3 Varus Deformity

Introduction

Varus deformity, the most commonly encountered deformity in patients undergoing total knee arthroplasty (TKA), is associated with a limb alignment (hip-knee-ankle angle) of less than 180° and varying degrees of contracture of medial soft-tissue structures, laxity of the lateral soft-tissue structures, flexion deformity and medial bone erosion at the knee joint. Medial osteophytes cause tethering and functional shortening of the medial soft-tissue structures in a varus deformity; posterior osteophytes exert the same effect on the posterior capsule leading to flexion contracture and obstruction to deep flexion. There may also be associated lengthening and attenuation of the lateral soft-tissue structures especially in severe varus deformities [1].

Hence, the challenges in performing TKA in a varus arthritic knee include restoration of limb alignment, balancing the medial and lateral soft-tissue tension, equalising flexion and extension gaps and restoring medial bone loss. Severe varus deformities may be associated with malrotation of the distal femur and tibia which makes conventional bony landmarks less reliable to determine rotational alignment of the femoral and tibial components [2–4]. Furthermore, severe varus deformities may also be associated with extra-articular deformities such as excessive coronal bowing of the femoral shaft and proximal tibia vara which makes TKA technically challenging [5]. The current chapter describes the principles of dealing with a varus deformity, both mild to moderate and severe deformities, during TKA.

Pathoanatomy

Stability and function of the knee joint involve a dynamic interplay of various soft-tissue structures around the knee joint. A sound knowledge of these structures, both under normal and diseased conditions, is crucial to achieve optimum alignment, balance and kinematics after TKA for the arthritic knee. The issue of stability and balancing of soft tissues around the knee joint during TKA is compounded by the fact that ligaments and muscles around the knee joint are dynamic structures which behave differently in knee extension and flexion.

A sequential release of soft-tissue structures has been recommended to achieve equal medial and lateral gaps during TKA [1, 6–9]. It is hence important to know the soft-tissue structures around the medial aspect of the knee joint and the effect of release of these structures on gaps and alignment.

Traditionally, medial soft-tissue structures of the knee joint have been described in three layers [10–12]. The first and most superficial layer consists of the deep crural fascia of the knee joint including the retinacula and the pes anserinus (sartorius, gracilis and semitendinosus) attachment on the anteromedial aspect of the

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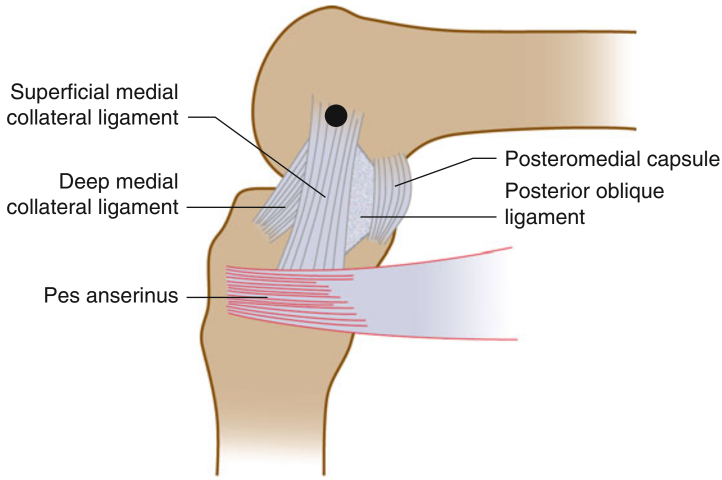

Fig. 3.1 Medial soft-tissue structures of the knee joint

proximal tibia distally. The second layer consists of the superficial part of the medial collateral ligament (MCL) which also gives rise to the posterior oblique ligament (POL) posteromedially (Fig. 3.1). The third and the deepest layer consists of the deep part of MCL, the deep capsular layer and the insertion of the semimembranosus tendon at the posteromedial corner of the tibia just below the joint line. We performed a cadaveric study to quantify the effect of sequential posteromedial release on flexion and extension gaps using an image-free computer navigation system [13]. Our study demonstrated that sequential soft-tissue releases led to an incremental and differential effect on flexion and extension gaps [13]. Hence, judicious and titrated use of this posteromedial soft-tissue releases sequence and following an algorithmic approach will help in correcting deformity and restoring limb alignment and balance during TKA. Although several authors have described different sequence of soft-tissue release for varus deformities [1, 6–9], we follow our technique of sequential soft-tissue release as described here for a cruciate-substituting TKA (Fig. 3.2).

As described in Chap. 1 , a lot of information can be derived about the pathologic soft-tissue and bony changes which have occurred in an arthritic knee based on preoperative radiographic features and examination of the knee under anaesthesia during TKA. Depending on the clinicoradiographic features presented by each varus arthritic knee, the surgeon will have to individualise the amount of bone resection, soft-tissue release and component size and position for each TKA in order to achieve optimum limb alignment and gap balance. Based on our experience of nearly 10,000 TKAs over the last 20 years, the authors have identified several clinical and radiographic features in varus arthritic knees which form the basis of their surgical technique.

The three principal clinical features of varus deformity on clinical examination (under anaesthesia) which need to be noted are (1) correctibility of the deformity (rigid, partially correctible, fully correctible and unstable) with knee in maximum extension, (2) associated sagittal plane deformity (fixed flexion or hyperextension) and (3) extent of lateral side soft-tissue laxity (mild, moderate or severe) (Fig. 3.3). The degree of correctibility of deformity will decide the amount of soft-tissue release required medially in order to achieve correction and balance. Similarly, amount of soft-tissue laxity on the lateral side of the knee in a varus deformity decides the extent of medial soft-tissue release required in order to equalise the medial and lateral soft-tissue gaps. Any associated sagittal plane deformity will require titrating the amount of tibial and distal femoral bony resection and posterior soft-tissue release to achieve deformity correction and flexion-extension gap balance.

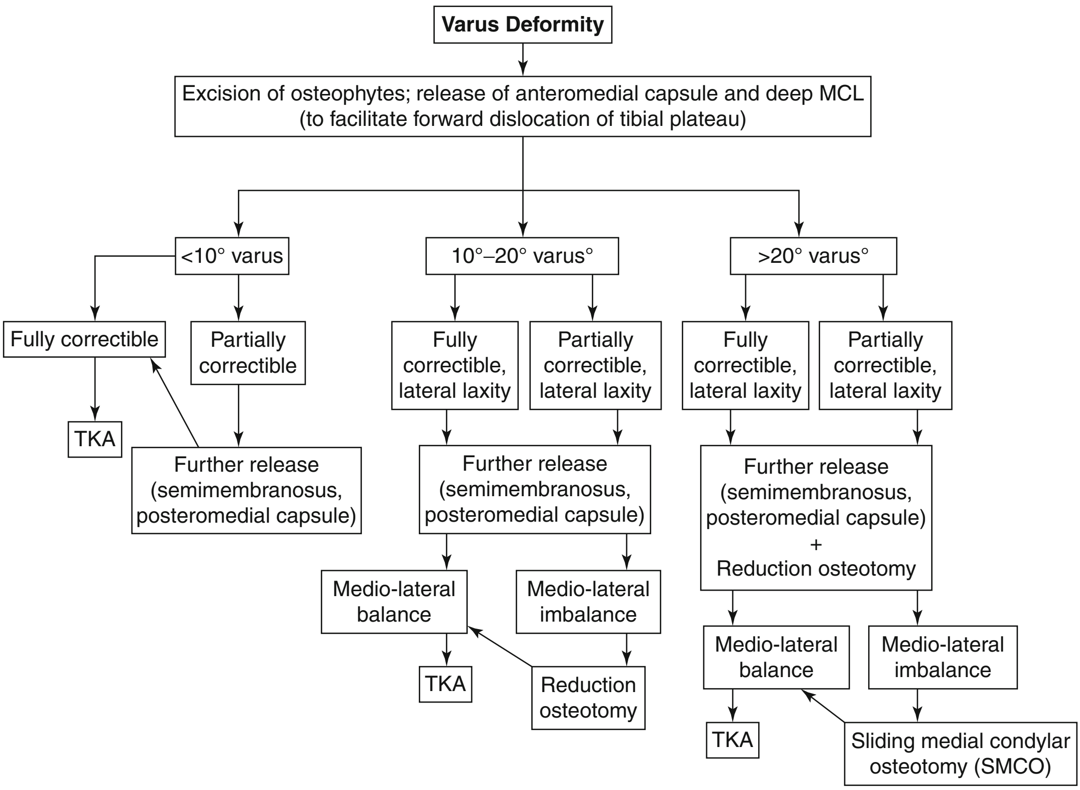

Fig. 3.2 Algorithmic approach to achieve limb alignment and soft-tissue balance in varus deformity during TKA

Preoperative radiographic features will usually provide hints as to what manoeuvres need to be carried out to correct the deformity and achieve optimum soft-tissue balance and can also help predict the difficulty a surgeon may face in achieving these goals. The five radiographic features of varus arthritic knees which need attention are (1) degree of deformity (as measured on full-length hip-to-ankle radiographs), (2) amount of lateral laxity (based on joint divergence angle and lateral translation of tibia), (3) presence of extra-articular deformity (coronal femoral bowing based on valgus correction angle, tibia vara based on tibial plateau angle), (4) medial bone loss (mild, moderate, severe) and (5) presence of osteophytes (minimal, moderate, abundant) (Fig. 3.4).

Several of the above features may be present or absent primarily based on the severity of arthritic involvement and the degree of knee deformity. Rigidity, associated sagittal plane deformities, excessive lateral laxity, abundant osteophytes and severe medial bone loss are more commonly seen in knees with severe long-standing varus deformities (especially ≥20°) than in knees with mild to moderate varus deformities [4]. In some knees, where the degree of arthritic involvement and the amount of intra-articular deformity is less severe, the above features may be absent. However, in these knees the degree of deformity may be confounded by the presence of an extra-articular deformity (commonly excessive coronal bowing of the femur) which adds to the overall severity of limb deformity and makes the case more challenging to treat (Fig. 3.5). Furthermore, increase in varus deformity may also cause variation in the distal valgus correction angle (VCA) and rotational profile of the distal femur and the tibia which needs to be accounted for while positioning the femoral and tibial components [2–4, 14–19].

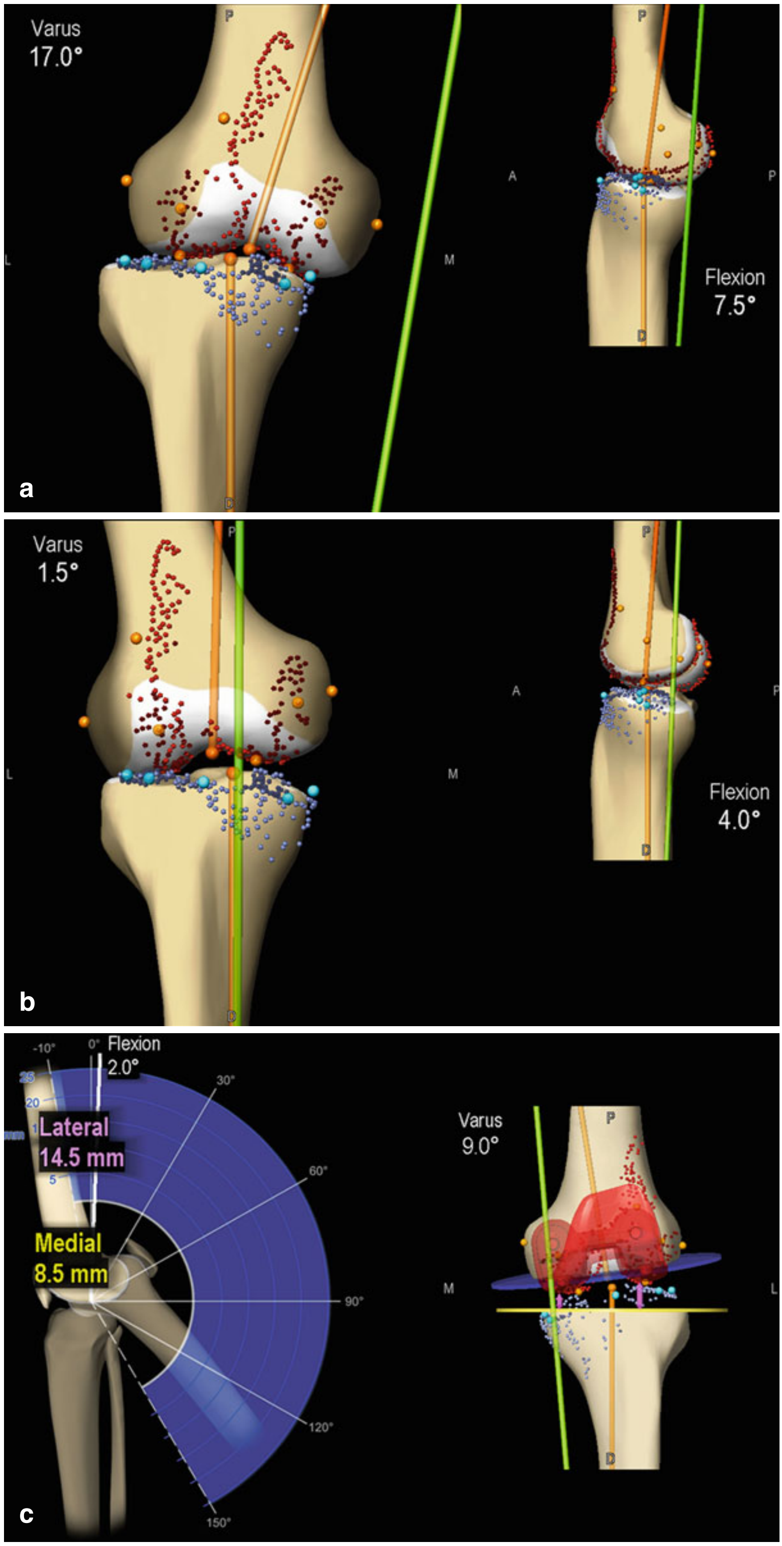

Fig. 3.3 The three principal clinical features of varus arthritic deformity which needs to be noted during TKA (shown here using computer navigation screen shot images). (**a**) Maximum varus deformity (using a varus stress at the knee joint in maximum extension) and maximum knee deformity in the sagittal plane (flexion). (**b**) Maximum correctibility of varus deformity (using a valgus stress at the knee joint in maximum extension). (**c**) Maximum lateral soft-tissue laxity (using a varus stress at the knee joint in maximum extension)

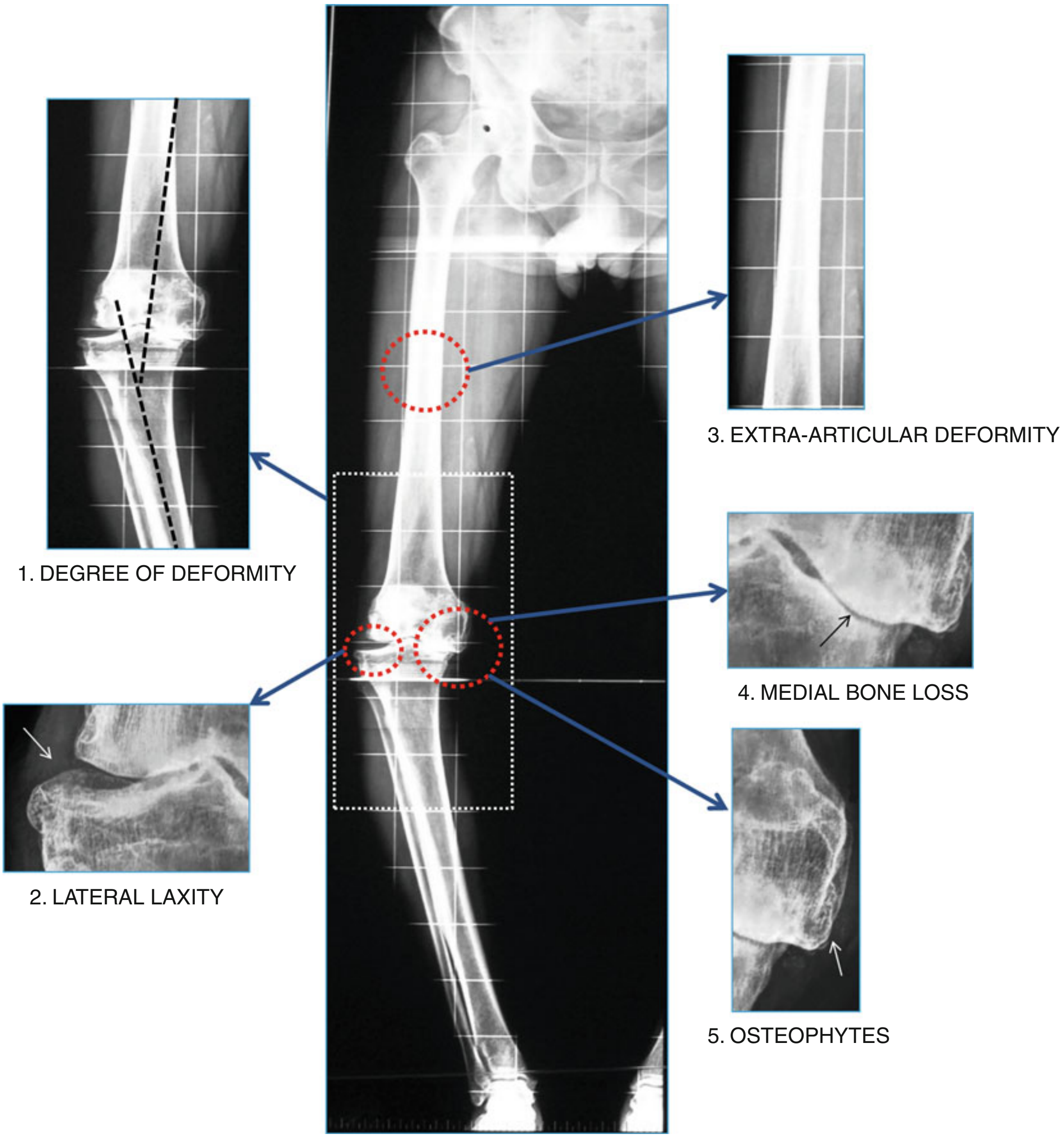

Fig. 3.4 The five principal radiographic features of varus arthritic deformity which needs to be noted on preoperative full-length hip-to-ankle radiographs

Based on radiographic analysis of 1,500 computer-assisted TKAs [5], the authors have described features of an "*at-risk*" *knee* which can be identified on preoperative standing, full-length hip-to-ankle radiographs (Fig. 3.6). The presence of these preoperative radiographic features put the knee at greater risk for malalignment after TKA [5]. Hence, the surgeon should identify such "at-risk" knees, and every measure must be undertaken to ensure optimum limb and component alignment and soft-tissue balance during TKA.

Fig. 3.5 Extra-articular deformity confounding the severity of deformity in an arthritic knee. (**a**) Preoperative standing knee radiograph showing mild changes in terms of deformity, bone loss, osteophytes and lateral laxity. Dotted line shows femorotibial angle. (**b**) Preoperative standing, full-length hip-to-ankle radiograph of the same patient (**a**) showing significant coronal bowing of the femoral shaft (*arrow*) because of which the distal femoral valgus correction angle (*VCA*) in this patient is almost 10.5°. *Dotted line* is the anatomic axis of the distal femur and the black line shows the femoral mechanical axis; the angle formed by the two lines is the VCA

Surgical Technique

The surgical technique followed by the authors for varus TKA is based on the presence of any combination of the three clinical and five radiographic features present in the arthritic knee. The basic technique followed is one of gap balancing where bone resection and soft-tissue release are tailored to each individual knee based on the presence or absence of the above clinicoradiologic features. The varus arthritic knee is treated with progressive release of medial soft-tissue structures to achieve full correction of deformity and to achieve "equipoise" with the

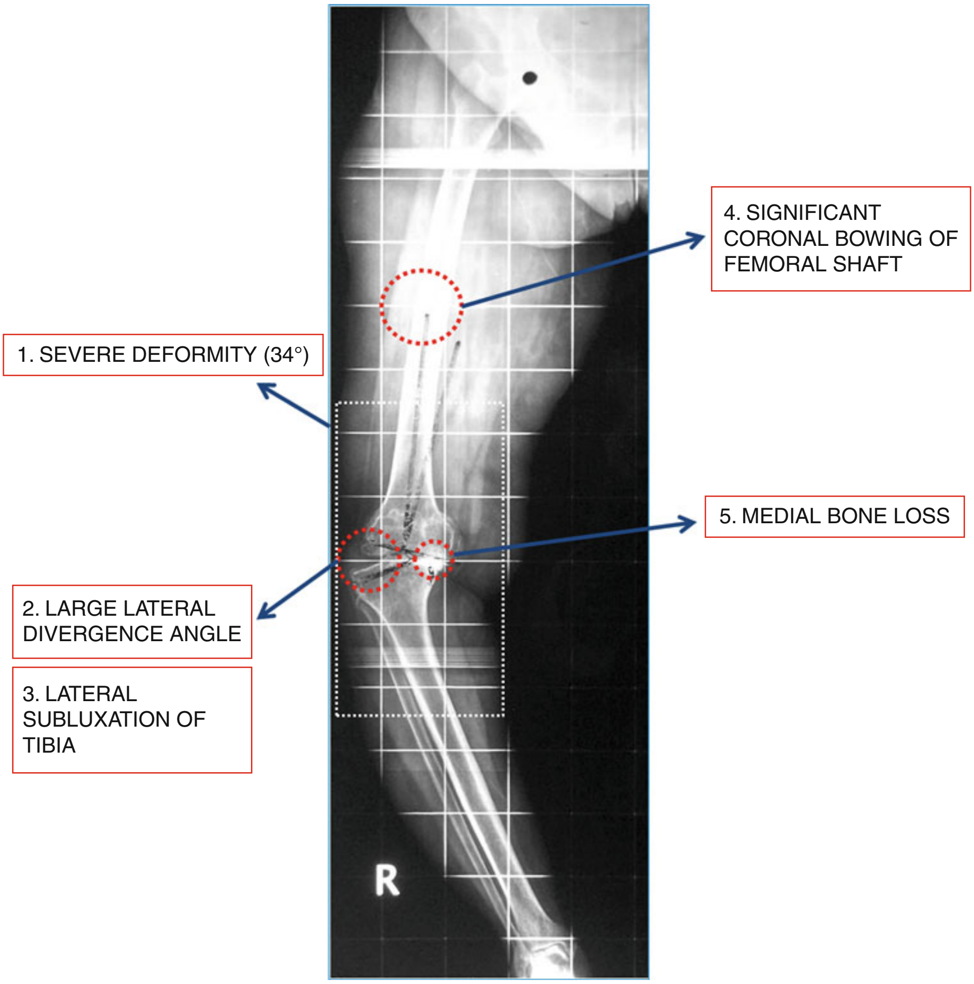

Fig. 3.6 The "at-risk" knee showing five features on preoperative full-length hip-to-ankle radiographs which may increase the risk of malalignment in this patient

lateral soft-tissue structures. However, this release of medial soft-tissue structures needs to be controlled and measured to avoid overcorrection or instability.

The first step to achieve these goals is to remove all osteophytes around the knee joint which will not only free the tethered soft-tissue structures but also helps avoid unnecessary soft-tissue release. Following this principal step, the surgeon can accurately assess in full extension how much residual deformity and soft-tissue tightness persists and which may require a formal soft-tissue release. Based on whether the deformity is fully correctible, partially correctible, rigid or unstable, further soft-tissue release may be required in order to correct the deformity. Most partially correctible deformities get fully corrected with removal of osteophytes and the preliminary soft-tissue release (deep MCL and semimembranosus) performed for exposure of the joint and anterior dislocation of tibia. However, the medial release required may be extensive (posteromedial capsular attachment to proximal tibia and segmental excision of the posteromedial capsule) in cases with rigid deformities or knees with severe medio-lateral soft-tissue imbalance and may also require performing a reduction osteotomy of the tibia (see Chap. 11 for technique) with or without undersizing the tibial component [20]. In contrast, soft-tissue releases should be restricted and controlled in knees which are unstable in coronal and or sagittal planes.

The next step after achieving deformity correction is to assess how lax the lateral soft-tissue structure vis-à-vis the medial structures. This is best done by giving a varus stress with a spacer block placed in the extension gap to determine how much the LCL is elongated. Although a varus deformity may appear to be fully corrected with medial soft-tissue release as evidenced by correct alignment being achieved with a spacer block in extension with a valgus stress being applied, medio-lateral soft-tissue balance may still prove to be elusive due to excessive lateral soft-tissue laxity. Similarly, in the presence of an extra-articular deformity, achieving optimum deformity correction and soft-tissue balance may not be possible despite extensive medial release. Both these scenarios warrant performing either a sliding medial condylar osteotomy or a corrective osteotomy of the extra-articular deformity (see Chap. 11 for technique) [21, 22].

Knee Deformity <10°

Typically, knees with mild deformities (<10° varus or HKA angle >170–180°) have minimal or no osteophytes, medial bone loss or extra-articular deformities and no associated sagittal plane deformities. Such knees are easily correctible with a preliminary medial soft-tissue release and standard bone cuts. However, these deformities may be sometimes associated with mild to moderate lateral laxity or an associated sagittal plane deformity. Excessive lateral laxity maybe dealt with by proportionately extending the amount of medial soft-tissue release. An associated fixed flexion deformity may get corrected by a thorough posterior clearance (osteophyte excision and capsular release) and as a last resort resecting additional distal femoral bone. However, when an associated hyperextension deformity is present, conservative tibial and distal femoral bone resection should be performed and posterior soft-tissue release avoided. Rarely, some of these knees may have an associated "reverse" bowing of the femoral shaft (Fig. 3.7) when analysed on preoperative full-length hip-to-ankle radiograph. This puts the knee at greater risk for overcorrecting the limb axis into valgus alignment. In such cases, the surgeon should strictly avoid over-release on the medial side and reduce the valgus correction angle (VCA) for the distal femoral cut.

Knee Deformity 10–20°

Such varus deformities are commonly associated with mild to moderate degree of lateral laxity, medial bone loss, sagittal plane deformity or extra-articular deformity. The amount of osteophytes present may vary from mild to moderate. Again, although most of these deformities can be easily tackled using the standard procedure, an associated extra-articular deformity either in the femur (excessive coronal bowing) or the tibia (proximal tibia vara) may make deformity correction and soft-tissue balancing a challenge. The presence of such extra-articular deformity will require more than the usual medial soft-tissue release to achieve limb realignment and gap balance. Rarely, when even extensive soft-tissue release fails to achieve the surgical goals (due to excessive lateral laxity with or without excessive medial tightness), a sliding medial condylar osteotomy (SMCO) may be required. The need for SMCO in such cases can usually be predicted on preoperative radiographs by the presence of an extra-articular deformity confounding the lesser degree of intra-articular knee deformity, often in combination with the presence of excessive lateral laxity of the knee joint (lateral divergence angle), lateral translation of the tibia and lack of osteophyte, excision of which would otherwise contribute to deformity correction without the need for excessive medial release.

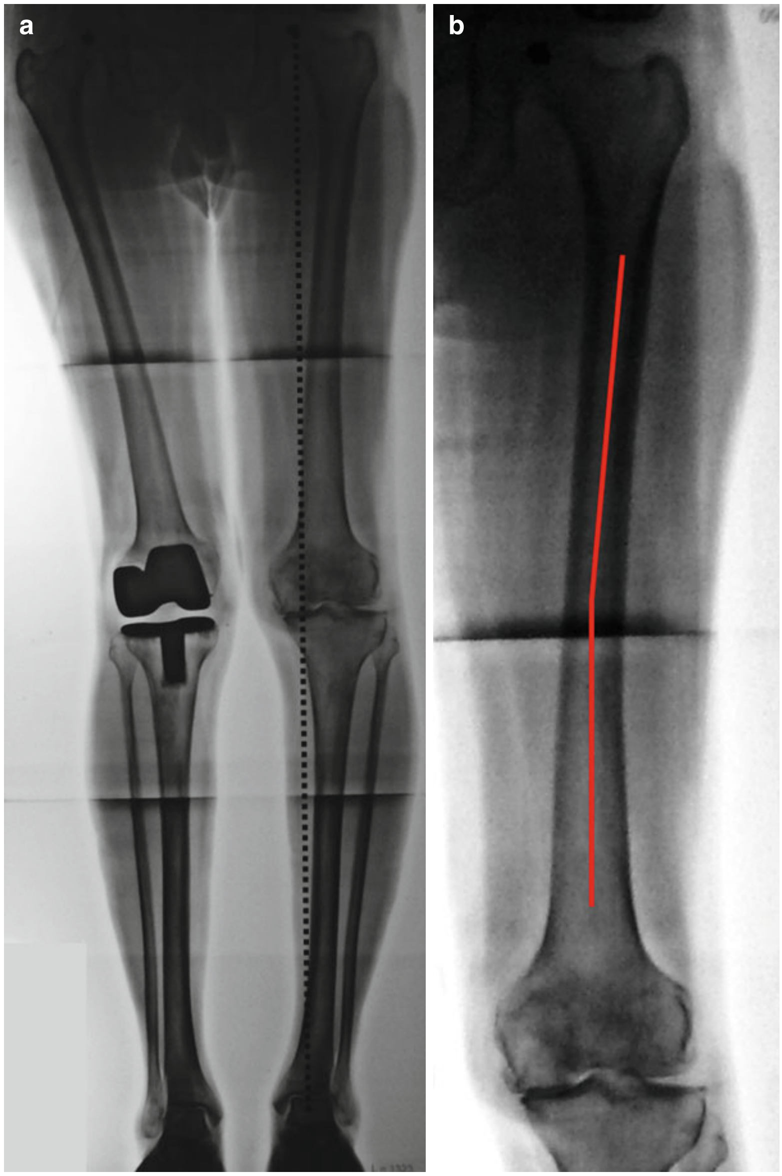

Fig. 3.7 Reverse bowing of the femoral shaft in the coronal plane. (**a**) Preoperative standing, full-length hip-to-ankle radiograph showing mild varus deformity of the left knee. Failure to recognize reverse bowing has led to valgus malalignment of the right knee. *Dotted black line* shows mechanical axis of lower limb. (**b**) An enlarged view of the femoral shaft shows reverse bowing in the coronal plane. *Red line* shows reverse bowing angle of the femoral shaft

Knee Deformity >20°

Severe varus deformities pose several challenges during TKA including severe extra-articular deformity, severe lateral laxity, medial bone loss and associated moderate to severe sagittal plane deformities. The degree of soft-tissue release is governed by the amount of soft-tissue tightness assessed using a tensioning device. An extensive, graded, stepwise soft-tissue release (subperiosteal elevation of the deep medial collateral ligament (MCL), posteromedial capsule and semimembranosus) is performed as per the technique previously described by the authors (Fig. 3.2). Excision of osteophytes along the posteromedial tibia and medial femoral condyle is initially performed. Tibial resection is restricted at approximately 6–7 mm of bone with respect to the lateral tibial condyle when the deformity is associated with excessive lateral laxity or an associated hyperextension deformity [23]. In the presence of a medial tibial bone defect, this cut

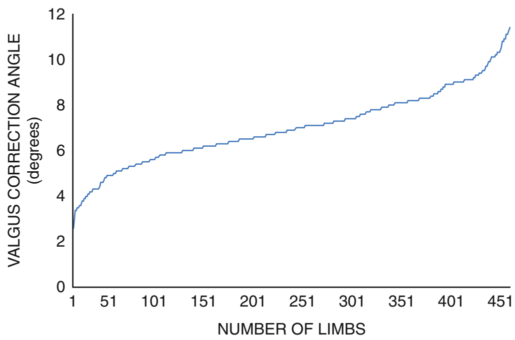

Fig. 3.8 Graph showing distribution of the valgus correction angle (*VCA*) in our series of 459 varus limbs. The VCA in 47 % of varus limbs was >7°

usually passes some distance above it and not through its base. An additional 1–2 mm is resected if it reduces the size of the bone defect. By lowering the tibial surface with this additional resection, a smaller tibial component could be used, which in turns helps in increasing the amount of reduction osteotomy which can be performed for deformity correction and/or medio-lateral soft-tissue balancing [20].

The distal femur is cut at a valgus correction angle (VCA) determined on preoperative long hip-to-ankle radiographs for each individual limb since this may show wide variation among individuals (Fig. 3.8). The thickness of the distal cut is determined by the extent of medial femoral condylar bone defect and the severity of the flexion contracture. The thickness must be reduced if the medial condyle shows significant bone loss or in the presence of an associated hyperextension deformity or severe instability. Additional bone may have to be resected from the distal femur in the presence of a significant flexion deformity which has not improved with removal of posterior osteophytes and release of posterior capsular adhesions. In the presence of excessive coronal bowing of the femur, a short intramedullary guide rod should be used to avoid malposition of the distal cutting block with respect to the mechanical axis of the femur, or computer navigation should be used to accurately align the cutting block and to bypass the extra-articular deformity in the femur.

The medio-lateral gap balance in knee extension is assessed with a spacer block, and any discrepancy is address with additional soft-tissue release and reduction osteotomy. Usually the flexion gap may be larger than the extension gap (due to extensive soft-tissue release), and the femoral component may have to be upsized, flexed 2–5° and translated posteriorly to achieve balance. If the flexion gap is still larger than the extension gap, additional resection of distal femur is needed to accommodate a thicker spacer.

Despite associated femoral and tibial extra-articular deformities and excessive lateral laxity, the above technique of bone resection and soft-tissue release results in well-aligned and balanced knees in majority of limbs with severe varus deformity undergoing TKA. However, in a few cases of rigid deformities, medial tightness may persist even after extensive medial soft-tissue release, and a sliding medial condylar osteotomy (SMCO) may be required. This involves distalising and fixing the medial femoral condylar fragment using cancellous screws after the implant has been cemented (see Chap. 11 for technique). Rarely, in cases with persistent and severe lateral side soft-tissue laxity and severe instability, a constrained implant may have to be used.

Medial tibial bone defects may be significant even after the tibial cut has been performed. Bone defects are dealt with based on their size and position (Fig. 3.9). Usually, uncontained medial tibial bone defects less than 10 mm deep are filled with bone cement, whereas defects ≥10 mm are filled with autologous bone graft (typically using bone from the notch cut). The bone defect should be first gently fashioned into a step-cut defect using a saw and then the bone block shaped to match the defect. The graft is usually punched into position or fixed into place using 2-mm K-wires or cancellous screw if the size of the graft is large (Fig. 3.9). These should be directed parallel to the tibial surface to avoid the peg or stem of the tibial component. A tibial stem extender is usually used in cases with large medial bone defects of >10 mm (Fig. 3.9). Rarely, significant medial femoral bone defects may require the use of metal augments supplemented with a femoral stem (Fig. 3.10).

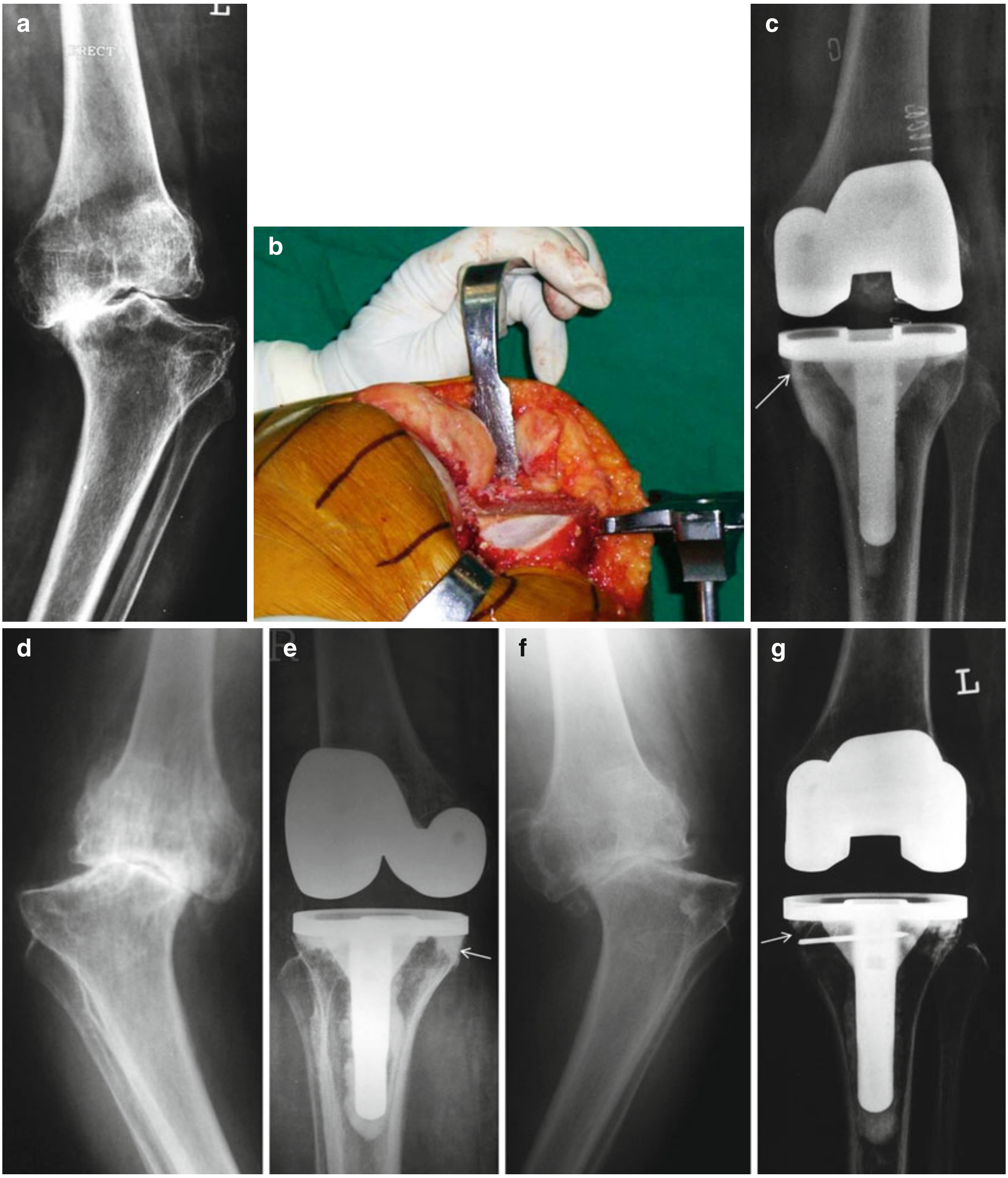

Fig. 3.9 Medial tibial bone defect in varus arthritic knees undergoing TKA. (**a**) Preoperative anteroposterior standing knee radiograph showing significant medial tibial bone defect. (**b**) Intraoperative photograph of the same patient (**a**) showing the medial tibial bone defect. Note that the tibial cut passes much above the deepest point of the bone defect. (**c**) Postoperative anteroposterior standing knee radiograph of the same patient (**a**) where the tibial bone defect was treated with autograft punched in position without fixation (*arrow*) and supported with a long stem tibial implant. (**d**) Preoperative anteroposterior standing knee radiograph showing significant medial tibial bone defect. (**e**) Postoperative anteroposterior standing knee radiograph of the same patient (**d**) where the tibial bone defect was not large enough to warrant grafting and hence was filled with bone cement (*arrow*) and supported with a long stem tibial implant. (**f**) Preoperative anteroposterior standing knee radiograph showing significant medial tibial bone defect. (**g**) Postoperative anteroposterior standing knee radiograph of the same patient (**f**) where the tibial bone defect was large enough to require bone grafting and fixation with wires (*arrow*) and supported with a long stem tibial implant. (**h**) Preoperative anteroposterior standing knee radiograph showing significant medial tibial bone defect and subluxation of the knee joint. (**i**) Postoperative anteroposterior standing knee radiograph of the same patient (**h**) where a constrained design was used and the tibial bone defect was treated with bone grafting and screw fixation

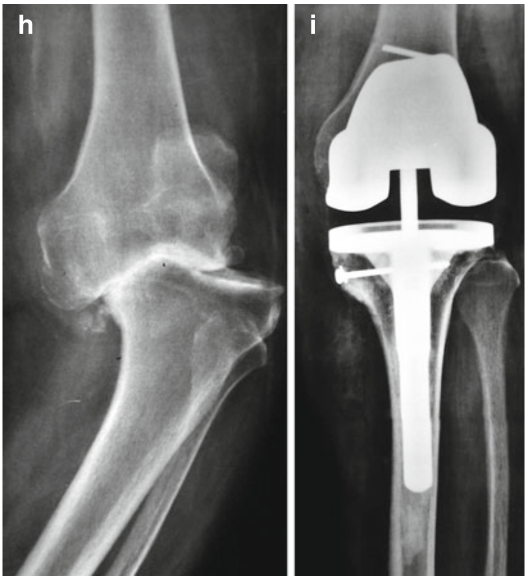

Fig. 3.9 (continued)

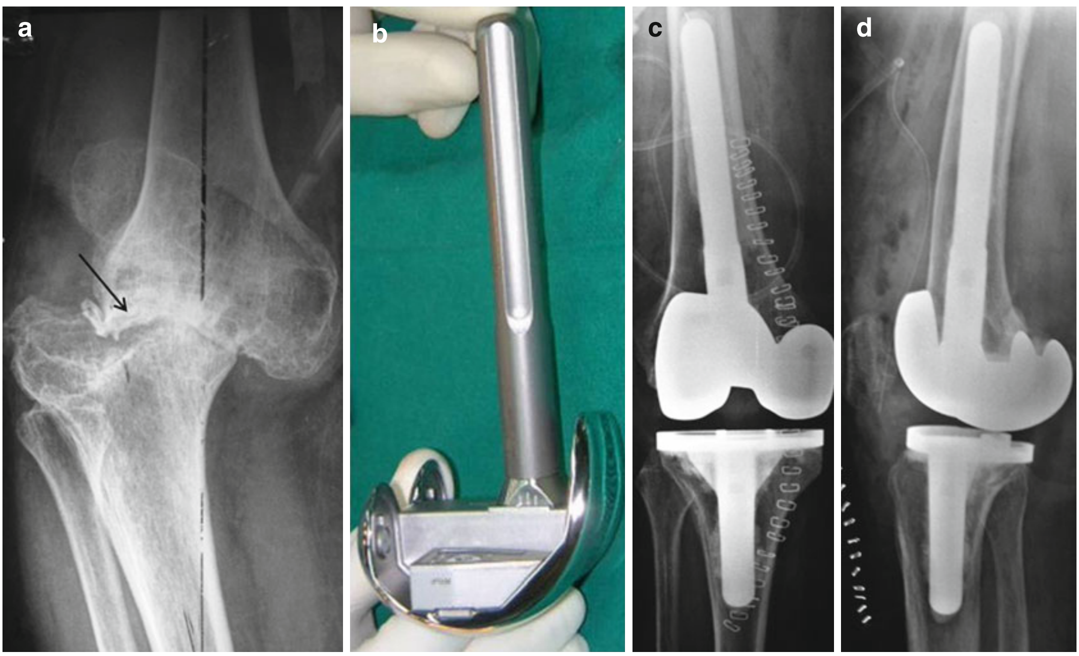

Fig. 3.10 Lateral femoral condyle bone defect in a varus arthritic knees undergoing TKA. (**a**) Preoperative anteroposterior standing knee radiograph showing substantial lateral femoral and tibial bone defect. *Arrow* shows substantial lateral femoral bone loss. (**b**) A distal femoral metal augment along with a femoral stem was used in the same patient (**a**) to treat the bone defect. (**c**) Postoperative anteroposterior standing knee radiograph of the same patient (**a**). (**d**) Postoperative lateral knee radiograph of the same patient (**a**)

Computer-Assisted Technique

The basic surgical technique for computer-assisted TKA in varus knees is similar to the one previously described for conventional TKA. Navigation allows for precise, quantitative and graduated medial soft-tissue release (as described above) to achieve rectangular balanced gaps and a fully restored mechanical axis. The navigation system with its software offers several advantages during TKA especially in severe varus arthritic knees. It bypasses extra-articular deformities such as excessive coronal bowing of the femur or malunited fractures or hardware from a previous surgery and avoids the difficulty in using intramedullary guide rods. Furthermore, in limbs where an additional reduction osteotomy or sliding medial condylar osteotomy may be required, navigation allows for precise, controlled, quantitative lengthening of the tight medial soft-tissue structures and proper restoration of soft-tissue balance and knee alignment [20, 21]. Similarly in rare cases where a corrective osteotomy for an extra-articular deformity in the femur or tibia is required, navigation allows for precise correction of the deformity and accurate realignment of the limb [22].

References

1. Mihalko WM, Saleh KJ, Krackow KA, Whiteside LA. Soft-tissue balancing during total knee arthroplasty in the varus knee. J Am Acad Orthop Surg. 2009;17:766–74.
2. Matsuda S, Miura H, Nagamine R, Urabe K, Mawatari T, Iwamoto Y. A comparison of rotational landmarks in the distal femur and the tibial shaft. Clin Orthop Relat Res. 2003;414:183–8.
3. Matsui Y, Kadoya Y, Uehara K, Kobayashi A, Takaoka K. Rotational deformity in varus osteoarthritis of the knee: analysis with computed tomography. Clin Orthop Relat Res. 2005;433:147–51.
4. Nagamine R, Miyanishi K, Miura H, Urabe K, Matsuda S, Iwamoto Y. Medial torsion of the tibia in Japanese patients with osteoarthritis of the knee. Clin Orthop Relat Res. 2003;408:218–24.
5. Mullaji AB, Shetty GM, Lingaraju AP, Bhayde S. Which factors increase risk of malalignment of the hip-knee-ankle axis in TKA? Clin Orthop Relat Res. 2013;471:134–41.
6. Whiteside LA. Soft tissue balancing: the knee. J Arthroplasty. 2002;17(4 Suppl 1):23–7.
7. Verdonk PC, Pernin J, Pinaroli A, Ait Si Selmi T, Neyret P. Soft tissue balancing in varus total knee arthroplasty: an algorithmic approach. Knee Surg Sports Traumatol Arthrosc. 2009;17:660–6.
8. Mullaji A, Marawar S, Sharma A. Correcting varus deformity. J Arthroplasty. 2007;22(4 Suppl 1):15–9.
9. Mullaji AB, Padmanabhan V, Jindal G. Total knee arthroplasty for profound varus deformity: technique and radiological results in 173 knees with varus of more than 20 degrees. J Arthroplasty. 2005;20:550–61.
10. LaPrade RF, Engebretsen AH, Ly TV, Johansen S, Wentorf FA, Engebretsen L. The anatomy of the medial part of the knee. J Bone Joint Surg Am. 2007;89:2000–10.
11. Warren LF, Marshall JL. The supporting structures and layers on the medial side of the knee: an anatomical analysis. J Bone Joint Surg Am. 1979;61:56–62.
12. De Maeseneer M, Van Roy F, Lenchik L, Barbaix E, De Ridder F, Osteaux M. Three layers of the medial capsular and supporting structures of the knee: MR imaging-anatomic correlation. Radiographics. 2000;20:83–9.
13. Mullaji A, Sharma A, Marawar S, Kanna R. Quantification of effect of sequential posteromedial release on flexion and extension gaps: a computer-assisted study in cadaveric knees. J Arthroplasty. 2009;24:795–805.
14. Mullaji AB, Sharma AK, Marawar SV, Kohli AF. Tibial torsion in non-arthritic Indian adults: a computer tomography study of 100 limbs. Indian J Orthop. 2008;42:309–13.
15. Siston RA, Patel JJ, Goodman SB, Delp SL, Giori NJ. The variability of femoral rotational alignment in total knee arthroplasty. J Bone Joint Surg Am. 2005;87:2276–80.
16. Mullaji AB, Sharma AK, Marawar SV, Kohli AF, Singh DP. Distal femoral rotational axes in Indian knees. J Orthop Surg (Hong Kong). 2009;17:166–9.
17. Sahin N, Atıcı T, Öztürk A, Özkaya G, Özkan Y, Avcu B. Accuracy of anatomical references used for rotational alignment of tibial component in total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc. 2012;20:565–70.
18. Sun T, Lu H, Hong N, Wu J, Feng C. Bony landmarks and rotational alignment in total knee arthroplasty for Chinese osteoarthritic knees with varus or valgus deformities. J Arthroplasty. 2009;24:427–31.
19. Mullaji AB, Shetty GM, Kanna R, Vadapalli RC. The influence of preoperative deformity on valgus correction angle: an analysis of 503 total knee arthroplasties. J Arthroplasty. 2013;28:20–7.

20. Mullaji AB, Shetty GM. Correction of varus deformity during TKA with reduction osteotomy. Clin Orthop Relat Res. 2014;472:126–32.
21. Mullaji AB, Shetty GM. Surgical technique: computer-assisted sliding medial condylar osteotomy to achieve gap balance in varus knees during TKA. Clin Orthop Relat Res. 2013;471:1484–91.
22. Mullaji A, Shetty GM. Computer-assisted total knee arthroplasty for arthritis with extra-articular deformity. J Arthroplasty. 2009;24:1164–9.
23. Mullaji A, Lingaraju AP, Shetty GM. Computer-assisted total knee replacement in patients with arthritis and a recurvatum deformity. J Bone Joint Surg Br. 2012;94:642–7.