as knee flexion of <90°) was present in nine of the fifty-one patients. The common causes of the knee flexion deficits were joint effusion, abnormal pain response, quadriceps scarring, tightness of the patellar tendon, tightness of the rectus femoris, and tightness of the iliotibial band.

We identified several nerve problems related to peroneal nerve entrapment as well as neuromas of the sciatic and superficial nerves in this group. Three patients had peroneal nerve entrapment that produced burning pain down to the dorsum of the foot, paresthesias of the foot, increased foot pain, mild weakness of the extensor hallucis longus, and a positive Tinel sign (in one case). Two patients had a history of sciatica that resulted in increased peroneal nerve symptoms postoperatively. In addition, two patients had a superficial neuroma involving the saphenous nerve, with symptoms that resolved with nerve blocks.

Four of the fifty-one patients who had had a total knee arthroplasty demonstrated a limb-length difference, with the side of the arthroplasty longer than the contralateral side. These discrepancies resulted in a flexed knee posture and a resultant flexion contracture. We determined that these flexion contractures had developed as compensation for the limb-length difference. Two of the four patients who had a limb-length difference after the unilateral total knee arthroplasty had preoperative bilateral genu varum deformity. The discrepancy occurred in those two patients when the surgical side gained length as a result of the correction of the varus deformity.

There was malalignment on the side of the total knee arthroplasty in four patients, three of whom had substantial planovalgus deformity of the foot. Two of the three had a dysfunctional posterior tibial tendon with hindfoot valgus and a pronated hindfoot, and one had a tarsal coalition and a planovalgus foot deformity. The fourth patient had substantial ligamentous laxity of the knee in both flexion and extension. This patient was dissatisfied with the result and went on to have a revision total knee arthroplasty to improve the stability of the joint.

Correlation of Functional Impairment with Symptoms and Physical Findings

We attempted to correlate the physical impairments with the symptoms in the patients in our study. In the population treated with a total hip arthroplasty, we identified four major impairments: hip flexion contracture, hip abduction contracture, hip abductor weakness, and a true or functional limb-length difference (Table II). The major symptoms in the patients who exhibited a contracture included anterior hip pain or groin pain, abnormal gait, and low back pain. These impairments were found in most of the patients. Many patients, especially younger ones, reported that their sexual relations had been altered. The main symptoms in the patients with hip abductor weakness were increased energy consumption during gait, as suggested by the patient tiring too easily, and an abnormal appearance. The weakness also resulted in an inability to participate in light sports or recreational activities such as golf, tennis, dancing, or gardening. The main problems associated with a limb-length difference were low back pain and abnormal gait.

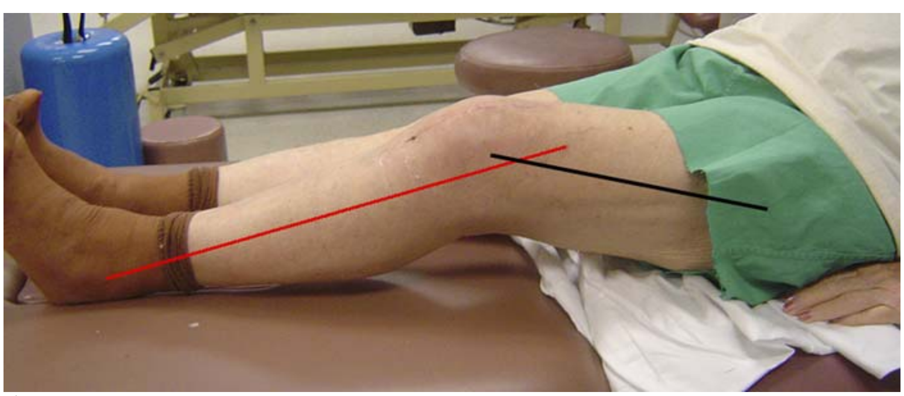

Fig. 4

A 25° knee flexion contracture seen five weeks following a primary total knee arthroplasty in a sixty-nine-year-old woman. The contracture was due to joint swelling, capsular contracture, and previously unrecognized tightness of the gastrocnemius.

TABLE II Symptoms and Physical Findings Related to Problems Following Total Hip Arthroplasty

Impairment	Symptoms	Physical Findings
Hip flexion contracture	Deep anterior hip pain, abnormal gait, difficulty with sexual relations, low back pain	Iliopsoas contracture, rectus femoris contracture, sartorius and tensor fasciae latae contracture, decreased step length and increased pelvic rotation during gait
Hip abduction contracture	Lateral hip pain, limb-length difference, abnormal gait, back pain, unable to participate in light sports or recreational activity*	Tensor fasciae latae tightness, apparent limb-length difference, lateral trunk-lean during gait, trochanteric bursitis
Hip abductor weakness	Lateral hip pain, abnormal gait, need to use cane, back pain, hip-muscle fatigue pain, difficulty walking long distances, unable to participate in light sports or recreational activity*	Weakness of gluteus medius and minimus, positive Trendelenburg sign and gait, trochanteric bursitis, poor balance, lateral trunk-lean during gait
True limb-length difference (shortening on the surgically treated side)	Back pain, abnormal gait	Trunk lean on surgically treated side during gait, contralateral knee flexion and ipsilateral equinus posture, increased patellofemoral stress and pain on contralateral side, tightness of contralateral quadratus lumborum
Apparent limb-length difference	Back pain, abnormal gait, unable to participate in light sports or recreational activity*	Pseudo-Trendelenburg gait, ipsilateral tensor fasciae latae contracture, contralateral adduction contracture, contralateral hip or knee flexion contracture

*Golf, doubles tennis, light dancing, gardening, etc.

In the population with a total knee arthroplasty, we identified five impairments: knee flexion contracture, knee flexion deficit, quadriceps weakness, peroneal nerve entrapment syndrome or nerve symptoms, and malalignment (Table III). Knee flexion contractures frequently resulted in anterior knee pain or retropatellar pain with quadriceps fatigue pain, back pain, limping gait, difficulty walking long distances, or the inability to participate in light sports. A flexion deficit did not result in a clinically relevant gait abnormality but did result in difficulty sitting in a chair or rising from a seated position, difficulty ascending or descending stairs, inability to use a bicycle for recreation, and difficulty with sexual relations. Patients with quadriceps weakness had quadriceps fatigue pain, buckling, or a giving-way sensation, especially those who demonstrated a quadriceps lag of >15° when they were tested in a seated or straight-leg-raise position. These patients lacked quadriceps control at the initial stance phase of the gait cycle and experienced some instability with a giving-way sensation. Quadriceps weakness also resulted in difficulty with walking on uneven ground and on ramps, difficulty climbing stairs and walking long distances, and the inability to participate in sports.

Peroneal nerve symptoms caused difficulty with sleeping at night, radiating pain to the dorsum of the foot, and difficulty walking long distances, especially at heel-strike during the gait cycle, with tripping or stumbling occurring in severe cases. Malalignment usually resulted in knee pain and laxity with buckling at the knee. Patients also needed to use braces, which some found cumbersome.

Treatment of Problems Following Total Hip Arthroplasty

Muscle Contractures

In our study, we identified hip flexion contractures due to tightness of the iliopsoas, rectus femoris, sartorius, adductors, and sometimes the tensor fasciae latae. Our initial strategy for treatment of hip flexion contractures involved manual therapy. This included an aggressive customized stretching protocol with at least seven to ten stretches of each affected muscle during each physical therapy session, at a frequency of four or five times a week for the first two to three weeks followed by a frequency of three times a week (Fig. 5). All patients were also provided with a home exercise regimen, which they performed either by themselves or with assistance from family members. In addition to aggressive physical therapy to stretch the hip flexor contracture, we injected 2 mL of triamcinolone with 3 mL of 1% lidocaine into the iliopsoas tendon with image-intensifer-guided assistance (Fig. 6). Tendinitis was diagnosed when resisted hip flexion was found to be painful in a seated position. Stretching was initiated forty-eight hours after the injection.

Of our four patients with adductor tightness, one responded well to standard manual therapy, one underwent adductor lengthening surgery, one received a Botox injection into the adductor muscle, and one had resolution of the adductor spasm after a revision total hip arthroplasty. Of the fifteen tensor fasciae latae contractures, four resulted in an apparent limb-length difference, with the tight side being longer by 1 to 2.5 cm. The patients with this complication responded well to a specific tensor fasciae latae stretching regimen as shown in Figure 7. Stabilizing the hip with the patient in either the prone or side-lying position stretched the tensor fasciae latae, after which the therapist performed extension and adduction mobilization of the hip joint to increase tension in the tensor fasciae latae. In addition to stretching, manual massage and soft-tissue mobilization techniques involving deep massage had good results in patients with tightness of the tensor fasciae latae. All of the patients with muscle contractures were asked to perform home-stretching regimens daily. We avoided giving a shoe lift initially to patients in whom the limb-length difference was due to tightness of the tensor fasciae latae; instead, we instructed them to walk in order to stretch the tensor fasciae latae. In our opinion, a shoe lift would have prevented effective stretching.

Abductor Weakness

Hip abductor weakness was a major problem in a large proportion (54%) of our patients. Our treatment strategies depended on the degree of weakness. If the muscle weakness was less than grade 2 (of 5), we always began with aquatic therapy[4]. Aquatic therapy improves muscle performance by utilizing buoyancy to reduce gravitational forces, and the warm temperature of the water increases blood flow to the affected muscles. Once muscle strength was increased to at least grade 3, we began a land-based strengthening regimen. We used electrical stimulation to augment the strengthening program for the gluteus minimus and medius muscles (Fig. 8). Instead of completing a standard hip-abduction exercise program with use of resistance, we focused mainly on muscle pattern techniques that strengthened hip abduction through the use of correct positioning to enhance muscle performance. For example, the gluteus medius is best strengthened in the side-lying position with the hip in about 10° of extension and external rotation while the abduction motion is completed. This maneuver specifically addresses the role of the gluteus medius in abduction. The gluteus minimus was strengthened in pure abduction with the patient in the side-lying position, whereas the tensor fasciae latae was strengthened with the patient in the supine position with the hip held in external rotation and abduction completed in a 45° arc. As the muscle performance increased, we applied weights, first at the knee and then at the ankle, to increase the lever arm of the resistance. The maximum weight used with this specific regimen never exceeded 10 lb (4.5 kg). In addition to hip abductor strengthening with the patient in the side-lying position, we utilized functional retraining with the Balance Master System (NeuroCom International, Clackamas, Oregon).

Once the patient graduated from treatment with these techniques, balance enhancement with use of functional exercises, such as standing on one leg in front of a mirror to obtain biofeedback and use of the BAPS (Biomechanical Ankle Plat-

TABLE III Symptoms and Physical Findings Related to Problems Following Total Knee Arthroplasty

Impairment	Symptoms	Physical Findings
Knee flexion contracture	Anterior knee pain (retropatellar or patellar tendon), quadriceps fatigue pain, back pain, limp, difficulty walking long distances, unable to participate in light sports or recreational activity*	Gastrocnemius contracture, hamstrings contracture, posterior capsule and cruciate ligament contracture, hip flexion contracture compensated for by knee flexion contracture, flatfoot gait with quadriceps avoidance, inflammation of patellar tendon, peroneal nerve entrapment or sciatica, true or apparent limb-length difference
Knee flexion deficit (flexion <90°)	Difficulty sitting in and rising from a chair, descending and ascending stairs, bicycling, and with sexual relations. Unable to participate in light sports or recreational activity*	Rectus femoris contracture, quadriceps or patellar tendon adhesions, retropatellar scarring or adhesions, joint effusion, reflex sympathetic dystrophy, abnormal pain response
Quadriceps weakness	Quadriceps fatigue pain, buckling or giving-way especially on uneven ground, difficulty climbing steps, difficulty walking long distances, unable to participate in light sports or recreational activity*	Active extension lag, quadriceps atrophy, anterior trunk-lean in stance phase, lack of knee flexion or quadriceps-avoidance gait in early stance phase
Peroneal nerve entrapment syndrome	Numbness, weakness, radiating pain in dorsum of foot; difficulty walking, with tripping or stumbling	Positive Tinel sign; weakness of extensor hallucis longus, extensor digitorum longus, tibialis anterior; hypesthesia or anesthesia at dorsum of foot; knee extension increases radiating pain; fixed flexion posture of knee to avoid peroneal nerve symptoms
Malalignment	Knee pain, laxity with buckling, need to use brace or cane	Planovalgus foot, tibialis posterior weakness or rupture, ligamentous laxity

*Golf, doubles tennis, light dancing, gardening, etc.

Fig. 5
Iliopsoas stretching with the patient stabilizing the lumbar spine and pelvis by maintaining a "back-flat" posture. This exercise is best done at the end of a table.

form System) board (Spectrum Therapy Products, Jasper, Michigan) were encouraged to increase the total limb function and pelvic stability in single-limb stance. This was the progression of hip abductor strengthening for all patients who had major hip abductor weakness. After most revision total hip arthroplasties, and some primary arthroplasties, the average duration of the exercise program with and without a supervised physical therapy regimen was three to six months until the patient returned to full function. In two patients in this series, the hip abductor weakness was extensive and did not respond to the treatment regimen described above. When we found no improvement in these two patients, we referred them for electromyography and nerve conduction studies. Both demonstrated L4-L5 radiculopathy, and they were referred to spine physicians for specific interventions. One patient underwent surgical decompression of the spine with fusion, and had improvement, and the other patient refused additional treatment.

We always attempted to address apparent limb-length differences due to tightness of the hip abductors with aggressive stretching and manual physical therapy techniques to improve the length of the tensor fasciae latae. One patient had no improvement with this treatment, and one patient did not comply with our program and chose to have a surgical lengthening. Patients who had a true limb-length difference, with the surgically treated side longer than the uninvolved side, had trochanteric pain and pain around the total hip arthroplasty incision. These symptoms appeared to be due to a pelvic tilt

Fig. 6
Image-intensifier-guided injection into the iliopsoas tendon just above the lesser trochanter. Intra-articular and extra-articular hip injections were used to provide pain relief and to decrease inflammation so that patients could tolerate stretching of the hip contracture and improve the range of motion.

Fig. 7

Stretching of the tensor fasciae latae with the contralateral hip positioned in 90° of flexion. The table stabilizes the pelvis, and the affected limb is stretched into extension and adduction.

Fig. 8

Neuromuscular electrical stimulation to strengthen the gluteus medius. The electrodes are placed posterior and posterosuperior to the greater trochanter, and the patient is instructed to abduct, extend, and externally rotate the hip while the stimulator is active.

compensation that placed the long limb in adduction and the short limb in abduction. This problem resolved only after an appropriate shoe lift was worn on the contralateral side, and it did not resolve in all patients. The patients with a longer limb on the contralateral side than on the surgically treated side and some stiffness of the hip joint were always given a shoe lift that was 0.5 to 1 cm shorter than the true limb-length difference in order to aid in foot clearance.

Ten patients had malalignment that was not directly related to the hip joint but rather was in the knee or foot and resulted in pain or an abnormal gait. Two patients with a pronated foot on the surgically treated side were treated with a medial wedge and corrective footwear that improved the gait and reduced the pain in the foot. Two patients had substantial genu varum on the contralateral side, which was corrected with a high tibial osteotomy in one and with a total knee arthroplasty in the other. Five patients had substantial ipsilateral genu valgum. Three of them also had substantial abductor weakness and, as a result of positioning of the trunk over the foot in order to reduce the abductor lurch, the lateral knee pain was considerably increased. As the abductor lurch was reduced with improvements in strength, the lateral knee pain was reduced as well. The other three patients had no resolution of symptoms; substantial pain in the lateral compartment continued. Two patients had an osteotomy of the distal part of the femur to correct the mechanical axis,

Fig. 9

The customized knee device was used to increase the range of knee extension and to eliminate a knee flexion contracture. The patient lies supine with the knee extended. The brace is applied with tension produced by a Theraband in a figure-of-eight fashion to create a knee extension moment and a sustained end-range stretch of the posterior knee structures. Patients used the device three times a day for thirty minutes each time, before physical therapy. In some recalcitrant cases, the device was used for an extended period of time, for up to eight hours in total.

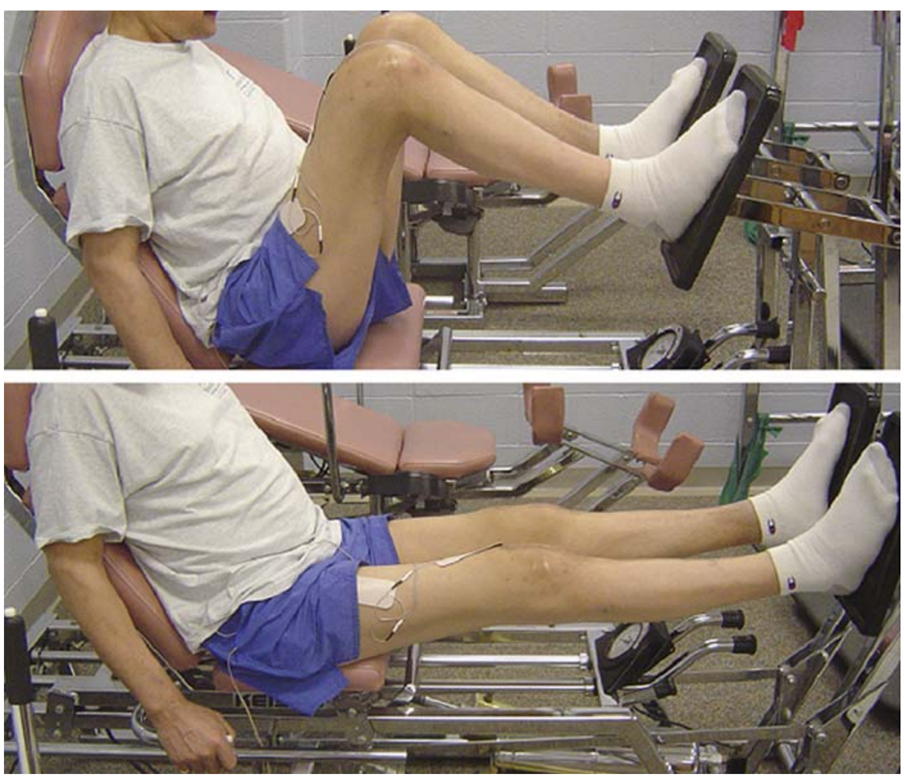

Fig. 10

Closed-chain exercise for improving concentric and eccentric quadriceps strength. This exercise promotes full knee extension to train proper gait, helps to gain knee flexion, and provides proprioceptive input.

Fig. 11

The custom knee device that is used to improve knee flexion. The patient sits while a posterior force from the elastic tubing maintains maximal knee flexion for thirty minutes, two to three times per day. Note the use of a cylindrical tube to achieve a flexion force perpendicular to the tibia.

and one patient used an off-loader brace and was satisfied with the outcome.

Treatment of Problems Following Total Knee Arthroplasty

We identified five types of impairment that resulted in substantial dysfunction following total knee arthroplasty. A knee flexion contracture was found in twenty-three of the fifty-one patients. The causes of the knee flexion contracture were preoperative loss of motion with muscle-shortening, previous surgery with exuberant scar formation, knee effusion resulting in pain and quadriceps inhibition causing hamstring overactivity, unrecognized gastrocnemius tightness, a limb-length difference with the side of the total knee arthroplasty being longer and resulting in a flexed-knee posture, periarticular remodeling, joint subluxation, and peroneal nerve entrapment.

Our preferred method for treatment was aggressive and customized. All patients with a knee flexion contracture were assigned to be treated with our aggressive regimen, which was carried out five times a week for the first few weeks. In addition, they were all fitted with a customized knee device that we had developed[5]. This device allows knee-extension positioning with use of a Theraband attached in a figure-of-eight fashion to produce an extension moment at the knee (Fig. 9). We used polyester-based casting tape (Dynacast PII; BSN Medical, Charlotte, North Carolina) to fabricate the splint. This material is lightweight and conforms well. At the same time, it is rigid enough to transmit optimal force. Patients wore the customized knee device at maximally tolerated tension for thirty

Fig. 12

The joint mobilization technique to improve knee flexion. Posterior glide of the tibia on the femur mobilizes the knee with the patient prone. This mobilization directly addresses tight structures and increases the range of knee flexion.

Fig. 13
Rectus femoris stretch with inferior patellar mobilization. This technique promotes true elongation of the quadriceps without increasing joint contact forces of the patellofemoral joint. It also reduces pain during flexion mobilization.

to forty-five minutes three times a day. The heel was propped up on a pillow to utilize gravity and promote knee extension with the patient in a long-sitting or supine position.

In addition, we used an aggressive adjunctive therapy consisting of application of moist heat and soft-tissue mobilization at the posterior aspect of the knee (at the distal hamstring insertion and the proximal gastrocnemius insertion) with the patient prone and the knee in maximal extension. Anterior-posterior joint mobilization of the femur while the patient was in the supine position, and the proximal part of the tibia was supported by a bolster, was used to promote end-range knee extension. Gastrocnemius stretching with the patient supine, the heel propped, and the knee in maximum extension was also used. Neuromuscular electrical stimulation involved applying electrodes to the quadriceps over the vastus medialis obliquus fibers, and over the proximal part of the vastus lateralis. It was used for twenty to thirty minutes with a five-second on-time and a fifteen-second off-time and a waveform at 70 to 90 pulses per second with 400-microsecond pulse duration. The intensity of the stimulation was the maximum that could be tolerated[6]. We instructed patients to complete a quadriceps set when the electrical stimulation was active. Closed-chain weight-bearing exercise with use of a leg-press to promote end-range knee extension was also utilized (Fig. 10).

The majority of the patients responded well to this regimen, but we used Botox injections into the hamstring and gastrocnemius muscles to reduce muscle spasm in two patients. This resulted in the resolution of symptoms, and aggressive therapy could continue. Three other patients were not doing well because of persistent effusions of the joint, and they responded to the vigorous physical therapy and bracing only after aspiration of the joint followed by intra-articular injections of 1 mL of triamcinolone with 4 mL of 1% lidocaine. One patient underwent arthroscopic lysis of adhesions followed by a continuous epidural block and continuous passive motion with aggressive manual therapy to increase knee extension. This patient went on to have a persistent knee flexion contraction of 5° but was functioning well. Another patient in this group did not respond to any of these interventions and chose to have a revision total knee arthroplasty and scar-tissue release.

As stated, our treatment regimen for flexion contracture was successful in the majority of cases. It was aggressive to address joint positioning with careful assessment of joint subluxation (if any) and use of an anterior drawer maneuver to mobilize the knee into extension. A customized knee device was used for prolonged knee-extension positioning at home and sometimes at night. Aggressive mobilization of the joint and electrical stimulation of the quadriceps muscle were used to increase the passive range of motion achieved with active extension. Gait training was employed to improve active heel strike at initial contact once the flexion contracture had resolved, and any limb-length difference was managed with an appropriate shoe lift (used for two patients).

Knee flexion deficits (<90° of flexion) resulted in functional deficits in the ability to ascend and descend stairs, rise from and sit in a chair, sit for a prolonged period of time, and

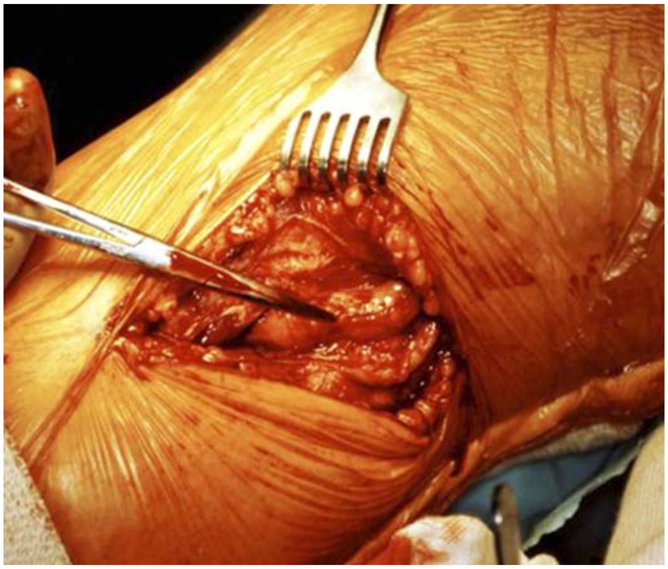

Fig. 14
Peroneal nerve release to decrease peroneal nerve symptoms so that the patient can gain functional knee extension.

sexual activities. These problems were mainly related to tightness of the rectus femoris, patellar tracking problems, and tightness or inflammation of the patellar tendon. Four patients in this group required manipulation under anesthesia followed by aggressive physical therapy to improve knee flexion. We also devised a customized knee device to increase knee flexion (Fig. 11), as we had to increase extension. The patients were instructed to use the device for thirty to forty-five minutes three times a day to improve knee flexion. In addition, careful knee joint mobilization with posterior glides of the tibia (Fig. 12), inferior patellar mobilization (Fig. 13), and mobilization of the quadriceps tendon and the patellar tendon were all techniques that were applied to increase knee flexion. Treatment with physical therapy and customized bracing alone was successful in five of the nine patients. The other four patients required manipulation under anesthesia as outlined above, and one of the four also required arthroscopic lysis of adhesions. With this combination of invasive and noninvasive modalities, all of the nine patients had an increase in knee flexion and most had an increase of at least 30°.

We defined quadriceps weakness as either an active extension lag of >15° or quadriceps strength, in the available range of motion tested isokinetically, that was <50% of that on the contralateral side. For patients with quadriceps weakness, we used the muscle-stimulation protocol to augment the muscle contraction during strengthening. This regimen is more effective than are voluntary contractions alone, presumably because of the neural overflow produced by the electrical stimulation. Use of this regimen improved quadriceps strength in most patients.

Three patients had peroneal nerve entrapment resulting in a lack of knee extension. These patients had no frank motor involvement except for mild weakness of the extensor hallucis longus in one patient. Knee extension made the foot pain worse, and knee flexion made it better. Sensory testing with use of a pressure-specified sensory device and additional testing with electromyography in both the extended-knee and the flexed-knee position were used to test the sensitivity of the peroneal nerve at the fibular head. Frank electromyographic changes with knee extension or substantial clinical symptoms were present in these three patients. Two underwent surgical release (Fig. 14), and one responded well to medications. Two patients with sciatica had less severe symptoms and could be treated with medications; the symptoms resolved within three months. A saphenous neuroma was found in two patients. One underwent excision of the neuroma followed by release of scar tissue and had an excellent outcome. The second patient refused further treatment for this problem.

Three patients had planovalgus malalignment of the foot, which resulted in maltracking at the knee. The changes in the pressure distribution on the foot were managed with appropriate shoe modifications, and all three patients had substantial improvement of gait and decreased pain after that intervention. One patient had ligamentous laxity of the knee, which required a revision total knee arthroplasty with an adjustment in the height of the spacer. This patient eventually had 0° to 110° of motion with a substantially improved gait pattern.

Overview

Overall, our aggressive, customized, invasive and noninvasive treatment protocols that addressed limitations following total hip or knee arthroplasty reduced symptoms and restored function in 92% (108) of the 118 patients in the series. The 8% for whom this treatment failed required a major surgical intervention.

Although such an aggressive regimen is not required following most total hip and knee arthroplasties, some patients do require, to a lesser degree, a structured program. A careful physical examination of selected patients can help the clinician to identify specific physical findings and impairments, which can then be treated with the noninvasive or invasive therapeutic modalities described above. ■

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