Managing instability with osteotomies in both plans

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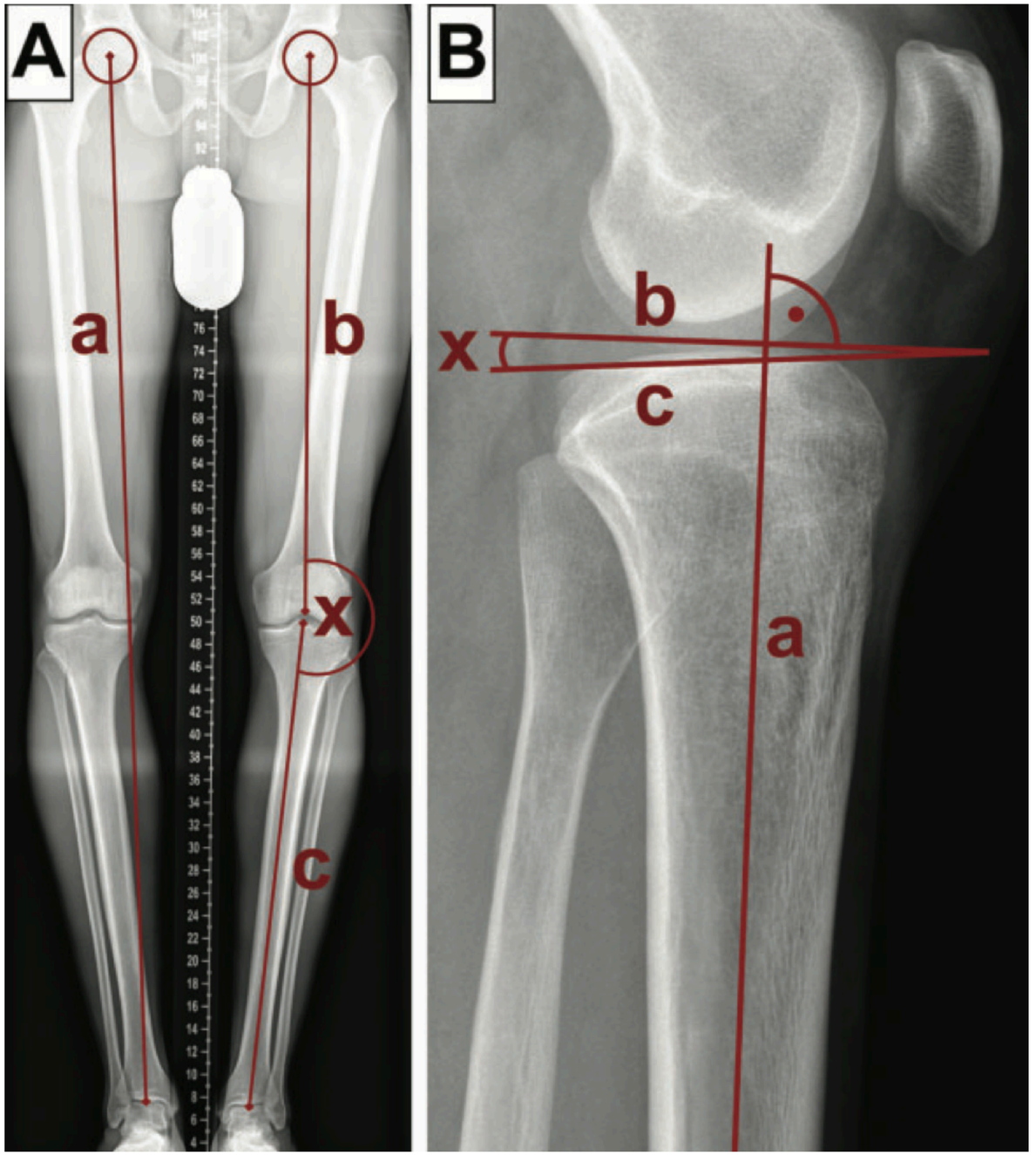
Conflict of interest

- Smith & Nephew
- Arthrex
- Medacta

Knee geometry

- Two main deformations:
  - **Varus**
  - **High posterior tibial slope**
  - *Valgus*

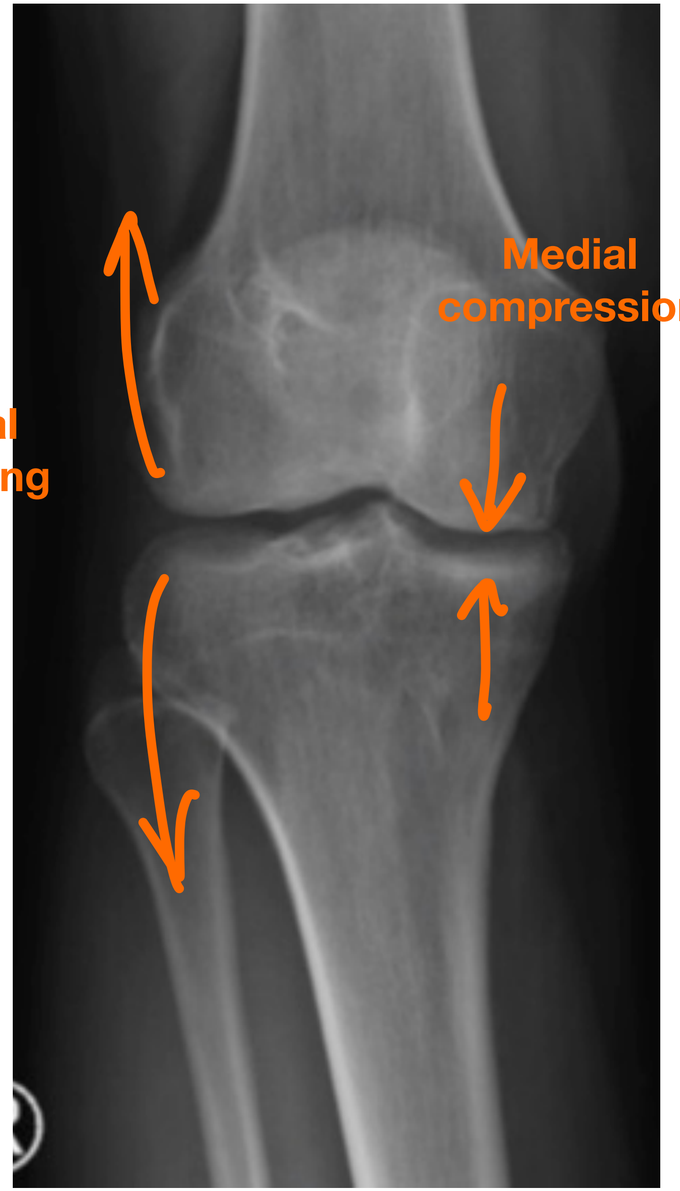


Tischer et al.

Varus

Particularly a challenge in chronic multiple ligament pathology

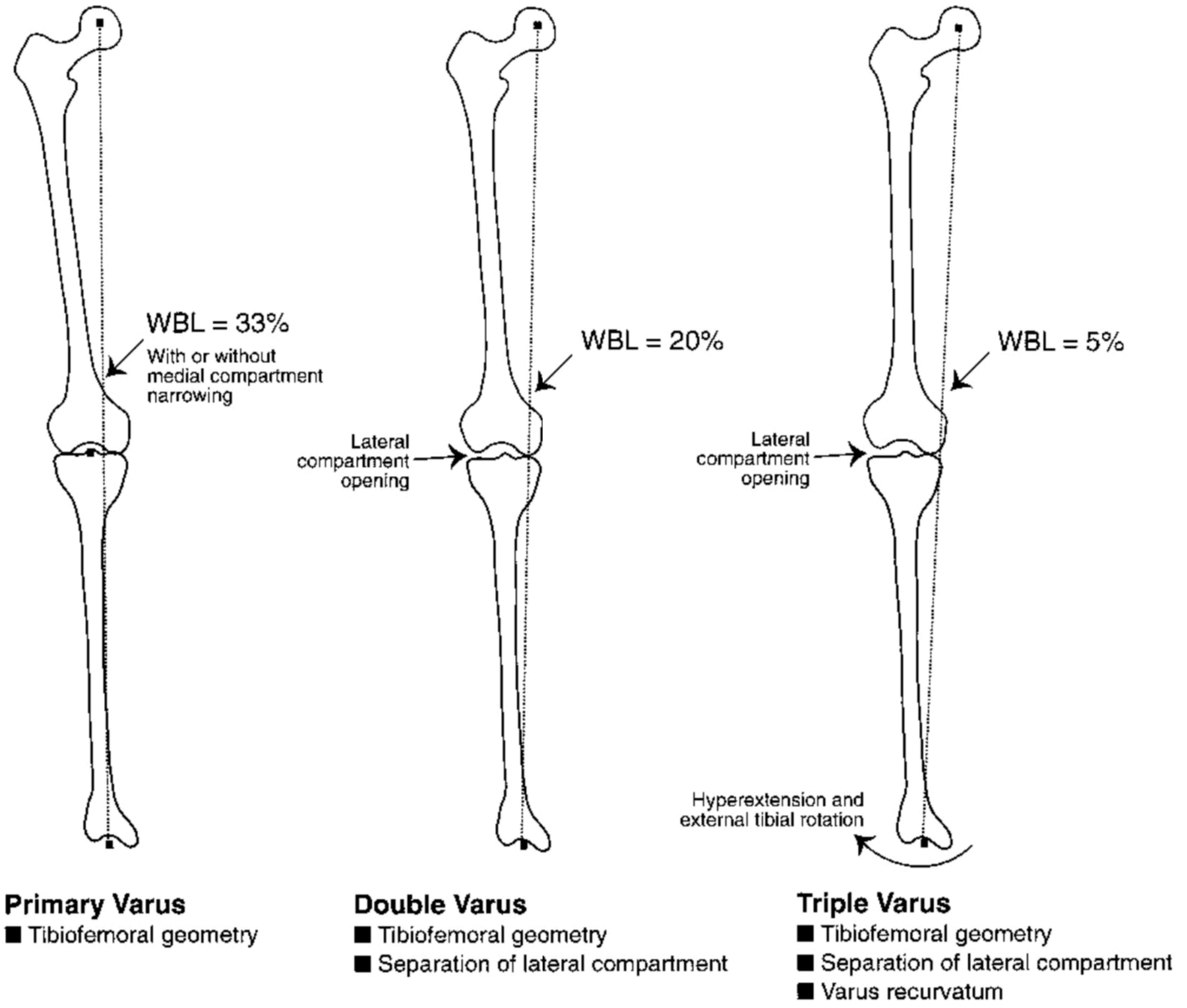
- In the presence of varus and chronic anterior cruciate ligament (ACL) deficiency, patients may develop
- **Cartilage wear of the posteromedial tibial plateau with worsening of the varus deformity**
- **Progressive slackening of the lateral and posterolateral ligamentous structures, with lateral joint opening.**



Cantivalli A, Rosso F, Bonasia DE, Rossi R. High Tibial Osteotomy and Anterior Cruciate Ligament Reconstruction/Revision. Clin Sports Med. 2019 Jul;38(3):417-433.

Varus

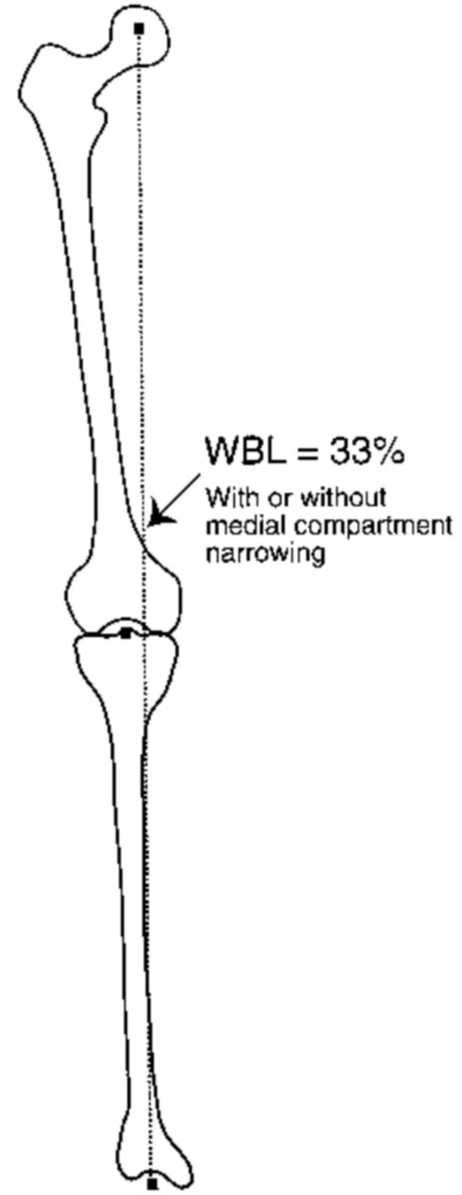
- **Noyes developed the concept of primary, double, and triple varus.**



Noyes FR, Barber-Westin SD, Hewett TE. High Tibial Osteotomy and Ligament Reconstruction for Varus Angulated Anterior Cruciate Ligament-Deficient Knees. *The American Journal of Sports Medicine*. 2000;28(3):282-296.

Primary varus

- Primary varus refers to **tibiofemoral osseous alignment and geometry of the knee**, including the varus alignment occurring after medial meniscectomy and damage to the medial articular cartilage.



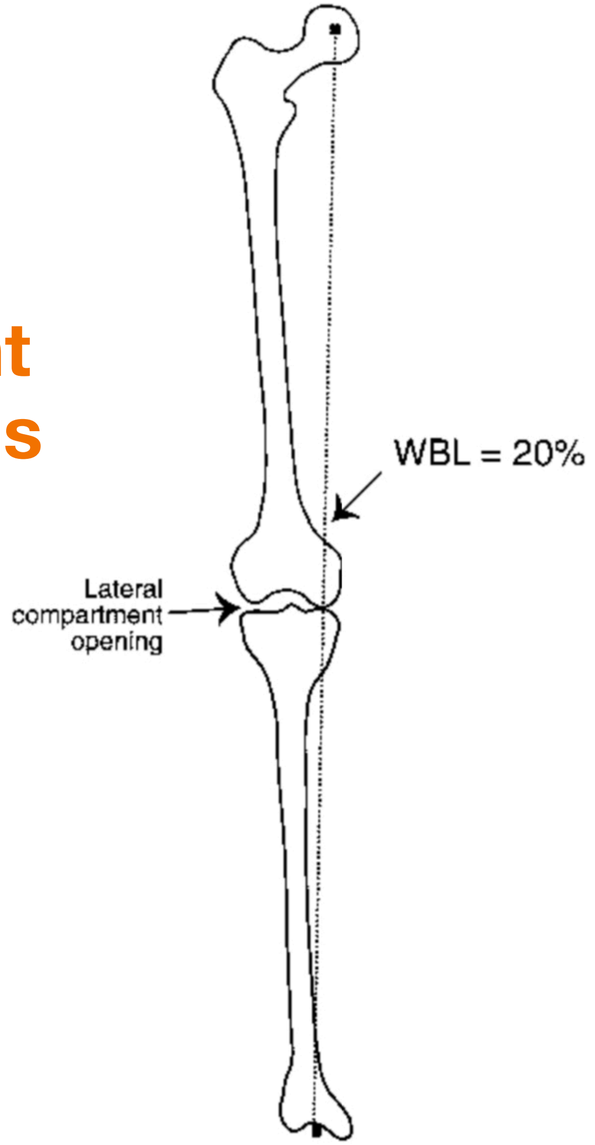
Primary Varus
■ Tibiofemoral geometry

Noyes FR, Barber-Westin SD, Hewett TE. High Tibial Osteotomy and Ligament Reconstruction for Varus Angulated Anterior Cruciate Ligament-Deficient Knees. *The American Journal of Sports Medicine*. 2000;28(3):282-296.

Double varus

- “Double varus” refers to the presence of **varus alignment due to tibiofemoral osseous alignment associated with lateral joint space opening due to lateral soft tissue slackening.**

- These patients normally present a varus thrust when ambulating.



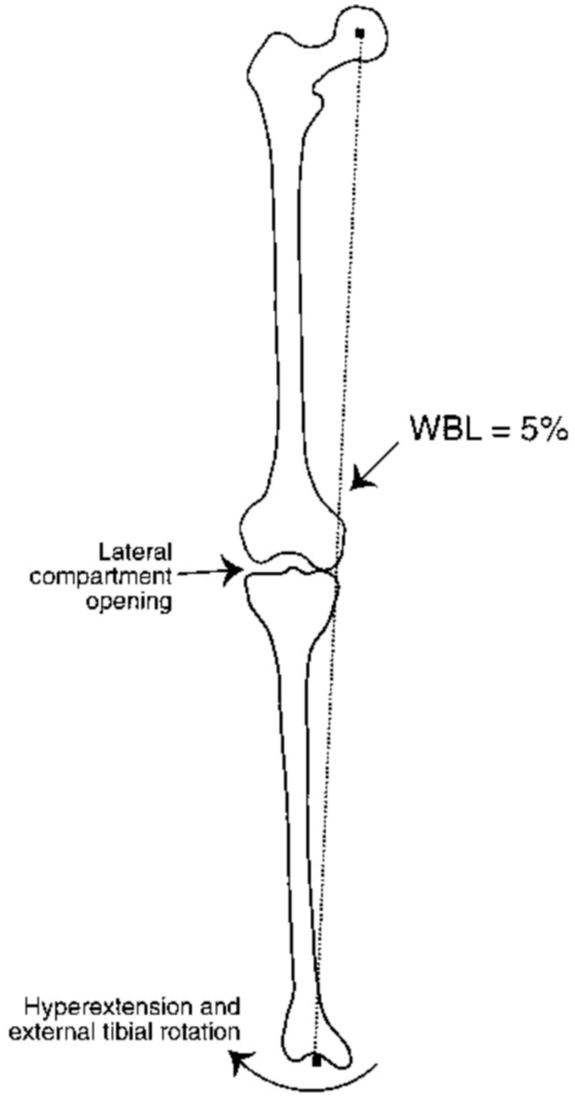
Double Varus
- Tibiofemoral geometry
- Separation of lateral compartment

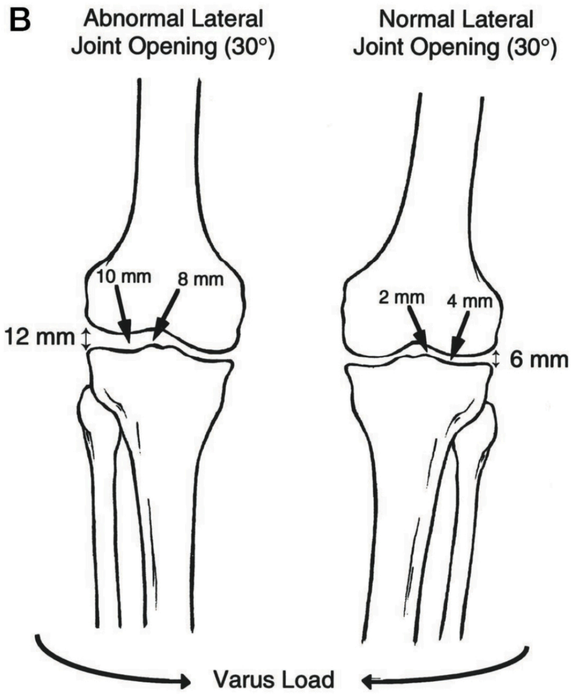
Noyes FR, Barber-Westin SD, Hewett TE. High Tibial Osteotomy and Ligament Reconstruction for Varus Angulated Anterior Cruciate Ligament-Deficient Knees. *The American Journal of Sports Medicine*. 2000;28(3):282-296.

Triple varus

- In these cases, the varus deformity is due to **tibiofemoral varus alignment, lateral joint space opening, and increased external tibial rotation and hyperextension, with an abnormal varus recurvatum position.**

- *Actually more frequent in PCL + PLC deficiency*





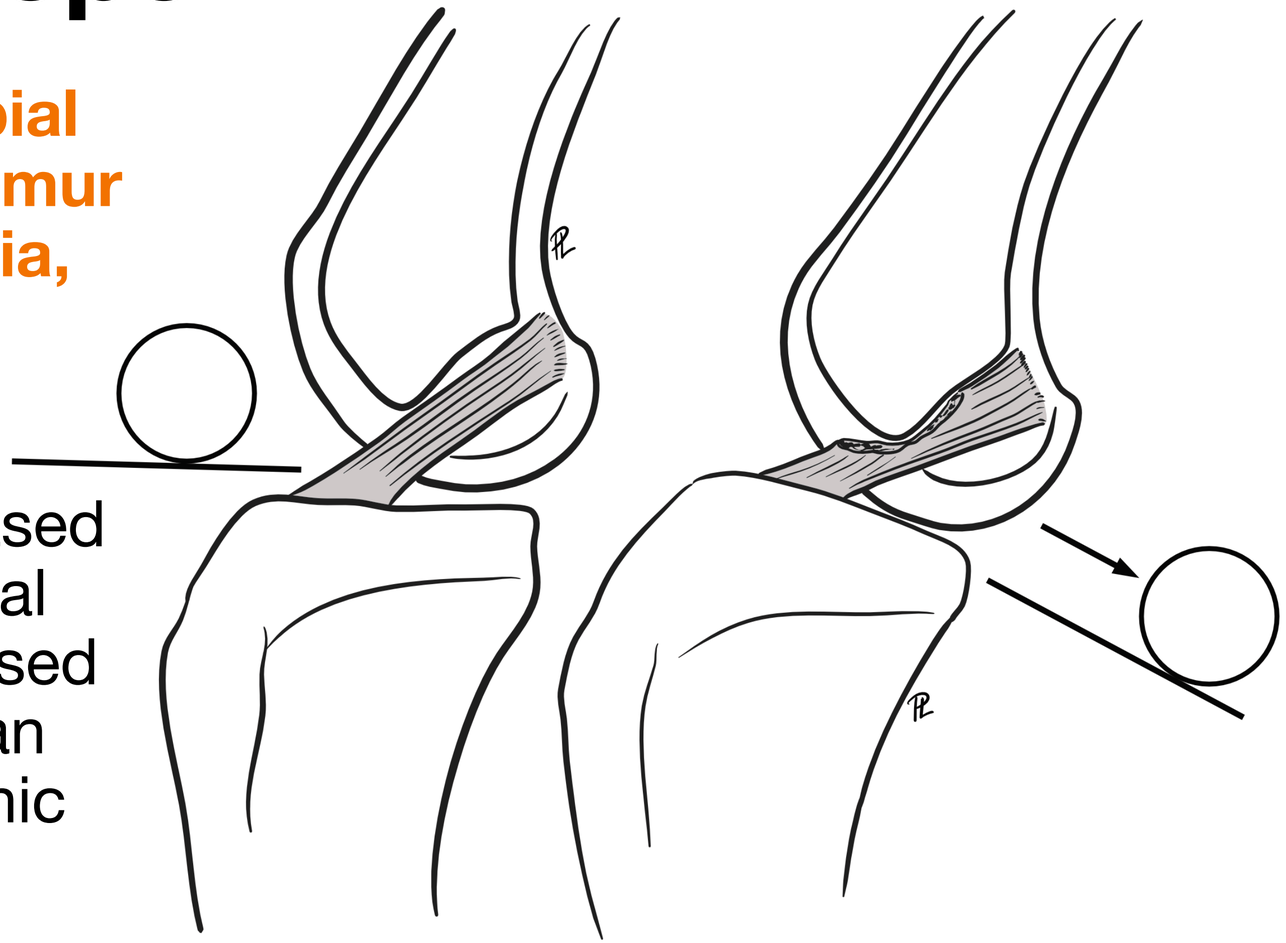
Triple Varus
- Tibiofemoral geometry
- Separation of lateral compartment
- Varus recurvatum

Noyes FR, Barber-Westin SD, Hewett TE. High Tibial Osteotomy and Ligament Reconstruction for Varus Angulated Anterior Cruciate Ligament-Deficient Knees. *The American Journal of Sports Medicine*. 2000;28(3):282-296.

High posterior tibial slope

- Theoretically, **increased posterior tibial slope leads to a tendency for the femur to slide backward relative to the tibia, decreasing load on the PCL and increasing load on the ACL.**

- Dejour et al; demonstrates that increased anterior tibial translation on monopodal stance views is correlated with increased posterior tibial slope in patients with an intact ACL as well as those with chronic anterior laxity.



Cantin O, Magnussen RA, Corbi F, Servien E, Neyret P, Lustig S. The role of high tibial osteotomy in the treatment of knee laxity: a comprehensive review. Knee Surg Sports Traumatol Arthrosc. 2015 Oct;23(10):3026-37.

Dejour H, Bonnin M. Tibial translation after anterior cruciate ligament rupture. Two radiological tests compared. J Bone Joint Surg Br. 1994;76:745–9.

Impact of geometry on knee laxity

- There is clinical evidence supporting **osseous malalignment as a factor contributing to failure of knee ligament surgery**.

- There is clinical evidence that **realignment surgery can improve function and stability, especially in cases of PLC insufficiency and in combination with revision ACL surgery.**

Tischer T, Paul J, Pape D, Hirschmann MT, Imhoff AB, Hinterwimmer S, Feucht MJ. The Impact of Osseous Malalignment and Realignment Procedures in Knee Ligament Surgery: A Systematic Review of the Clinical Evidence. Orthop J Sports Med. 2017 Mar 27;5(3): 1-16

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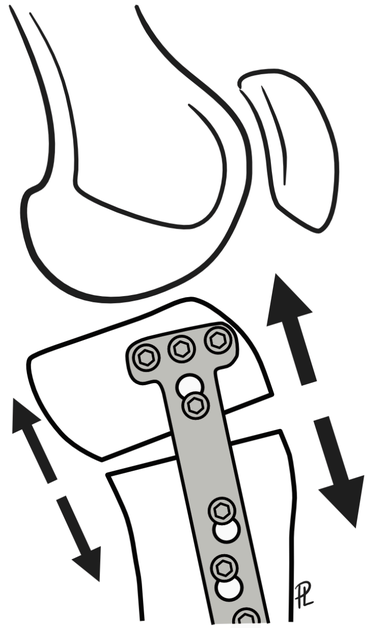
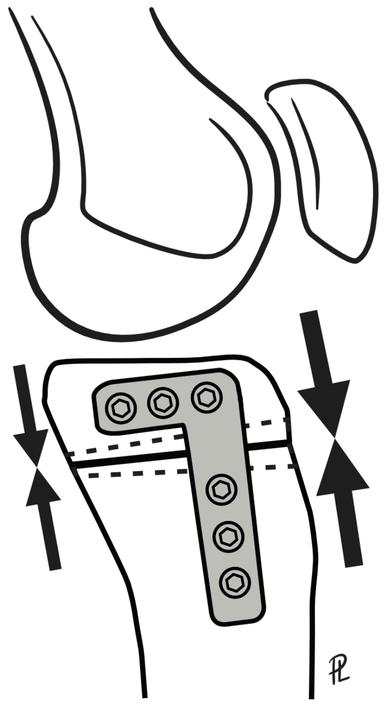
Evidence?

Impact of geometry on knee laxity

- **Slope-reducing HTO appears to reduce the ACL graft rupture rate and to increase knee stability** in literature. **In particular, second revision ACLR** appears to benefit from a reduced PTS through HTO. **Reduction of PTS and varus may protect the reconstructed ACL from fatigue failure.**

- Surgeons should therefore be especially aware of the potential impact of PTS on revision ACLR. **In this regard, the surgeon should bear in mind that open-wedge HTO tends to increase the slope, whereas closed-wedge HTO tends to decrease the PTS.**





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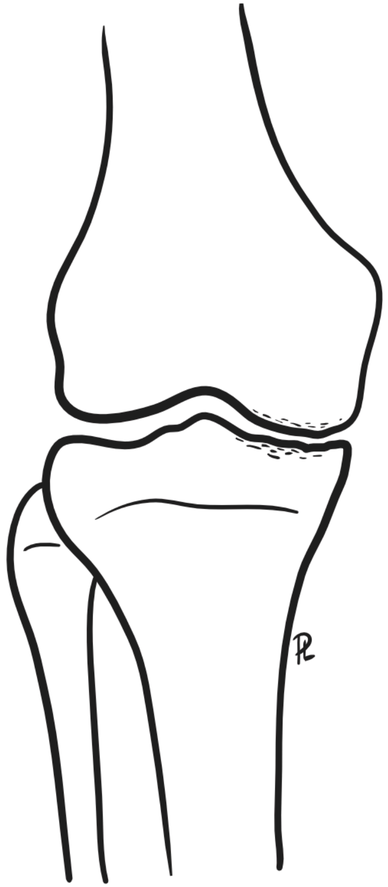
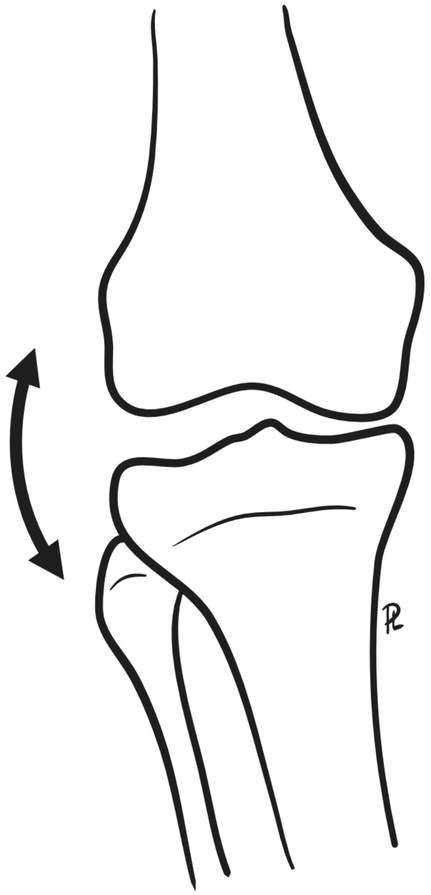
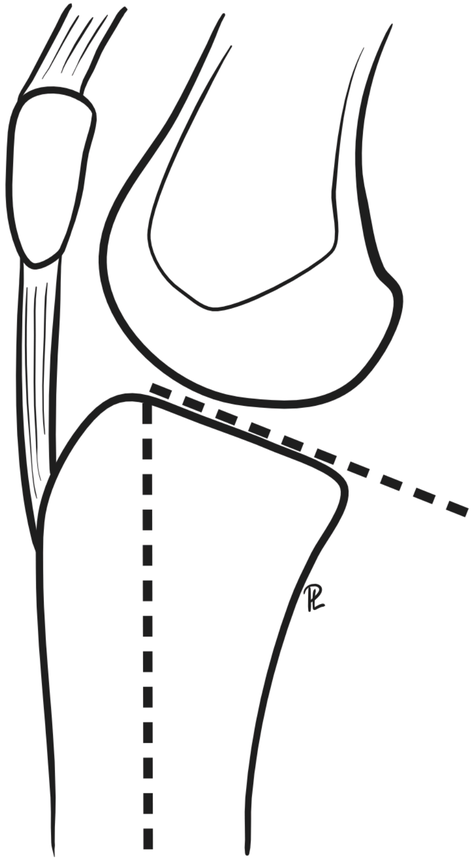
3 main scenarios



Anterior laxity +
Varus osteoarthritis



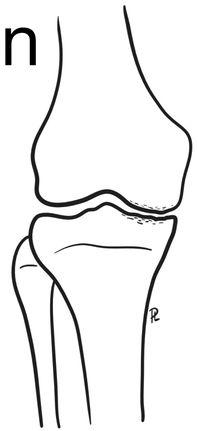
Anterior laxity +
varus +
lateral / posterolateral laxity



Anterior laxity +
High posterior tibial slope

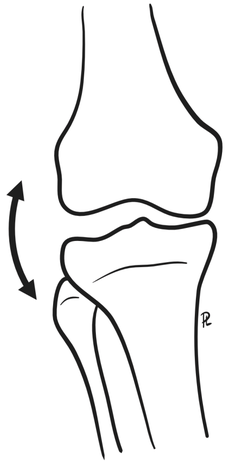
1. Anterior laxity + varus osteoarthritis

- Indication if **pain combined to instability**.
- Simultaneous high tibial osteotomy (HTO) and ACL reconstruction is best considered as a **salvage procedure** as patients have typically previously undergone many prior procedures.
- Performance of combined HTO and ACLR **can slow the progression of arthritis** but **progression** of lateral compartment OA can be observed.
- Limited expectation in Return to Sport (particularly same competition level).
- **Careful patient selection: HTO alone or combined?**



2. Anterior laxity + varus + lateral / posterolateral laxity

- Challenging cases.
- All authors agree that **isolated soft tissue procedures provided unsatisfactory results in these knees**.
- Uncorrected alignment resulted in repetitive stress and failure of the surgically reconstructed lateral structures.

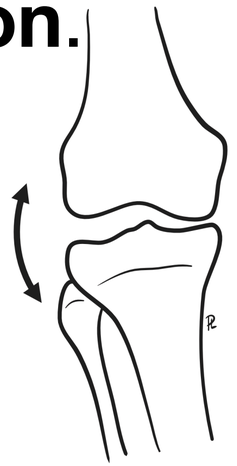


2. Anterior laxity + varus + lateral / posterolateral laxity

- **In double varus**: An **opening wedge tibial osteotomy without ligament reconstruction** may stabilize the knee and avoid the need for a ligament reconstruction.

- (In the setting of mild deficiency of the posterolateral complex, **a posterolateral ligament reconstruction may not be necessary after valgus alignement is achieved.)**

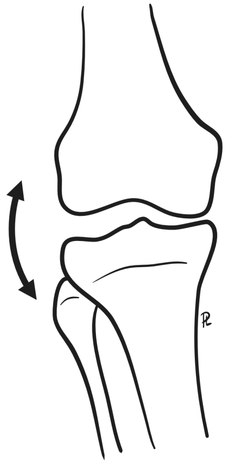
- Some authors recommended to combine **HTO + ACL revision**.



2. Anterior laxity + varus + lateral / posterolateral laxity

- **In triple varus**: Noyes recommended staging approach:

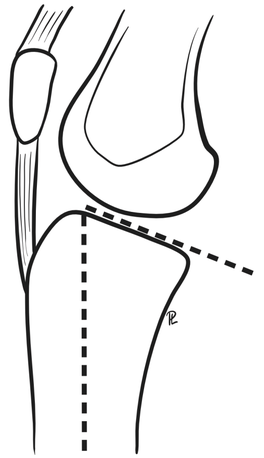
    1. **Correction of varus alignement**.
    2. **ACL revision + posterolateral reconstruction few months later**.



3. Anterior laxity + high posterior tibial slope

- **Posterior tibial slope** has been described as excessive when it is **greater than 12-13°**.

- Some authors recommend the addition of a tibial deflexion osteotomy to a revision ACLR in patients with a posterior tibial slope greater than 13° **associated with chronic anterior laxity evidenced with increased anterior tibial translation at least 10 mm compared with the contralateral knee on standing radiographs.**



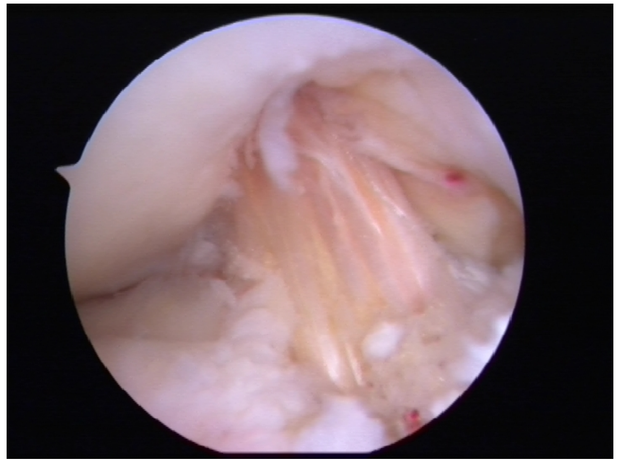
Magnussen RA, Dahm DL, Neyret P (2013) Osteotomy for slope correction following failed ACL reconstruction. In: Marx RG (ed) Revision ACL reconstruction: management and surgical technique. Springer, New York

Case

- 30 yo male, recreational football player.
- Right ACLR Hamstrings
- Return to play during 4 years
- New injury
- Lachman 11 mm
- Pivot shift grade 2

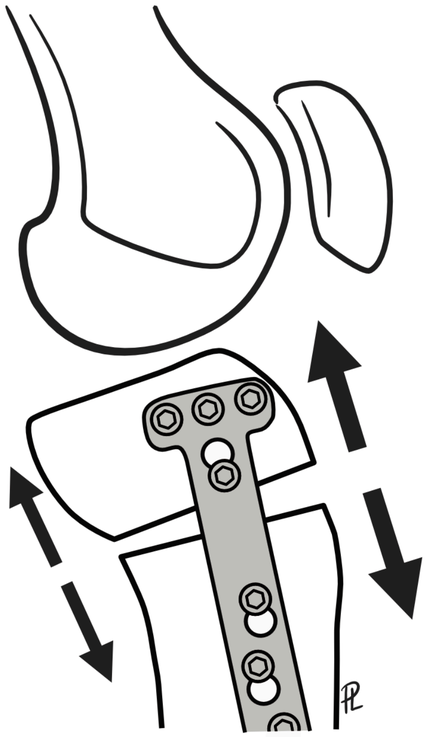
Case

- ACL revision using BTB
- Deflexion osteotomy



Surgical techniques: valgisation

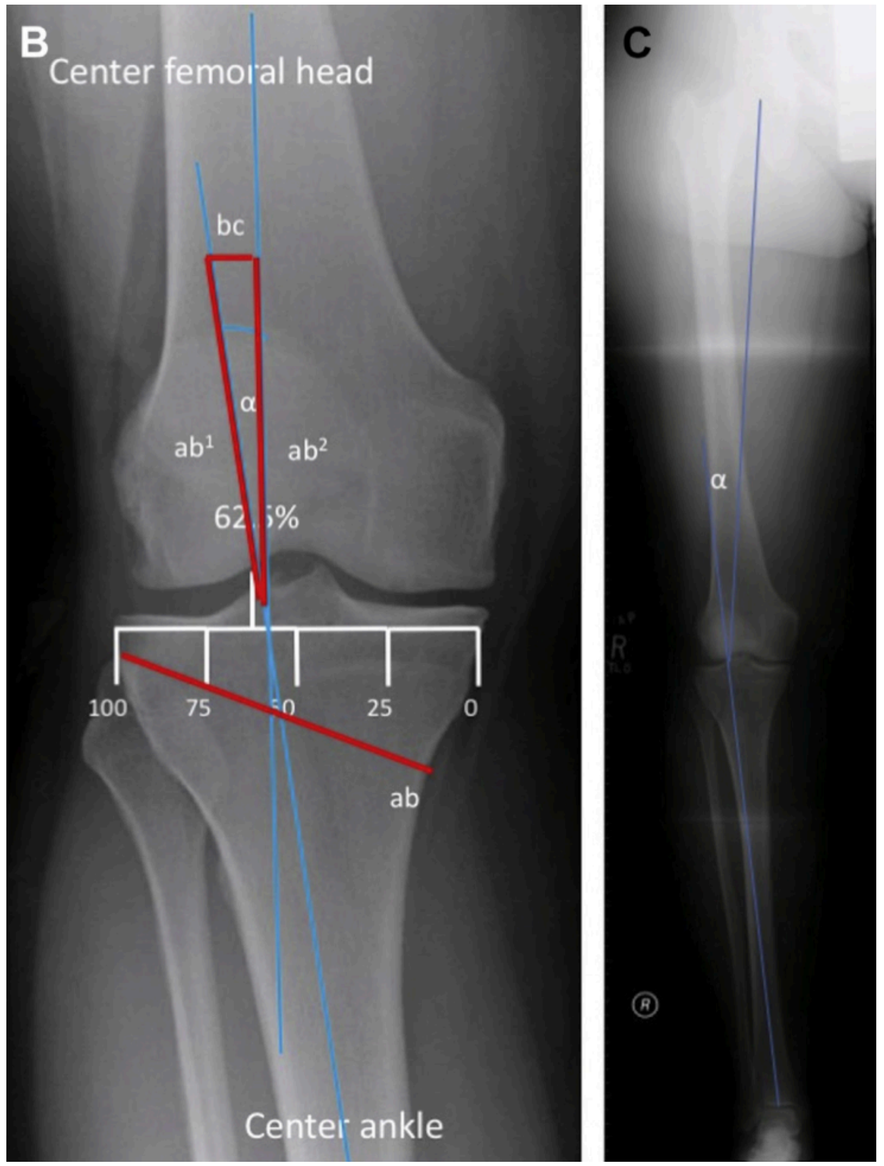
- Yes, closed Wedge HTO helps to decrease posterior tibial slope.
- However, **in most of the studies on combined HTO and ACL-R, an OWHTO is performed because it is more accurate for correction, integrates the ACL graft revision and allows also for PTS modification.**
- If a combined procedure is performed, the osteotomy should be performed first in order not to damage the graft.
- **The plate should be positioned more posteriorly compared with a standard HTO in order to avoid PTS increase and to leave more space for ACL tunnel on the tibia.**
- Postoperatively, complete weight-bearing is allowed between 4 and 8 postoperative weeks, ROM exercise may be early started.



Open Wedge HTO planification

- OWHTO is planned with a **line from the center of femoral head to the 62.5% tibial plateau (from medial to lateral, a line) and another line from the center of the ankle to the same point of tibial plateau (b line)**. The angle between the 2 lines (alpha) is the correction angle. The osteotomy line (ab) is performed from medial (4 cm under the joint line) to lateral (1 cm below the joint line). The length of ab line is transferred on both lines passing from 62.5% of the tibial plateau, and according to trigonometric rules, **bc is equal to the opening needed.**

- **62.5% allows slight valgus overcorrection (3-5°); <u>50% is used for neutral alignement.</u>**

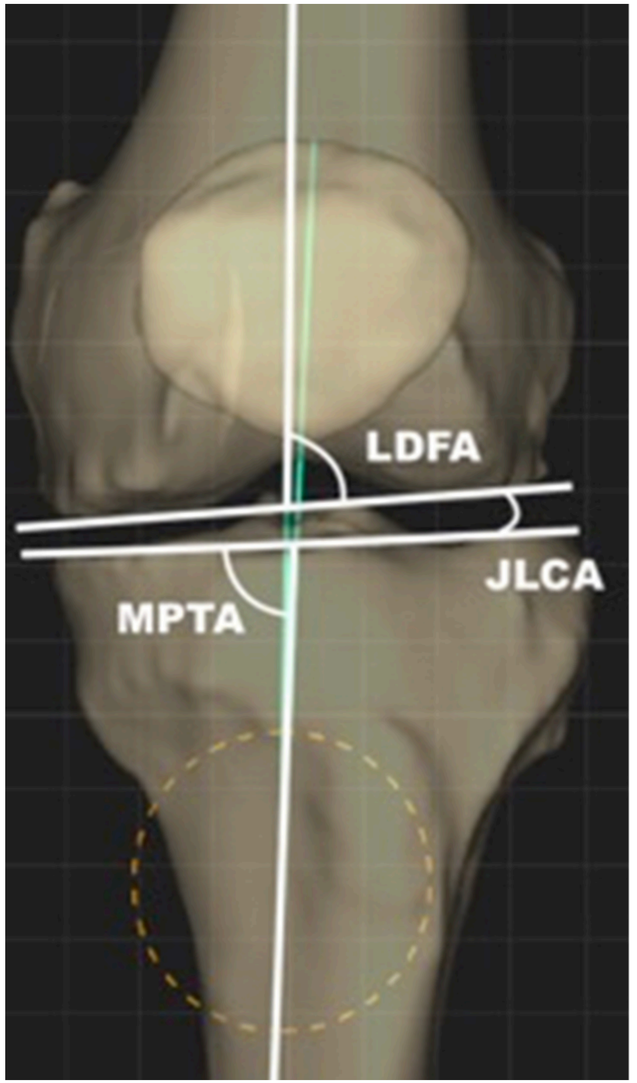


Dugdale TW, Noyes FR, Styer D. Preoperative planning for high tibial osteotomy. The effect of lateral tibiofemoral separation and tibiofemoral length. Clin Orthop Relat Res. 1992 Jan;(274):248-64.

Cantivalli A, Rosso F, Bonasia DE, Rossi R. High Tibial Osteotomy and Anterior Cruciate Ligament Reconstruction/Revision. Clin Sports Med. 2019 Jul;38(3):417-433.

Open Wedge HTO planification

- The **joint line convergence angle (JLCA)**: defined as the angle between the tangent to the most distal part of the medial and lateral femoral condyle and the subchondral plate of the tibial plateau.
- JLCA must be integrated in the calculation.
- Otherwise, risk of overcorrection.

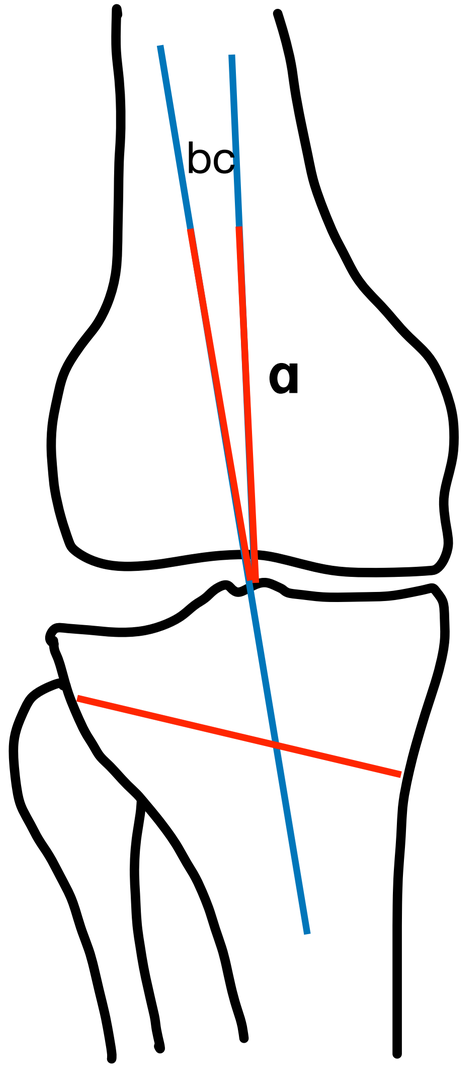


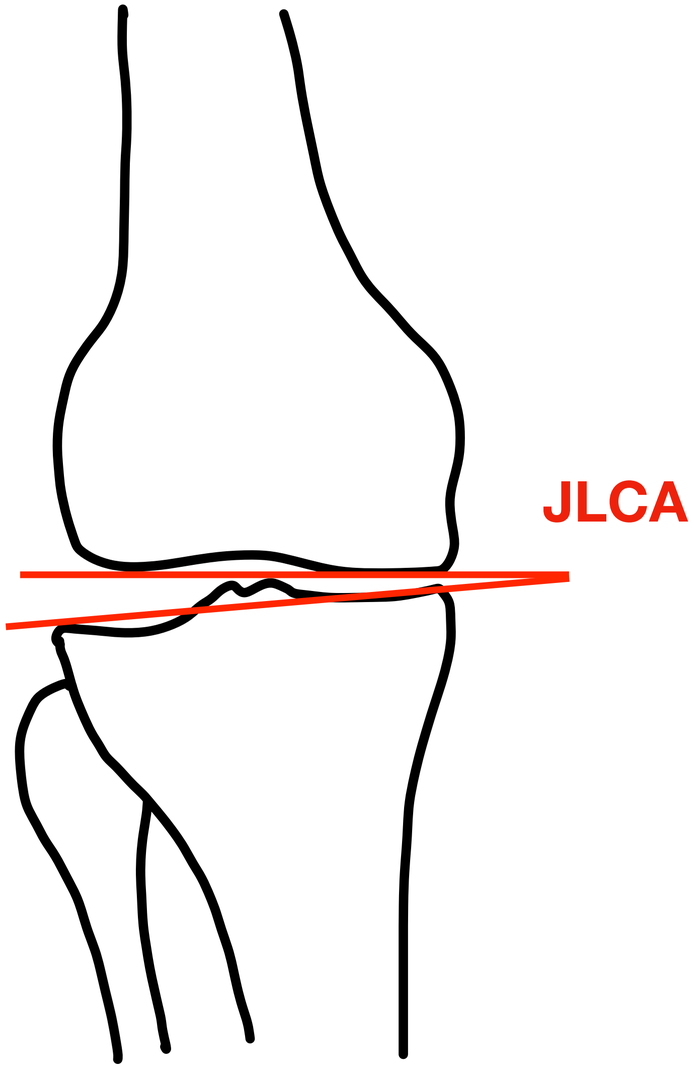
Micicoi et al. Managing intra-articular deformity in high Tibial osteotomy: a narrative review. Journal of Experimental Orthopaedics (2020)

Open Wedge HTO planification

- The **joint line convergence angle (JLCA)**

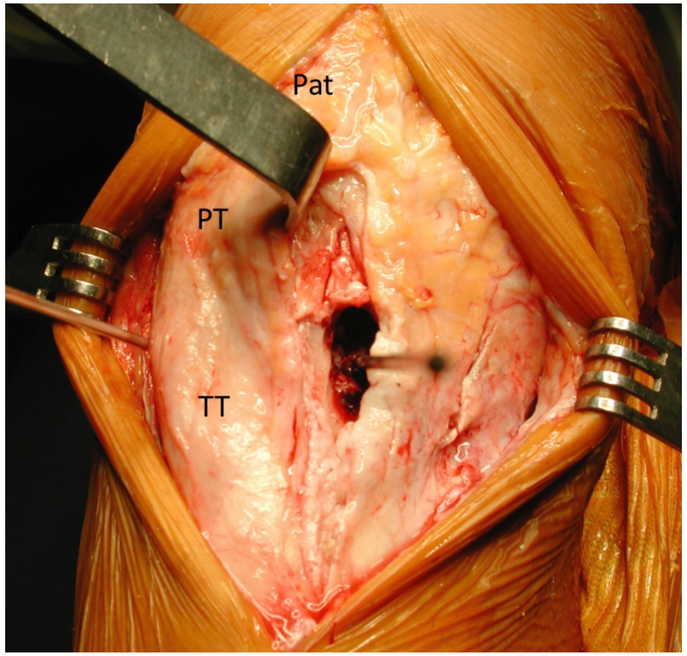
- **Risk of overcorrection**

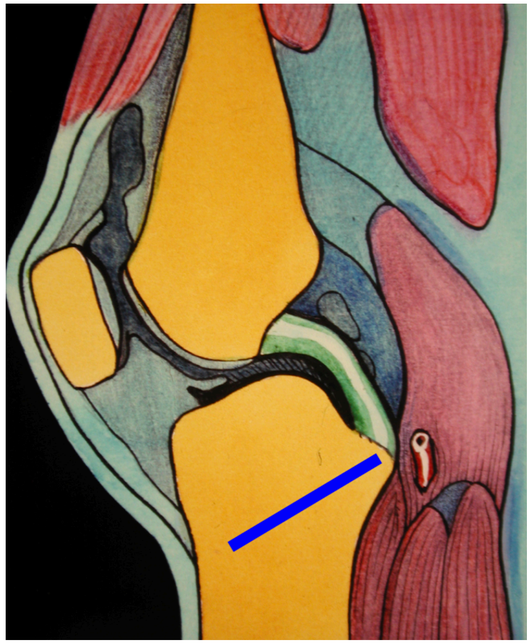




Surgical techniques: deflexion

- Osteotomy should be performed with the knee in **90° of flexion to minimize risk to neurovascular structures.**
- The anterior closing wedge osteotomy is performed **just proximal to the attachment site of the patellar tendon.**

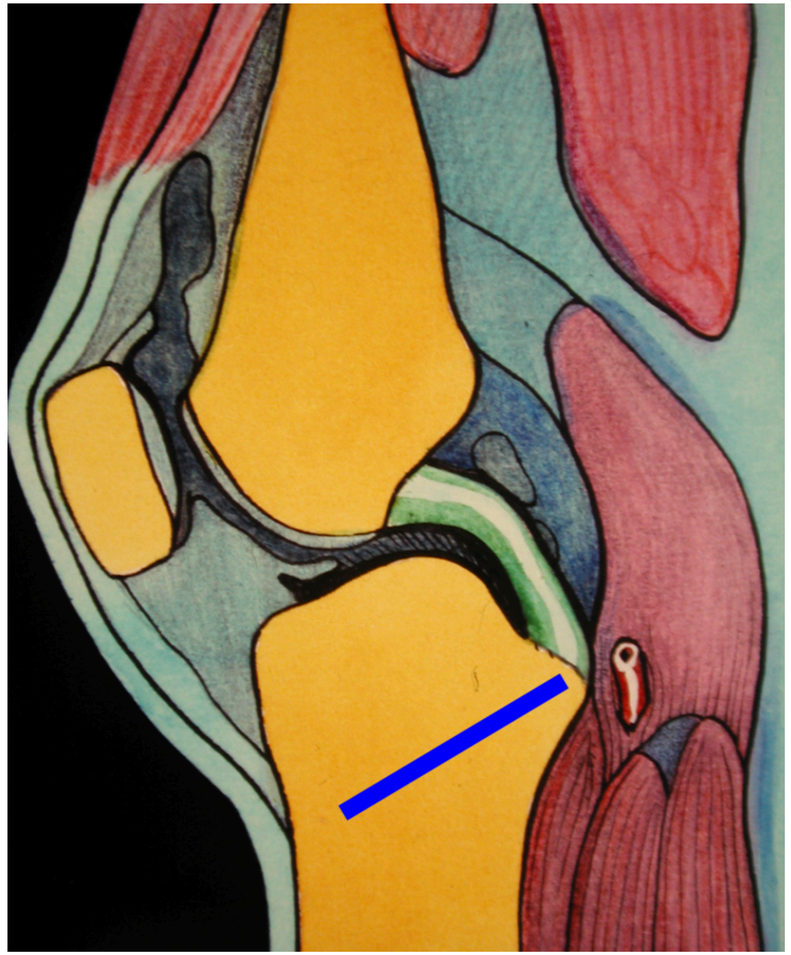




Magnussen RA, Dahm DL, Neyret P (2013) Osteotomy for slope correction following failed ACL reconstruction. In: Marx RG (ed) Revision ACL reconstruction: management and surgical technique. Springer, New York

Surgical techniques: deflexion

- **Guidepins.**
- As a general rule, **each 1 mm of closing results in a slope change of approximately 2°.**
- It is critical that the pins enter the posterior tibial cortex **proximal to the tibial insertion of the posterior capsule of the knee joint** in the area of the tibial attachment of the PCL. This location is key to ensuring the **integrity of the posterior hinge during closure of the osteotomy.**



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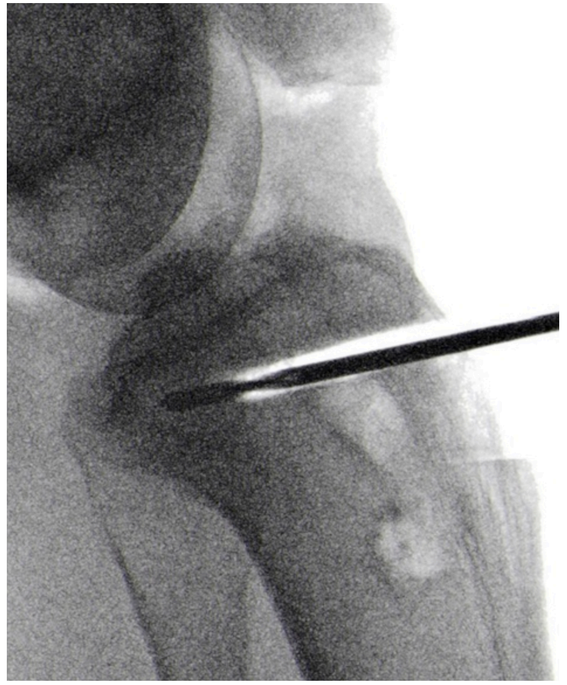
Surgical techniques: deflexion

- The posterior cortex is **perforated** numerous times with a **3.5 mm drill**.
- One can then gently extend the knee, closing the osteotomy. Fixation is achieved with **two large staples, one on either side of the patellar tendon.**



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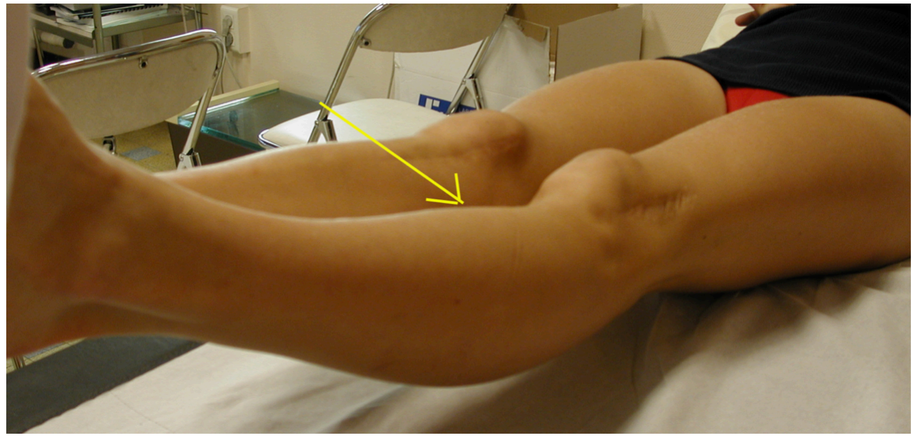
Surgical techniques: deflexion

- Ensures symmetrical closure of the osteotomy site to **avoid varus deformation.**
- Treatment of important recurvatum?



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Evidence

- **Revision ACLR combined with HTO resulted in significant improvements in anterior tibial translation, anterior laxity, posterior tibial slopes (especially in patients with posterior tibial slopes greater than 12°), subjective IKDC scores, Tegner–Lysholm scores, and VAS pain scores.**
- Notably, there was a **0% re-rupture rate compared to ACLR revision failures rates ranging from 2 to 28%**
- Concerning **Osteoarthritis, there is no evidence to know if there is high benefit**.
- **Low rate of complications.**
- Currently, there is **no comparative data on patients who receive a combined HTO and ACLR versus patients who receive ACLR alone or HTO alone**; therefore, although the results were overall positive in this review, it is unclear how much the addition of the HTO adds to these outcomes.

Gupta A, Tejpal T, Shanmugaraj A, Horner NS, Simunovic N, Duong A, Ayeni OR. Surgical Techniques, Outcomes, Indications, and Complications of Simultaneous High Tibial Osteotomy and Anterior Cruciate Ligament Revision Surgery: A Systematic Review. HSS J. 2019 Jul;15(2):176-184.

Evidence

- **Lack of high-quality studies with large sample sizes in the literature pertaining to simultaneous HTO and ACLR revision and heterogeneity** (due to inconsistency in patients, pathology, surgical techniques, length of follow-up, and outcomes). All studies in this review are of **level III and IV** evidence, with small sample sizes.

- The use of HTO along with ACLR revision seems promising due to the good post-operative functional outcomes, low complication rates, and no observed re-ruptures.

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Conclusion

- Any evaluation of knee ligament deficiency must integrate **complete assessment of the knee geometry** particularly the varus alignement (Primary, double and triple) and the posterior tibial slope.
- Missing these deformation increases the **risk of ligament reconstruction failure**.