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Original article

Varus-valgus constrained implants in total knee arthroplasty: indications and technique

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Summary. Total knee arthroplasty is a successful operation that significantly improves patient's quality of life. However, studies demonstrated as only 82% to 89% of patients are satisfied with their surgery, being the other disappointed with regard to their expectations. Two to 5.7% of total knee arthroplasties (TKAs) require revision within 5 years. Both complex primary cases and revision TKA often necessitate for a higher degree of constrain than cruciate retaining or postero-stabilized implant design. In the 1970s varus-valgus constrained (VVC) or semi-constrained implants have been developed by Insall and associates from the PS design, which provide varus-valgus stability preserving a fair amount of host bone. VVC TKAs allows for a small amount of movement in the coronal, antero-posterior and axial planes. In this paper, the authors give an overview of the indications, outcomes and technique for varus-valgus constrained implants, both in the setting of primary and revision knee arthroplasty**.** (www.actabiomedica.it)

Key words: varus-valgus constrained, semi-constrained, constrained non-linked, TKA

Introduction

Knee osteoarthritis (OA) is common condition, with a prevalence of 19% (14) to 28% (21), and characterized by pain and functional limitation. Total knee artrhoplasty (TKA) has shown to be an effective treatment for pain relief and restoring function (7, 18, 35). However studies demonstrated as only 82% to 89% of patients are satisfied with their surgery, being the other disappointed with regard to their expectation (6, 34, 41). Two to 5.7% of total knee arthroplasties (TKAs) require revision within 5 years (5). When looking at the causes of failure, aseptic loosening accounts for 31.2%, followed by instability (18.7%), infection (16.2%), polyethylene wear (10.0%), arthrofibrosis (6.9%) and malalignment (6.6%) (27).

Therefore instability is considered the second cause of implant failure and, among the causes of instability after TKA, there are surgical errors and poor design selection.

Implant designs show a various degree of constrain, ranging from posterior stabilized prosthesis (PS) to rotating hinged implants (RH).

PS implants do not provide for varus-valgus stability, therefore they are not suitable for revision arthroplasty when instability is present and for difficult primary arthroplasties when severe deformity is present and collateral ligaments are insufficient. In the 1970s varus-valgus constrained (VVC) or semi-constrained implants have been developed by Insall and associates from the PS design, which provide varus-valgus stability preserving a fair amount of host bone (13). However for severer instabilities VVC maybe insufficient and it would be necessary to increase the level of constrain to a hinged implant, in which the tibia and femur components are connected by an axle that limits the varus-valugs and anterior-posterior translations.

Generally the least amount of constrain should be chosen, in fact although increasing the constrain improves stability, it allows for less range of motion,

increases stress at the bone-cement-implant interface and sacrifices larger amount of bone stock (32, 33). It is the authors' aim to provide an overview of the indications, outcomes and technique for varus-valgus constrained implants, both in the setting of primary and revision knee arthroplasty.

Implant design

VVC implants derive from the posterior stabilized design in which the tibial post is taller and larger with a deeper femoral box. This allows for a small amount of movement in the coronal, antero-posterior and axial planes. VVC implants among the most popular provide about 2° to 3° of varus- valgus stability and ± 2° of rotation (19, 33). However, conversely to the hinged designs, the tibial and femoral components are not linked. Similarly to the PS design, VVCs suffer the potential risk for post and cam dissociation in case of severe flexion instability (32).

Further VVCs limits are the need for removing a wider amount of femoral intercondylar bone and potential higher risk for aseptic loosening, resulting from increased constraint (30, 38). VVCs are usually considered to be less constrained than RHK. This is true for the coronal and antero-posterior planes, but not for the axial plane. In fact RHKs have more rotational freedom than VVC implants, and finite element analysis showed lower contact shear stress and a more uniform von-Mises stress resulting into lower polyethylene stress compared to VVC (40).

Indications

Primary total knee

Usually the need for a constrained implant over a PS or a CR implant is infrequent. However, it maybe necessary to increase the constraint level to achieve the proper knee stability in complex primary cases. Severe deformities in which soft tissue release does not provide for symmetric balance, severe bone loss and incompetent medial collateral ligament are the traditional indications (13,17, 20, 42). Further relative indications are reported in literature (table 1).

Total knee arthroplasty revision

Most commonly, VVC are used in the total knee arthroplasty revision setting. Independently from the cause of failure of the primary implant, insufficient bone stock and consequent need for augments and stems, inadequate collateral ligaments, flexion contracture are common indications for choosing a constrained implant (44).

Instability after total knee arthroplasty represents one of the most common causes of failure. Identifying the reason for instability is paramount, and a thorough history and physical examination and appropriate radiological studies are essential to draw a diagnosis.

Table 1. Indications to VVC implants in primary TKA. ROM: range of motion; MCL: medial collateral ligament

Indications to VVC in primary TKA
Valgus deformity with incompetent MCL (25)
Bone defects (17)
Severe flexion contracture with inability to balance the knee (24)
Varus-valgus laxity > 5mm throughout the whole ROM (31)
Extra-articular deformity (11)
Incontrollable flexion-extension imbalance (17)
Rheumatoid arthritis (which usually leads to valgus deformity with an incompetent MCL) (17)
Sequelae of poliomyelitis (16)
Neuropathic arthropathy (22)

The patient should be carefully evaluated looking for pain localization and sense of instability, and onset of symptoms. Moreover details about the postoperative should be asked (wound complications, rehab) as well as previous x-rays, which will give information about pre-existing deformities and original indication for surgery. Besides local conditions, global causes such as neuromuscular disorders or hip or ankle deformity should be considered (9, 37).

The onset of instability gives crucial information on the possible cause: early postoperative instability maybe secondary to malalignment, unbalanced ligaments or iatrogenic ligament injury. Late postoperative onset could be linked to asymmetric polyethylene wear or, in case of CR implants, posterior cruciate ligament insufficiency (9, 36, 37). Patient's examination will include gait evaluation, varus-valgus stress test both in extension and in flexion (30° and 90°) (36). X-rays study should necessarily includes standard weigh bearing AP and lateral views, but also full length hip-to-ankle view, varus-valgus stress views and skyline view (15). CT scan is often useful to investigate components malrotation issues (23).

Instability has been traditionally classified into 3 patterns: flexion, extension and genu recurvatum (9, 36, 37). In more recent years, a fourth type of instability has been described: the mid-flexion one (39, 45).

Acute flexion instability is usually secondary to a neglected intraoperative lesion to one or more lateral ligaments, in the attempt to balance a valgus knee (10, 43). In those cases, according to the degree of instability either a VVC or a hinged implants is suggested (29). Chronic flexion instability is due to an increased tibial slope or a reduced posterior off-set. This causes the tibia to anteriorly translate during knee flexion. In this instability pattern, it is essential to restore balance between the flexion and extension gaps, either by a PS or a VVC implant (1).

Extension instability can be further divided in symmetric and asymmetric. The symmetric one is the results of an excessive bone removal from either the distal femur or the tibia. This latter condition is easier to manage, in fact changing the polyethylene for a thicker one will restore stability. Distal femur over-resection leads to what is now recognized as mid-flexion instability, although further causes have been progressively identified. Overall, this pattern typically shows coronal instability when the knee is beyond 30° of flexion. To compensate over-resection of the distal femur, it is necessary to use implants with augments on the femoral component (36, 46). Asymmetric extension instability follows undercorrection of preoperative coronal deformity or inadequate release of the soft tissues. Revision surgery is necessary to restore the alignment and balance the ligaments. According to the ligaments status, a VVC maybe necessary (36, 46).

Recurvatum is often the results of a compromised extensor apparatus (typically polio patients). Only a hinged implant will control the hyperextension, although the huge forces on the axle will often cause failure of the prosthesis.

Outcomes

First generation of VVC implants showed up to 97.6% of survivorship at 10 years follow-up (31). However, because of the implant design, it was associated with a high rate of patellar complications (maltracking, fracture and osteonecrosis) (24). Since the second generation came out, the rate of patellar complication significantly plummeted (47).

For primary VVC implants with a mean 12.7 years follow-up, Cholewinski et al (8) reported no cases of osteolysis or aseptic loosening, and HSS, KSS knee, and KSS function scores were 80,90 and 61 respectively.

Satisfactory results have been similarly reported for VVC implants in revision TKA. Luque et al. reported an overall survivorship of 92.7 %, at 24 months, 87.8% at 60 months and 87.8% at 96 months. Moreover clinical and functional results were 68.24 points for KSS clinical and and 63.85 for KSS functional, and overall the KSS was excellent or good in 72.9 % of the patients. Interestingly, the authors performed an analysis of factors that are associated with poor survival of the revised implants. Those were: 1. patients younger than 70 years, 2. rheumatic diseases or kidney failure, 3. tibial tuberosity osteotomy, 3. PS primary arthroplasty, 4. replacement done before five years, 5. septic failure (28).

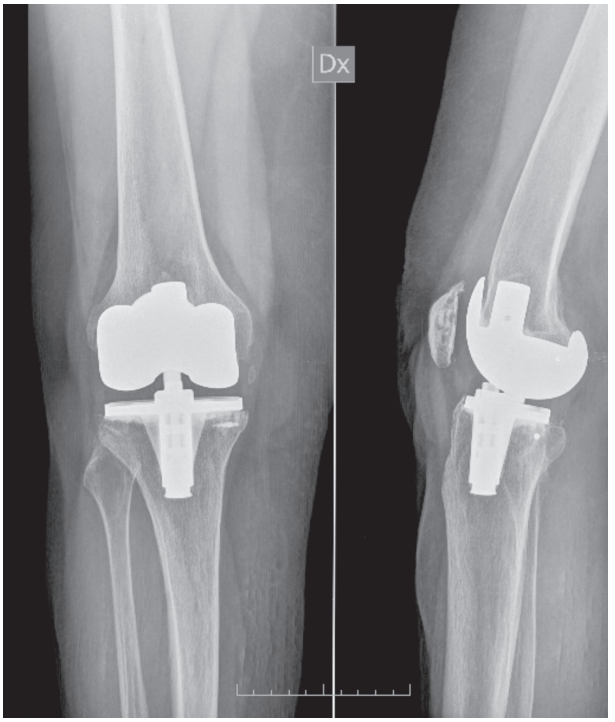

Figure 1. AP and Lateral x-rays, right knee. Severe valgus knee addressed with VVC implant type without stems (LCCK, NexGen, Zimmer). Since the MCL was insufficient, it was firstly attempted its repair with a small joint anchor on the medial tibial plateau. However, the surgeon was not completely satisfied with the valgus stability, therefore he switched from a PS to a VVC implant, with a CCK type polyethylene and no stems

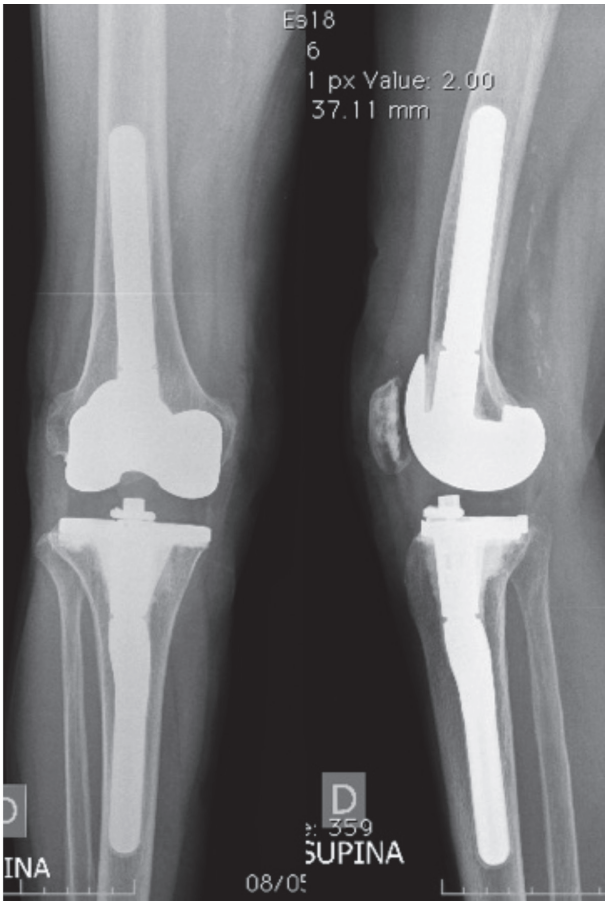

Figure 2. AP and Lateral x-rays, right knee. VVC implant type with stems (LCCK, NexGen, Zimmer). Although it was a revision TKA, the varus-valgus stability was found to be optimal, therefore a PS type polyethylene was used

Surgical technique

Concerning the correct choice of the implants, either in the primary setting or in the revision one, back in 2002 Robert Barrack proposed four criteria that should be followed when adopting VVC implants: flexion-extension gap balance within 5 to 10 mm, joint line restoration within 10mm, reproduction of the antero-posterior diameter of the femur within reasonable limits, and some degree of collateral ligament stability (4).

Whether using intramedullary stems in primary TKA is controversial. Some studies recommend them (12, 30) while others showed comparable results without stemming the implants with the advantages of decreasing the risk of fat embolization acutely and stem tip pain chronically (2, 3, 12). Furthermore, in those revision cases in which the medial and lateral soft tissue restraints to varus-valgus instability are still competent, it is possible to use a VVC implant with a PS polyethylene with satisfactory outcomes (26) (Fig. 1 and 2).

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