An Overview about Management of Tibial Bone Defects in Varus Deformity

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Conflict of interest: None declared
Funding: No funding sources

Abstract
A variety of management alternatives exists for bone deficiencies encountered at the time of TKA. The alternatives for management include increased bone resection, translation of the component away from the deficiency, filling the defect with cement with or without reinforcing screws or mesh, bone grafting, and metal augmentation. Bone resection is quick and easy option but it should be reserved for shallow defects because deep proximal tibial resection places the tibial component on relatively weak cancellous bone, danger of compromise of important ligament attachments, both gaps are increased, requiring a thicker tibial component for stability which will alter the patellofemoral kinematics and finally Sizing problems will likewise occur because of the diminished cross-sectional area as one progresses down the tibia distally . For defects larger than 10 mm depth, alternative methods of fixation probably should be used.

Keywords: of tibial bone defects, varus deformity

Tob Regul Sci. ™ 2023;9(1): 633-641
DOI: doi.org/10.18001/TRS.9.1.47

Introduction:

Peripheral bone defects of the medial tibia are frequently encountered in primary total knee arthroplasty (TKA) for varus knees [1]. Stable placement of components is difficult in these cases and thus presents technical challenges for the surgeon. Countermeasures for bone defects include increased bone resection, lateralizing of the tibial component, cement filling, bone grafting, metal augmentation, and the use of custom-made prostheses [2].

Metal augmentation is currently one of the most common countermeasures for bone defects [2]. Although wedge-shaped augmentation was previously preferred, this trend regarding the shape of metal augmentation changed to the rectangular block-shaped augmentation following a report by Fehring et al., which revealed that metal block augmentation could directly transmit torsional loads as a result of geometric interlock and could reduce cement mantle strains between the tray and tibial plateau [3]. However, to our knowledge, there has been only one clinical report of metal block augmentation during TKA [4], and that study had a major limitation of not including a control group. Although a high rate of radiolucent lines beneath the metal wedge has been reported [1,5,6], the rate of radiolucent lines beneath block-shaped augmentation has been unclear.

We evaluated clinical and radiographic outcomes of primary TKA combined with metal augmentation for bone defects and compared the clinical outcomes with those of standard TKA without bone defects. In addition, we investigated the frequency and risk factors for the development of radiolucent lines. We hypothesized that (1) clinical results were similar for TKA with and without metal augmentation and that (2) the radiolucent line beneath the tibial tray was not rare in metal-augmented TKA.

For primary TKA during the study period, we selected a posterior-stabilized cemented TKA prosthesis (Scorpio nonrestrictive geometry, Stryker Orthopaedics, Mahwah, NJ, USA). In cases where tibial bone defects were expected, we prepared modular prostheses (Scorpio total stabilizer, Stryker Orthopaedics). The decision to select the modular prosthesis was finally confirmed by intraoperative findings. We performed metal augmentation when the bone defect after bone cutting comprised an area of more than 60% of a single condyle to a depth of over 5 mm; when the defect was smaller than this, cement filling and/or increased tibial bone resection was performed. During the study period, we did not use the bone grafting technique for peripheral bone defects of the medial tibia.

The Scorpio total stabilizer system has options for metal augmentation of the proximal tibia of a (1) half 5-mm block, (2) half 10-mm block, (3) full 10-mm block, and (4) 5° full wedge. Moreover, to improve stability of the tibial component, a cemented or press-fit stem could be selected. The stem can transfer loads to the diaphyseal segment of the bone. Stem augmentation is considered to provide correct component positioning, enhance fixation, and decrease stress at the bone-implant interface [7]. When needed, the offset option could be used for the stem. Although a standard cruciate-retaining or posterior-stabilized prosthesis could be selected in this system, the constrained-type prosthesis could be selected when an acceptable soft tissue balance was not achieved.

urgeries were performed under dual lumbar and epidural anesthesia using a pneumatic tourniquet. All the arthroplasties were performed through the subvastus approach. Measured resection technique was used for bone cutting.

Before measuring the tibial bone defect, the osteophytes on the tibia were thoroughly excised. The thorough removal of tibial osteophytes often avoided the use of metal augmentation in cases in which metal augmentation was planned for tibial bone defects. Tibial osteotomy was performed perpendicular to the tibial axis in both the coronal and sagittal planes with an extramedullary rod. The amount of bone resection of the proximal tibia was determined by the thickness of the implant from the lateral tibial plateau. In the Scorpio total stabilizer system, the options for the metal block size were 5 or 10 mm. When the defect size was over 15 mm, the double-block technique described by Baek and Choi was performed [8]. A cemented stem was routinely added when metal augmentation was used. We used a 40-mm cemented stem as our first choice; however, an 80-mm cemented stem was used when the surgeon considered it adequate because of the tibial bone quality. A line connecting the medial border of the tibial tubercle with the insertion of the posterior cruciate ligament was used as a guide for the rotational position of the tibia.

Femoral osteotomy was performed using an intramedullary rod. The distal femoral osteotomy was aimed to be performed in valgus angulation equal to the angle between the anatomical and functional axes of the femur and in external rotation parallel to the epicondylar axis.

The target soft tissue balance was no varus-valgus imbalance and equal soft tissue tension in 0° extension and 90° flexion. However, complete soft tissue balance could not be easily obtained in cases of severe bone defect. Our target soft tissue tension in the 0° extension was that the soft tissue allowed full extension and avoided a recurvate knee. With regard to the varus-vulgus balance, a slightly tight medial soft tissue tension was accepted.

Patella resurfacing was performed selectively. The patella was resurfaced in patients with pain that was considered to be generated from the patellofemoral joint, with a positive patellar compression test or with severely damaged patellar cartilage.

Postoperative care was identical for patients who underwent TKA with or without metal augmentation. Weight-bearing and walking exercises were initiated 1 day after surgery. Range of motion exercises were performed without setting restrictions.

Clinical and radiographic outcomes

We collected data regarding the following background characteristics of patients with metal augmentation and of the control patients: age, sex, height, weight, body mass index, preoperative knee function score, preoperative diagnosis, and postoperative follow-up period. For clinical results, we used the knee function score at the final follow-up examination and the implant survival rate with revision surgery (regardless of the reason) as the endpoint. Knee joint function was evaluated using the Japanese Orthopedic Association Knee Score [9,10]. This score assesses knee joint function by pain, walking ability, range of motion, and joint swelling with a perfect score of 100. The scoring system considered the Japanese lifestyle (e.g., whether a person can kneel with the tops of the feet flat on the floor and sitting on the soles) and had been proven to be significantly correlated with the Short Form 36 Health Survey Scale [10].

We grouped the preoperative tibial bone defects into peripheral and central defects according to the definitions of Dorr et al. [11]: peripheral defects offer no peripheral support for the tibial component, whereas central defects have an intact bony rim that supports the tibial component.

The most important finding of the study was that the 3- to 6-year follow-up results of TKA with metal block augmentation for the medial tibia were not inferior to those of TKA for varus knee without bone defects in terms of knee scores and survival rates. The use of metal augmentation for bone defects is widely supported [2]. The advantages of modular metal augmentation are extensive modularity, quick and easy use, and wide availability [7]. However, the high rate of radiolucent lines just beneath the metal has often been pointed out as a shortcoming [1,4-6]. Pagnano et al. reported radiolucent lines between wedge-type augmentation cement and bone in 13 of 24 knees with an average radiographic follow-up period of 4.8 years [6]. Brand et al. reported that 6 of 22 knees had radiolucent lines beneath the metal wedge at an average follow-up of 3.1 years [5]. Although the definitive reason for the radiolucent line is unclear, it is hypothesized to be due to insufficient cementing, thermal necrosis caused by heat from the cement, blood or tissue debris, or micromotion of components [13]. Several biomechanical studies have revealed that the rectangular block is superior to the wedge [3,14]. Block-shaped augmentation is expected to directly transmit torsional loads as a result of geometric interlock and to reduce cement mantle strains between the tray and the tibial plateau [3]. In our study, no loosening was observed over 3–6 years, and the clinical results were not inferior to those of standard TKA; however, radiolucent lines beneath the metal were observed in 10 of 33 knees.

We assessed the patients' characteristics in an attempt to detect reasons for the incidence of radiolucent lines. When the postoperative alignment of the leg was valgus, the stress to the medial part of the knee might decrease. Thus, the stress shielding of the medial part could be related to the incidence of radiolucent lines. However, in our study, no patient data, including the femorotibial angle, could be associated with the incidence of the radiolucent line.

Rounding of the medial edge of the tibia, which to our knowledge has not been previously reported, was frequently observed in our study. We consider that the rounding was caused by stress shielding, similar to the rounding of the medial calcar after total hip arthroplasty [15]. The use of stem augmentation might influence the rounding because the stem transfers the load from the tibial surface to the distal portion. The rounding suggested that the cemented stem was absorbing the load and that the metal block was not actually loading the bone as designed.

An important limitation of the present study is its retrospective nature. Furthermore, the follow-up period was not long enough to determine the usefulness of metal augmentation. Even with these limitations, we consider that these encouraging clinical results might be beneficial for TKA with tibial bone defects.

A variety of management alternatives exists for bone deficiencies encountered at the time of TKA. The alternatives for management include increased bone resection, translation of the component away from the deficiency, filling the defect with cement with or without reinforcing screws or mesh, bone grafting, and metal augmentation(16)

1.Increased bone resection:

Bone resection is quick and easy option but it should be reserved for shallow defects because deep proximal tibial resection places the tibial component on relatively weak cancellous bone, danger of compromise of important ligament attachments, both gaps are increased, requiring a thicker tibial component for stability which will alter the patellofemoral kinematics and finally Sizing problems will likewise occur because of the diminished cross-sectional area as one progresses down the tibia distally . For defects larger than 10 mm depth, alternative methods of fixation probably should be used.[16]

2.Translation of the component:

Shifting the components and/or downsizing to accommodate defects can be effective. Translating the component away from the bone defect can be utilized for peripheral deficiencies involving less than 50% of a single condyle. The problem with this technique is that it requires the use of a smaller tibial component for coverage of a plateau and potentially alters force transmission across the implant that could lead to loosening.[16]

3.Cement fill:

Cement is the most widely used technique to fill small defects. The advantages of cement are that it is quick and accessible. The disadvantage is that it loses its mechanical strength if it is required to buttress components under larger defects. It is indicated for small bony defects up to 5 mm in depth, preferably contained, in older patients [17]

4.Bone grafting:

Many surgeons favor bone grafting in the management of bone loss for reasons of economy, physiology, and versatility. The incorporation of bone grafts leads to restoration of bone stock and simplification of future revisions. Protected weight bearing should be prolonged until trabeculation of the bone graft is visible on the radiographs.[17]

In primary knee arthroplasty, bone grafting is indicated for tibial defects 5 mm -10 mm in depth that involve up to two thirds of a plateau. Whereas particulate autograft can be used in contained lesions, the noncontained defects necessitate the use of corticocancellous segments from the routine bone cuts. The technique consists of exposing bleeding bone, precise fitting of the graft into the defect, rigid fixation with screws, and component coverage of the graft [17]

The graft is either held in position with two screws that are countersunk to a level below the horizontal cut surface of the remaining tibial condyle or with self locking technique after converting the defect into a trapezoidal shape and a matching trapezoid is made from the autogenous bone graft and is impacted into place. [17]

5.Metal augmentation:

Modualr metal augments allow selective filling of bone deficiencies on the femur or the tibia (more than 5mm) , provide intraoperative flexibility, and allow a variety of options, including wedges, rectangular blocks, and custom augments.[18]

Preoperative radiographs dictate the type of augmentation necessary, as templates for each size and type of augment exist for use with standard knee films. Occasionally, bone grafting techniques in conjunction with augmented prostheses improve the final result, especially if irregularly shaped deficiencies exist a modular system using full and half-wedges with a variety of thicknesses and angles together with the half and full blocks in different thickness superseded custom components because the modular system is less expensive and more adaptable during surgery.[74]

Elsebai introduced another way in management of bone defects in varus deformity which is either reconstructable or non-reconstructable solutions. [19]

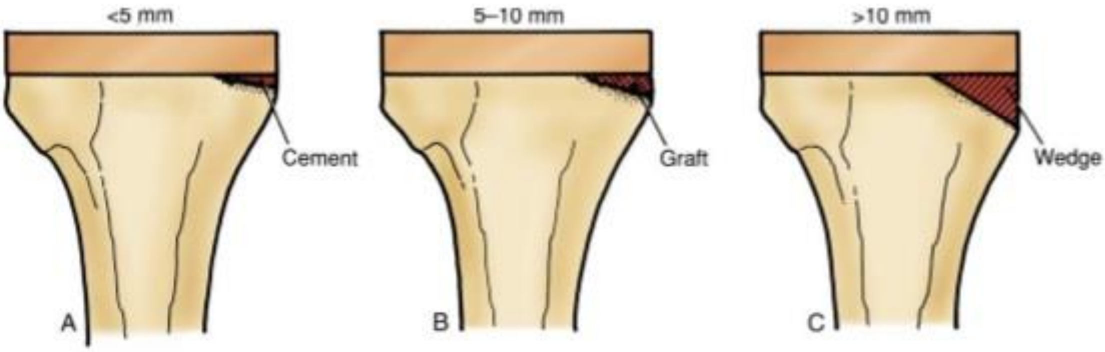

Fig.(1): Bone defects. **(A):** Small defects of less than 5 mm can be filled with cement. **(B):** Defects between 5 and 10 mm are suitable for bone grafting. **(C):** Defects larger than 10 mm are best treated with a metal wedge or augment. (

I- **Non reconstructable solutions:** i.e. without the use of bone grafts or metal augments. It's either:

A- Salvageable defects: The bone defects disappear by the optimal cut itself. This is usually in small (less than 2mm) contained surface defects.

B- Non salvageable defects: Here the bone defects don't disappear by the optimal cut itself and the defects are still present after performing the cut. The solutions are [21]

Solutions	Defect size
1. Sheeting cut: use the already weared Sclerotic platform as the cut but before cementaion, drilling the surface by a small drill bit for bone cement incorporation. 2. Leave a neglectable shallow defect.	In defects less than 2mm.
3. Ignore the defect and compensate by long stem to decrease stresses on the surface. 4. Ignore the defect and go away from it either by under sizing and/or lateralizing and/or external rotation.	In defects 2-5 mm

II- Reconstractable solutions: i.e. reconstructing the defect (more than 5mm) by either bone graft or metal augments.

Table (1): Comparison between Bone grafts and metal augments in reconstructing bone defects in Varus deformity. [76]

Bone graft	Metal augment
Usually used in young patients to reserve bone stock	In older patients
There must be good bone quality	In poor bone quality
In optimum defects	In severe steeping defects

Usually done in primary cases	Usually done in revision cases
Can tailor the graft according to defect	Tailor the defect according to shape of augment
Delayed mechanical stability	Immediate mechanical stability

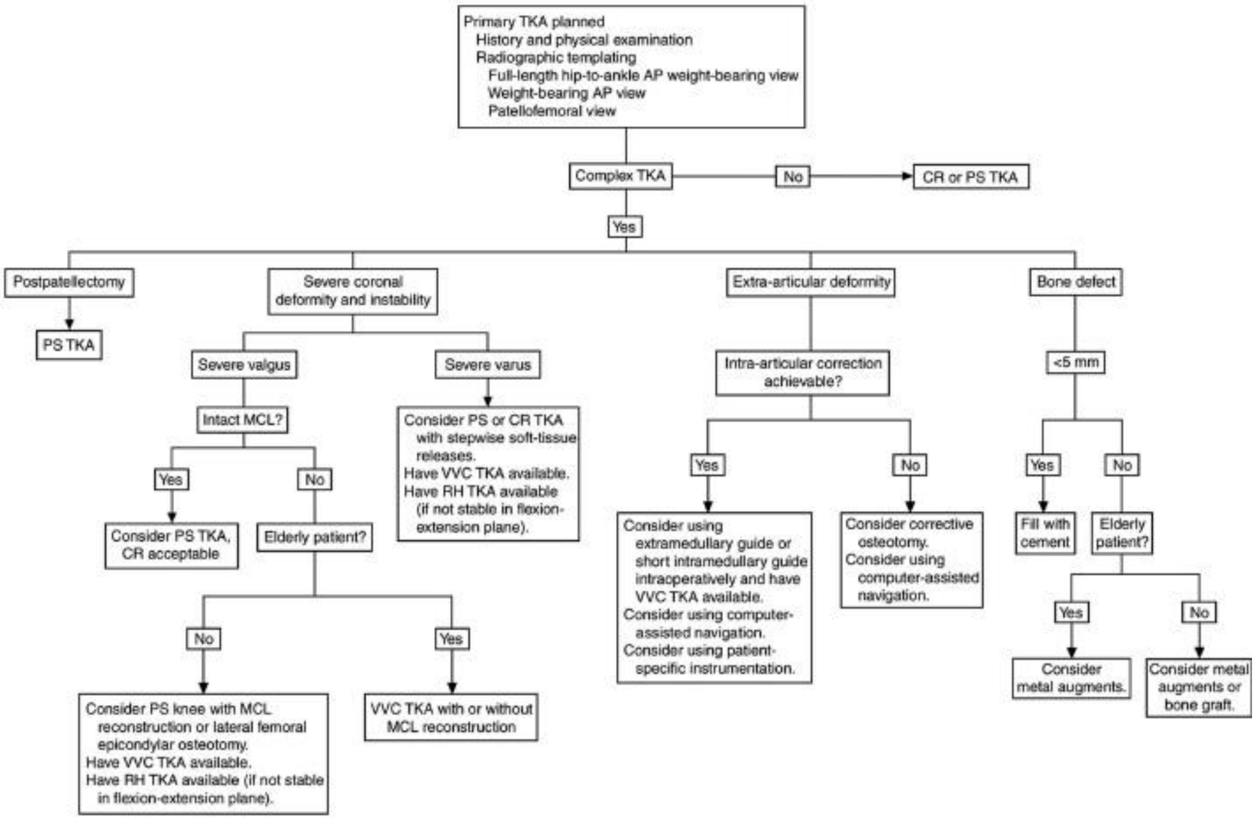

Fig.(2): Algorithm demonstrating the key elements required for the clinical approach, choice of implant design, and techniques used during primary total knee arthroplasty.. CR = cruciateretaining, MCL = medial collateral ligament, PS = posterior stabilized, RH = rotating hinge, TKA = total knee arthroplasty, VVC = varus–valgus constrained. (23)

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