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REVIEW

LOWER LIMB DEFORMITY AND TOTAL KNEE REPLACEMENT

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Abstract

As the population becomes more active and life expectancy increases, gonarthrosis has proportions of epidemics. Total knee arthroplasty (TKA) is an intervention that decreases pain and gives the patients the possibility of quickly returning to the desired level of activity. It is an intervention with a patient satisfaction rate of about 90-95% with a survival of the implant over 15 years of 90%.

When dealing with TKA the following elements should be taken into account: clinical examination (walking analysis), leg deformities and knee alignment (foot deformation management), posterior tibial tendon dysfunction, cavovarus foot, posttraumatic deformity, neuropathic arthropathies, ankle arthrosis, foot deformities and knee arthroplasty.

Ankle or foot deformity may be causes of progression of gonarthrosis or a TKA failure. Post-operative alignment of TKA is an extremely important element in the long-term survival of the prosthesis.

By improving biomechanical alignment of the complete pelvic limb, TKA survival and patient satisfaction will increase.

Keywords: TKA, gonarthrosis, pelvic limb alignment, leg deformities

Introduction

The population becomes more active and the life expectancy increases, so that the number of patients subjected to total knee arthroplasty also increases. In countries such as the United States of America, gonarthrosis has the proportions of an epidemics, one in three adults will be diagnosed with gonarthrosis by 2030 [1]. Although the number of patients increases considerably, the number of surgeons willing to perform a knee arthroplasty decreases [1].

Total knee arthroplasty (TKA) is an intervention that decreases pain and gives the patients the possibility of quickly returning to the desired level of activity. It is an intervention with a patient satisfaction rate of about 90-95% with a survival of the implant over 15 years of 90% [2,3]. Patients younger than 55 years old fall into the same statistics [4]. Approximately 15-20% of the patients will get important dysfunctions that cannot be managed with drug or recovery therapies and often require revision of arthroplasty [5]. Some studies show that nearly half of the revisions are performed in the first two years after implantation per primam [6]. 50% of these are due to malposition of components, instability, and early defixation. Symptoms precursor to an early revision are pain, volume increase, stiffness, deformity, and instability. X-ray investigation may reveal: defixation, polyethylene destruction or osteolysis [7]. These may be secondary to an infection, malrotation of a component or osteolysis. Recent literature does not take into account the deformations of the distal pelvic limb from the knee. Pain present before arthroplasty may suggest an extrinsic cause, dependant on a deformity of the lower limb [8]. Discovery of an ankle or leg deformity and its surgical treatment, which presupposes the relaxation of the pelvic limb, may lead to the improvement of implant survival and better clinical results.

Clinical examination

The clinical examination of the knee must include a full history of the onset of pain and a precise description of the trauma production mechanism that led to pain installation. The active and passive movement of the knee should be assessed, the patellofemoral joint and a careful neurovascular examination with the verification of quadriceps and gastrocnemius muscle strength. Active and passive knee movement, femoral-patellar joint, and careful neurovascular examination with quadriceps and gastrocnemius muscle strength testing. Finally, clinical examination should evaluate the lower pelvic limb in resting position, in loading. Both pelvic limbs should be examined with the patient in orthostatism. Thus, a deviation in varus or valgus can be estimated by goniometry or a shortening of one of the lower limbs can be noticed due to an excessive deviation.

After the clinical examination, an X-ray of lower pelvic limbs in loading, a lateral and an axial incidence of the patellas should be performed. The femorotibial angle (varus/valgus), which is normally 60 to valgus, can be calculated with the aid of the X-ray of lower pelvic limbs in loading. This valgus will lead to a 60% loading of the internal compartment and a 40% loading of the external compartment [9]. This angle based on mechanical axes is the best tool and represents the gold standard for the evaluation of the knee deflection [10]. Hip-knee-ankle alignment contributes to the distribution of forces at the medial and lateral joint surfaces during loading [11]. In a neutral alignment of the knee (0-20 to the varus), the medial compartment will be loaded with 60-70% of the forces during loading and the mechanical axis will pass through a point between the tibial spines [12]. In a knee deflected to varus, the axis will pass medial to the knee and will raise the forces at the level of the internal compartment [13]. On the opposite side, in a knee deflected to valgus, the external compartment will be more affected.

Walking analysis

Prior to total knee arthroplasty it is very important to evaluate the patient's walking. A careful assessment of walking can answer questions about the etiology of deformities. The normal walking cycle consists of two phases, the support phase or "stance" and the balance phase or "swing" for each lower limb. A single cycle is the movement between the heel strikes between two successive steps of the same foot. A cycle represents a resting phase and a balance phase of the same foot. The resting phase is the cycle loading phase, representing 62% of a cycle and lasts from the moment of the heel strike to the moment of toe-off. The swing or return phase is 38% and takes place from the toe-off moment to the heel strike. The "stance" phase consists of three stages: the heel strike, flatfoot phase, and heel rise [14]. There are two periods during walking when both legs have contact with the ground (from 0% to 12% and from 50% to 62% of the walking cycle) that are divided by an unipedal support period (12-50%) [15].

While walking, its asymmetries should be analyzed, with increased attention to the knee, back of leg, medial and anterior leg. Physiologically, loading of the pelvic limb starts from the lateral side of the calcaneus on the moment of heel strike and ends with the push-off stage of the great toe. The heel strike is the moment the foot absorbs the shock and the rest of the time, an adaptation of the leg for different surfaces appears. When the foot absorbs the weight of the body, the back of the leg is deviated in valgus while the calcaneus is passively deviated in eversion and the longitudinal vault flattens, both movements aiding in unlocking the tarsus joints [16]. To properly perform the "swing" phase, the patient requires a good flexion of the knee and hip to raise the leg and the support leg will go through eversions due to the swing phase of contralateral limb. At this moment, the medial leg will undergo inversion and the tarsus joint will stiffen and stabilize [17]. The final period of the "stance" phase will be a weight transfer on the opposite limb. At this point, the subtalar joint will continue the inversion movement, the longitudinal vault will be raised to a maximum and the tarsus will be even more rigid for the "toe-off". The posterior tibial tendon helps the subtalar inversion and the lifting of the calcaneus.

Leg deformities and knee alignment

Most gonarthrosis are the result of degenerative osteoarthritis and have a degree of instability, deformation, contracture, or a combination of these elements. Abnormal rotations in a joint will lead to increased forces in the proximal and distal joints. Deformities are a predictive factor for the progression of gonarthrosis and the postoperative alignment plays a crucial role in the long-term survival of arthroplasty [18]. Excessive loading of a tibial plateau secondary to positioning, limb alignment or lack of ligament balance is associated with the loading of tibial edges, bone collapse and component loosening [19]. A study of Berend et al. shows that posterolateral subluxation is associated with preoperative valgus [20]. The plano-valgus foot along with a genu valgum leads to a rotational imbalance and failure of arthroplasty [21].

Bhave, Mont et al. showed that 6% of the functional knee problems after arthroplasty are secondary to ipsilateral foot deformities [22]. These deformities include plano-valgus foot, cavovarus foot deformity, muscle contractions, gastrocnemius contractions, unconsolidated fractures, ipsilateral arthrosis and neuropathic arthropathies (diabetic). Deformities in the ankle or leg can lead to knee dislocation, progressive knee deformity, increased wear and loosening, all resulting in pain and patient's inability to move [23]. The medial compartment is the most affected when we have a focus on varus, this increasing the progression of gonarthrosis 4 times and the progression of the disease 2-5 times for the lateral compartment deviation in valgus [24]. For these reasons, biomechanical focus of the knee after the TKA is required, with the placement of the components between +/- 3° to the mechanical axis to prevent the early degradation and to increase the survival rate of the implant [25]. In patients with significant changes in the lower pelvic limb kinematics, the use of over-stabilized prostheses can lead to increased loosening rates, polyethylene destruction and osteolysis [26].

Lidtke et al. have shown that there is a correlation between foot deformities and gonarthrosis [27]. They showed that plantar pressure in patients with gonarthrosis of the internal compartment shows a higher loading on the lateral side of the leg during the support phase ("stance" and "mid-stance" phases) of walking compared to the control group, suggesting that the ways of loading of the leg are correlated with gonarthrosis. Another study suggested that the level of disability increases when a foot deformity is associated with gonarthrosis [28]. They analyzed 115 women with gonarthrosis and leg deformity including the flat foot and hallux valgus. WOMAC and VAS scores were worse in patients with foot deformity and found a correlation between the degrees of deformity. They concluded that the presence of a painful leg increases the level of disability in patients with gonarthrosis. Another study have demonstrated that foot alignment and rotation are important factors in the evolution of gonarthrosis but not coxarthrosis [29].

Foot deformation management

Progression of the disease in patients with gonarthrosis and lower pelvic limb deformity can be stopped by various therapeutic means [30]. Misalignment is associated with disease progression but is also synchronic with other risk factors such as obesity, cvadricipital force, laxity, and advanced stages of the disease. In conclusion, the orthopedic treatment consists of weight loss, shoe modification, and physiokinetotherapy aimed at cvadricipital force, ankle and foot mobility, stabilization. In the initial stages of the deformity of the foot with a crashed plantar vault but not rigid, a shoe insert can be worm that will lead to a decrease of the loading forces in the affected knee compartment. Patients with gonarthrosis are encouraged to lose weight and do exercises to maintain or strengthen the cvadricipital force, but it is not advisable to wear shoe inserts in case of associated foot deformities due to lack of sufficient evidence [31].

Following the failure of orthopedic treatment, surgical treatment is recommended, which may include tendon transfers, osteotomies, arthrodesis or arthroplasty in order to restore leg alignment and pain decrease. Treatment is specific for each deformity. All these interventions are technically difficult and require a relatively long recovery period.

Posterior tibial tendon dysfunction

The flat foot has several names that describe the same pathology: plano-valgus foot, calcaneovalgus, or crashed plantar vault. Dysfunction or insufficiency of posterior tibial tendon may have several causes, such as chronic degeneration, rheumatoid arthritis, degenerative joint diseases, posttraumatic arthroses, Charcot arthropathy. Most patients develop deformity over a long period of time without pain in the medial or lateral side of the medial leg. The crash of plantar vault is more common in female patients in the 4-6 decade, obese and hypertensive. In a study published by Sharkey et al., it resulted that although the incidence of the flat foot in the general population is not certainly known, it has a 25% prevalence in TKA revisions [32]. The deformation in valgus of the medial leg is common and disabling in patients with rheumatoid polyarthritis, being estimated that 89% of the patients with rheumatoid polyarthritis present foot deformities. Between 13% and 64% of these patients will develop insufficiency of posterior tibial tendon [32]. Brower et al. compared gonarthrosis patients with healthy subjects and showed that patients with knee arthrosis had a subtalar joint with a more pronounced inversion [33]. Genu valgum seems to accentuate the flat foot.

The posterior tibial tendon passes posterior to the ankle and medial to the subtalar joint and acts as a plantar flexor of the ankle, produces the inversion of medial leg and lifts the plantar vault medially. In normal foot, contraction of the posterior tibial will result in blocking the mediotarsal joint in varus so that the "stance" phase of walking is possible. The rigidity of mediotarsal joint will facilitate the "push-off" phase needed to propel the body forward during walking.

Cavovarus foot

When the leg and the ankle are in excessive supination, the axis representing the loading force will pass medially. This will increase the stress forces on the lateral side of the ankle and foot, that will increase tensions of long peroneal muscles tendon leading to plantarization and I ray flexion [34]. The muscular imbalance creates a more rigid leg that will lead to the distribution of forces to 1st and 5th metatarsals and to a weakly distributed "ground reaction force". These changes predispose the leg to sprains, peroneal tendinitis, varus knee deformity, and trochanteric bursitis. The Coleman test should identify the origin of the deformity: in front of the leg or medial leg and thus establish the surgical treatment. If the subtalar joint is flexible, the cavus can be corrected from the front of the leg [35]. The surgical techniques for cavovarus are partial plantar fasciotomy, transfer of long peroneal muscle on the short one, lateral and/ or closing wedge calcaneal osteotomy, closing, and dorsiflexion 1st metatarsal osteotomy, corrections of claw toes.

Posttraumatic deformity

Some patients may have a history of low pelvic limb with secondary deformity that may affect the knee. Fractures that heal with pseudarthrosis or non-consolidation with axis deviation in saggital or coronal plane may lead to the increase of forces at the knee or ankle level. Deformity must be corrected in order not to overload superior and subjacent joints so that progression of degenerative changes is slowed.

Neuropathic arthropathies

Charcot arthropathy (neuropathic arthropathy) is the final stage of the diabetic foot. It is known that this pathology affects 2% of diabetics, but the number of patients presenting with diabetic Charcot foot is increasing due to the increase in the incidence of diabetes [36]. Patients with diabetes additionally have systemic comorbidities due to diabetes. The patient loses sensitivity of the foot and the soft tissues are affected. Due to loss of sensitivity, patients will not feel certain trauma. In advanced stages, patients experience severe skin problems and significant bone deformities. Diabetic neuropathic arthropathy can lead to severe deformities that may compromise the TKA result.

Although a large number of diabetic patients develop the Charcot foot, they often stay active and want to perform their daily activities at a high level. Deformity in coronal plane is poorly tolerated and these patients cannot wear cast devices for immobilization. The significant loss of bone structures makes the surgical treatment not the optimal solution. TKA must be well focused and balanced in order not to worsen the deformities of the foot.

Ankle arthrosis

Ankle arthrosis as opposed to the hip or knee arthrosis is in 70% of the causes secondary to a trauma [35]. Moreover, it has 1/ 3 of the contact surface and is subjected to forces three times higher compared to the hip or knee [36]. Ankle arthrosis can become debilitating and cause changes in walking that will afterwards affect the knee on the same side. When conservative treatment fails, ankle arthrodesis is the gold standard for advanced arthrosis, particularly painful in young active patients. Ankle arthrodesis should be performed at 50 of the valgus and external rotation and in a plantigrade position with the talus placed below the tibia. This position maximizes the compensating potential of subtalar joint and Chopart joint for a normal walking without affecting the knee or leg. In this position, the loading axis will pass medially of the calcaneus, which will lead to the relaxation of the lateral collateral ligaments of the ankle. Excessive external rotation of arthrodesis will lead to medial laxity of the knee [37]. In case there is an unstable knee, as a result of a weak extensor, arthrodesis should be performed in 7-100 flexion to provide more stability [38]. Increased plantar flexion, of more than 100, will favor a genu recurvatum. Recent studies show that the long-term durability of ankle arthrodesis is low and that it favors the appearance of medial leg arthrosis [39].

Foot deformities and knee arthroplasty

Order of correction

In the current literature there are many controversies regarding this subject, current recommendations are to treat the joint with more significant symptomatology [37]. It is recommended solving a deformity from the initial level of the foot to diminish the stress on the prosthesis. It is suggested to perform the TKA before any other deformity because after the proper correction of the biomechanical alignment, the alignment between the ankle or the foot and the ground will be modified. If ankle or foot surgery is required, the reconstruction can be done having the biomechanical alignment as a landmark, correctly restored after TKA.

Conclusions

Ankle or foot deformity may be causes of progression of gonarthrosis or a TKA failure. Post-operative alignment of TKA is an extremely important element in the long-term survival of the prosthesis. Although current literature does not consider that ankle or foot misalignment may be a cause of TKA failure, these should be carefully examined and analyzed along with patient walking and correct alignment. Progression of gonarthrosis or TKA failure is based on many factors, including a change in biomechanical alignment of the complete lower pelvic limb, ligament imbalance, and instability. By improving biomechanical alignment of the complete pelvic limb, TKA survival and patient satisfaction will increase. Proper biomechanical alignment of the pelvic limb will lead to a decrease in the number of revisions and subsequently reduce the morbidity and mortality rates of this expensive intervention. In case of an association of deformities, the knee should be the first operated and subsequently a medial leg deformity with a properly aligned TKA.

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