

Technical User Guide for Patient-Specific Instrumentation (PSI) for Knee Osteotomy



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Surgical Preplanning and PSI Guides in Knee Osteotomy

Arthrex has been instrumental in advancing the surgical approach to knee osteotomies, focusing on high-precision implants, fixation systems, and supportive instrumentation designed to optimize surgical accuracy and reproducibility in high tibial osteotomy (HTO) and distal femoral osteotomy (DFO) procedures. Arthrex innovations emphasize minimally invasive approaches and strong fixation to facilitate early mobilization and optimal patient outcomes.

As a pioneer in this space, Arthrex is dedicated to the continuous innovation of osteotomy procedures, including adopting a digital surgical preplanning system. This system provides the ability to simulate corrections virtually, predict outcomes, and select implant size with high accuracy.¹ The introduction of patient-specific instrumentation (PSI) is a transformative leap in precision. PSI guides are custom-designed for each case based on the patient's CT imaging, simplifying preoperative planning and reducing manual intraoperative adjustments and surgery time.¹ Combining preplanning software and PSI aligns real-world execution with virtual planning, enhancing accuracy and patient safety.¹

- › **High Correction Accuracy:** Preoperative digital planning allows precise angular calculations and hinge point identification, while PSI guides ensure intended correction is replicated during surgery, reducing the risk of under- or overcorrection.^{1,2}
- › **Efficiency and Reduced Surgical Time:** Customized cutting guides eliminate the need for multiple intraoperative adjustments and repeated fluoroscopic checks. A streamlined workflow enhances operating room efficiency.³
- › **Improved Patient Safety:** Minimizes intraoperative variability and human error and reduces radiation exposure for patients and surgical staff by limiting fluoroscopy.³
- › **Better Implant Fit and Alignment:** A preplanned patient-specific approach leads to accurate implant positioning, enhances fixation stability, and supports long-term clinical outcomes.^{1,4}
- › **Enhanced Predictability and Consistent Outcomes:** Virtual osteotomy planning predicts postoperative mechanical axis alignment and joint line preservation,^{1,2} which are critical for long-term joint function.

All information in this guide is considered confidential unless available at <https://www.3d-side.com>. Products are subject to local regulations and product availability may be limited.

CT Scan Parameters

Patient Position

- › Standard position for a CT scan

Scan Type

- › Helical CT scan without contrast (no arthrography)

Region of Interest

- › 10 cm proximally and distally to the joint

Image Parameters

- › Continuous slices of <1 mm thickness at the osteotomy site
- › Slice thickness <2.5 mm at the secondary site
- › For DFO, HTO: 1 mm thickness on the knee, 2.5 mm thickness on the hip and ankle

Reconstruction Parameters

- › Metal artifact reduction should be applied when hardware is present
- › Standard algorithm without edge enhancement
- › Bone filter is suitable
- › Any filter beneficial to the diagnosis can be applied additionally to the primary acquisition
- › No gantry tilt
- › No oblique reconstructions

Important: Do not change the image parameters or concatenate several CT scan acquisitions into one scan.

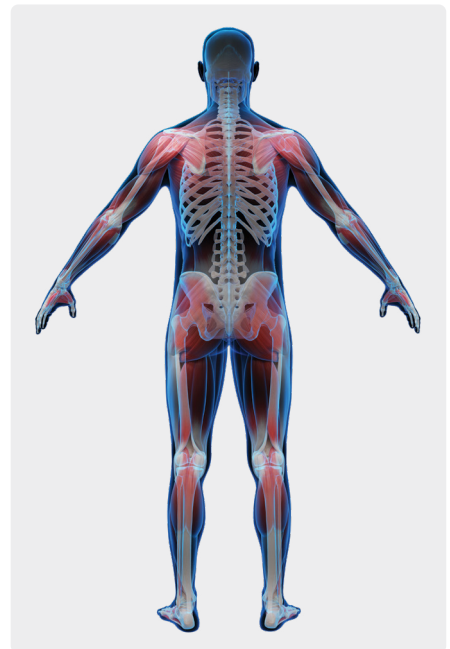
Sending the Scan

Upload CT scans to: <https://arthrexpsi.com/upload>

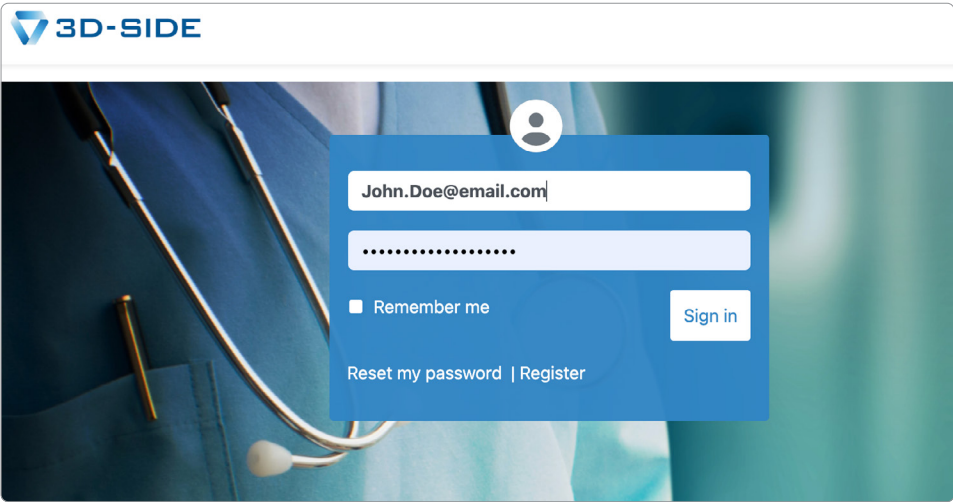
CT Scan Acquisition Protocol

CT Scan Parameters

Patient position	Standard CT scan position
Scan type	Helical CT scan without contrast (no arthrography)
Region of interest	› 3 joints: hip, knee, and ankle › 10 cm proximally and distally to the joint › Both legs
Image parameters	At the osteotomy site › Continuous slices of <1 mm thickness Secondary site › Slice thickness <2.5 mm For example: DFO and HTO <1 mm slice thickness at the knee, <2.5 mm slice thickness at the hip and ankle
Reconstruction parameters	› Metal artifact reduction should be applied when hardware is present › Standard algorithm without edge enhancement › Bone filter is suitable › Additional filters deemed beneficial for diagnosis can be applied to the primary acquisition › No gantry tilt › No oblique reconstructions
Do not:	› Change the image parameters › Concatenate several CT scan acquisitions into one



Website Account Creation or Login



1

Navigate to <https://arthrexpsi.com/login>

| **Note:** Returning users will enter login information and skip to the “Timeline View” step (see page 8).

New Users

1

Click “Register” or navigate to <https://arthrexpsi.com/register> to set up an account.

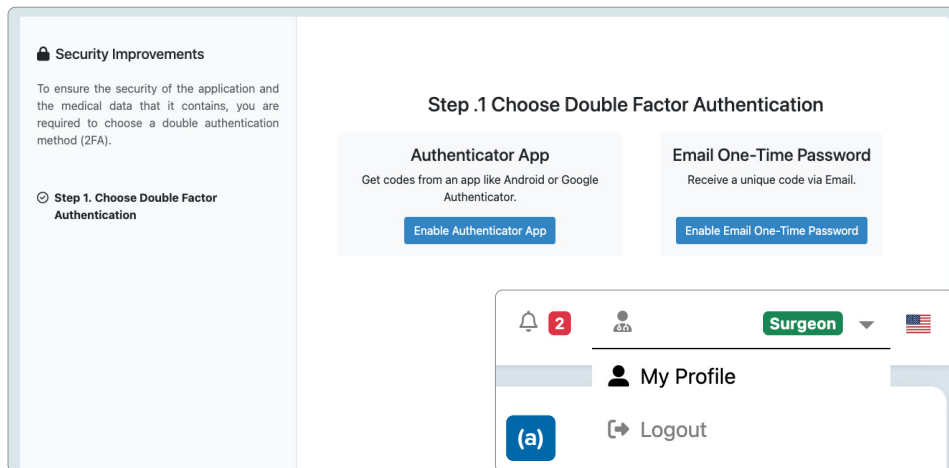
Fill out basic information **(a)**:

- › Enter and confirm email
- › Create password
- › Select role, either “Surgeon” or “Sales Representative” **(b)**

2

Accept the data processing policy and click “Next” to fill out address information **(a)**.

Two-Factor Authentication

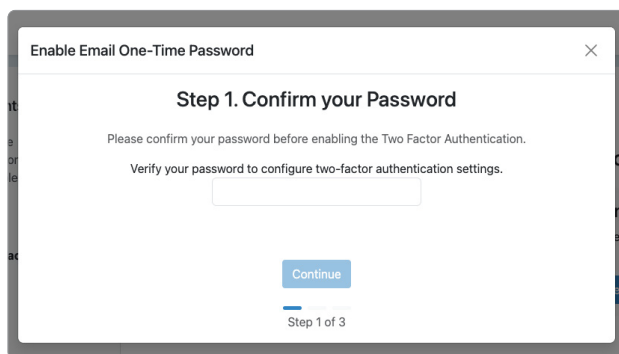


To comply with GDPR and HIPAA recommendations and reinforce the security of this platform, two-factor authentication is enabled.

- › New users will choose their preferred authentication method, either a six-digit code via email or the Google Authentication App.

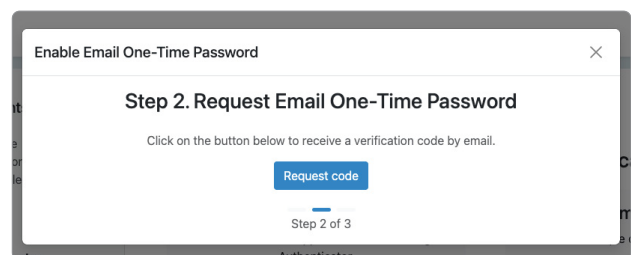
Users can change their authentication method in their profile management page under “My Profile” at the top right of the page, under the user’s name **(a)**.

Email Authentication



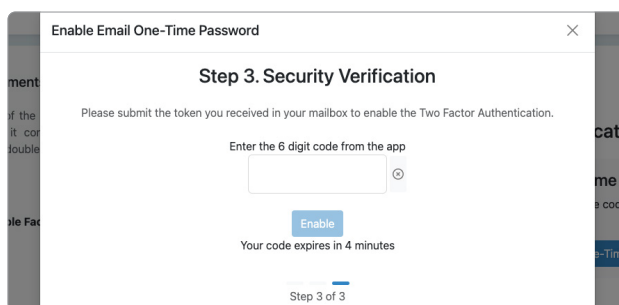
1

For email authentication, click “Enable Email One-Time Password,” then enter the password sent to the provided email address.



2

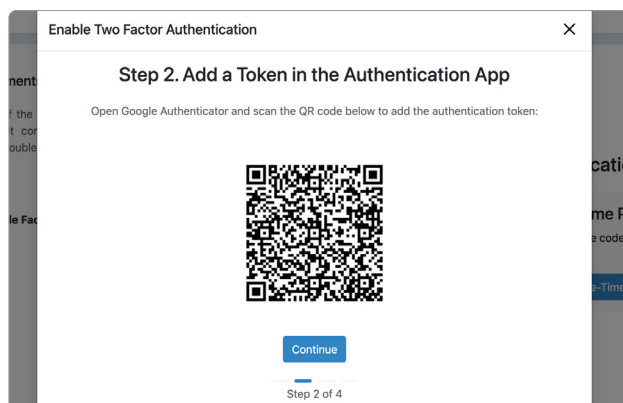
Click on “Request code.”



3

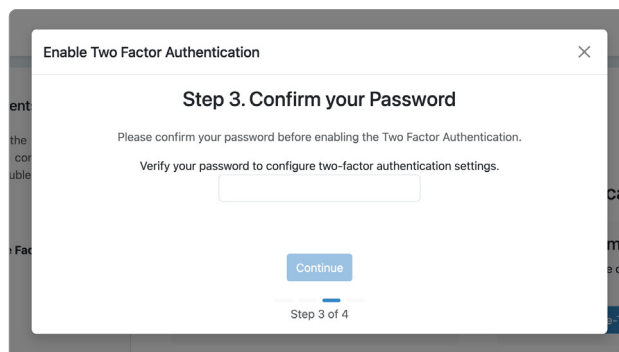
Enter the code sent to the provided email address.

Google Authentication App



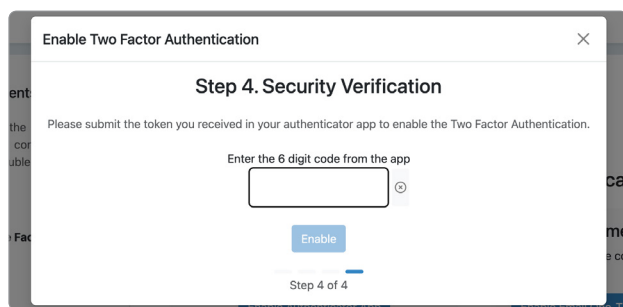
1

To use Google two-factor authentication, add a token in the authentication app by scanning the QR code displayed on the webpage then click “Continue.”



2

Confirm your password.

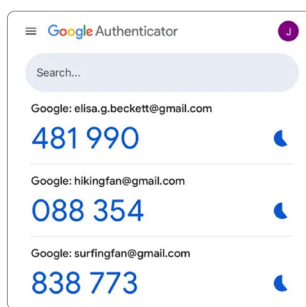


3

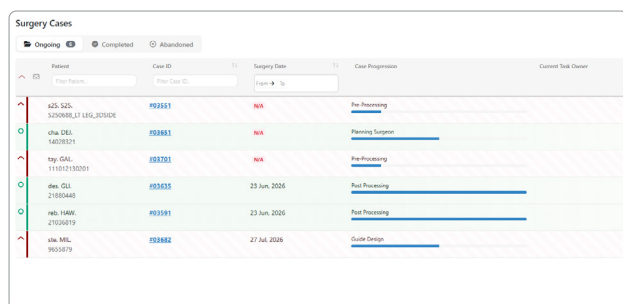
Enter the six-digit code found in the app into the space provided and click “Enable.”

Note: The code refreshes every 30 seconds.

Optional: If you have entered an incorrect code or need to switch accounts, click “Cancel Authentication Process” and restart the process.



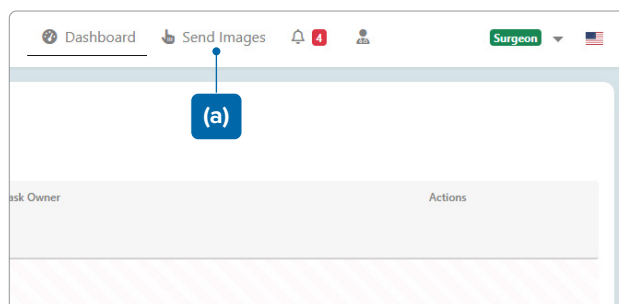
Website Timeline View



1

Bookmark <https://arthrexpsi.com/> to easily navigate to Timeline View, which is the standard landing page for users after creating an account.

- Surgeon users will see their upcoming cases and due dates, with high-priority tasks clearly marked.
- Arthrex sales representatives will see all currently pending cases for all surgeons.



2

To create a new case and upload a new CT scan, click “Send Images” at the top right of the screen (a).

Case Creation

1

Navigate to <https://arthrexpsi.com/upload>

For proper CT scan protocol, visit <https://www.arthrex.com/resources/DOC1-002268-en-US/knee-osteotomy-ct-scan-protocol-for-patientspecific-instrumentation?objectID=human.resource.en.3f110cd8-69c8-4114-89db-50c39249281a&queryID=b584551b8f0ef5052f10de7b52e9f4c7>

2

If using a preregistered account, surgeon information will be prefilled. Otherwise, fill out surgeon information including the surgery details.

Note: The surgery date must be at least 4 weeks in the future to allow time for the PSI guide to be created and shipped.

3

Under “Pathology,” the user must select “Osteotomy” (a), then “Surgical Side” (left or right) for the scan to be uploaded (b).

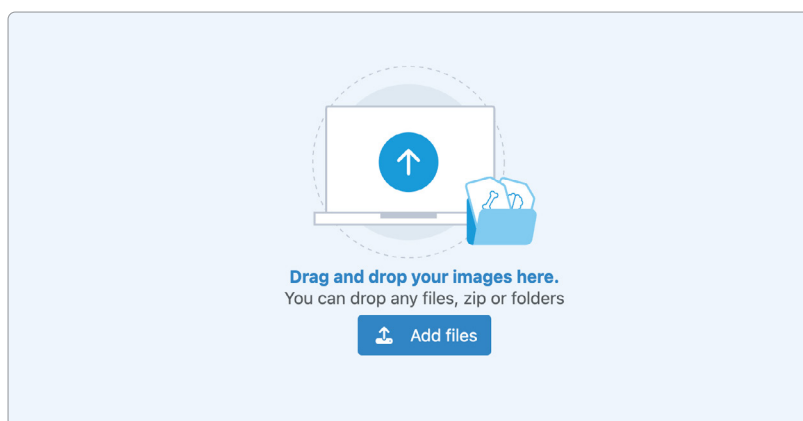
Select “Location” to choose a procedure type (ie, DFO or HTO) (c).

4

Add case details such as desired correction angle, concomitant procedures, and/or patient history in the “Additional Information” box.

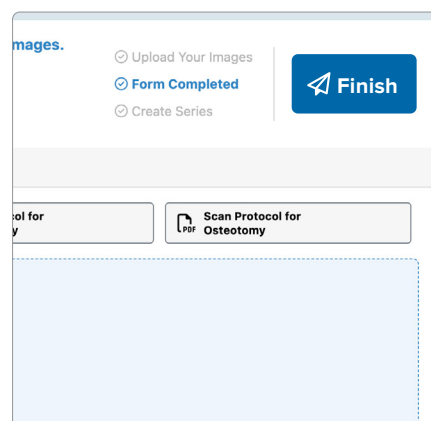
If a specific fixation method is desired (ie, the ContourLock™ plate, iBalance® system, or 4-hole technique), add the fixation method in the “Fixation” box (a).

Note: If left blank, the 3D-Side design team will suggest an appropriate fixation method.



5

After completing all fields, upload DICOM images by dragging the image files to the “Upload Images” field or selecting your file location using the “Add files” button.



6

After uploading files, click the “Finish” button at the top right of the screen.

Note: A confirmation email with further instructions will be sent to the address provided upon login.

Clinical Planning Reference

For ContourLock™ HTO and DFO, iBalance® HTO, and 4-Hole Plate HTO Systems

HTO and DFO are established joint-preserving procedures that redistribute mechanical load away from the affected compartment. HTO targets varus malalignment with medial compartment overload; DFO addresses valgus malalignment with lateral compartment disease. Both procedures offer a biologically active, bone-preserving solution for active patients less than 65 years old, potentially delaying or eliminating the need for arthroplasty in appropriately selected patients.⁵

A systematic review of 69 studies (4557 patients) found isolated HTO survival of 92.4% at 5 years, 84.5% at 10 years, 77.3% at 15 years, and 72.3% at 20 years,⁶ with up to 96.3% at 5 years using modern techniques even in advanced osteoarthritis (OA) cases.⁵

For DFO, pooled evidence shows a mean 80% survival rate at 10 years,⁷ supporting both procedures as clinically durable joint preservation options.

Note: Correction quality is the single-most modifiable predictor of HTO and DFO survivorship.^{1,8-10} Undercorrection (defined as a post-HTO hip-knee-ankle angle of <183°) is a statistically independent failure predictor.^{1,8-10} Patient-specific instrumentation is an evidence-supported mechanism for closing the gap between planned and executed correction.^{1,8-10}

Preoperative Planning Integration and Scope

- › CT segmentation of femur and tibia with automated landmark acquisition
- › Full coronal deformity analysis: HKA, MPTA, mLDFA, JLCA, MAD, TEAD%, and FEAD%
- › Sagittal slope measurement and planned slope-change simulation, which controls the primary sagittal risk of HTO^{11,12}
- › Correction simulation with real-time MPTA, mLDFA, and JLO verification against ESSKA safety limits¹³
- › Patient-specific cutting guide design compatible with ContourLock (HTO and DFO) and iBalance instrument sets
- › Published PSI accuracy: mean HKA error 0.8°, all cases within ±2° of target^{1,10}

Arthrex System Selection

Implant selection should be confirmed with your Arthrex representative using the procedure-specific instrument set and surgical technique guide. Biomechanical testing supports the mechanical strength of the ContourLock™ and iBalance® systems.¹⁴

System	Application	Key Design Features	Planning/PSI Notes
ContourLock HTO plate system	Opening or closing wedge proximal tibial osteotomy; varus correction, medial OA	➤ 3 plate variations: straight wedge, A/P sloped wedge, and flat ➤ Titanium, anatomically curved, low-profile ➤ Improved locking bushing; no separate locking guide required ➤ Best fatigue strength performance among compared HTO implants with an ultimate failure load of 2.2 kN after 173,000 cycles¹⁴	A/P sloped wedge variant used when intentional PTS reduction is planned directly addresses the slope-increase problem of standard opening wedge HTO. PSI cutting guide maps to plate size and wedge variant preoperatively.
ContourLock DFO plates and screws	Opening wedge DFO for valgus correction; lateral OA with femoral-origin deformity (mLDFA <87°)	➤ Right and left anatomic titanium plates available in multiple sizes ➤ Toothless design with infinite correction up to 20 mm ➤ Mobile bushing; screw angulation locks before final fixation ➤ Thin, low-profile guide minimizes soft-tissue irritation	Plate size selected by planned correction gap (mm), derived from preoperative mLDFA/HKA targets. Approach from distal femoral diaphyseal-metaphyseal flare—no medial exposure. PSI cutting guide eliminates need for intraoperative estimation of correction angle.
iBalance HTO system (PEEK)	Medial opening wedge, slope preserving HTO, varus correction; particularly suited for patients preferring metal-hardware-free construct	➤ PEEK anchors for permanent implantation, with no planned hardware removal in most cases ➤ Instrument system creates a locked-retractor safety envelope ➤ Easy-to-adopt technique ➤ Compatible with Arthrex orthobiologics and all osteotomy implants	iBalance instrument system provides both coronal and sagittal alignment controls for direct intraoperative slope management. PSI cutting guide integrates with iBalance instrument set for preplanned slope target.
4-hole plate	Opening wedge proximal HTO; optimized for lower-demand patients and/or a minimally invasive surgical approach; available in titanium (locking) or stainless steel (bendable for unique anatomy)	➤ Simple, low-profile 4-hole design ➤ Titanium version: ➤ Swiveling, locking bushing; each screw angles to proper anatomic orientation before locking ➤ Available with straight teeth (to preserve native PTS) or sloped teeth (to intentionally modify PTS) ➤ Stainless steel version: ➤ Bendable for nonstandard anatomy ➤ Nonlocking standard AO screws Note: Both versions use 6.5 mm cancellous and 4.5 mm cortical screws.	Plate selection (straight vs sloped tooth) mirrors PSI preoperative planning. Slope target is defined in 3D-Cut and drives tooth variant selection. Titanium 4-hole plate is MIS compatible, lower-profile than ContourLock plate, and most suitable for corrections of ≤12 mm; stainless steel plates can be used when plates need to be contoured intraoperatively to fit unique tibial morphology.

Note: For double-level osteotomies, when an isolated HTO would produce a planned MPTA of >94° or a JLO of >5°, use both ContourLock HTO and ContourLock DFO plates to distribute correction across both levels. PSI software will divide the correction proportionally across both levels.

Correction Targets, PSI Accuracy, and Safety Limits

Preoperative simulation should verify that the planned correction achieves target alignment without violating ESSKA limits.¹⁵ Published data on HTO found a mean HKA error of only 0.8° relative to the plan, with all cases within ±2° of target, outperforming conventional freehand techniques and comparable to or better than navigation, particularly for slope control.^{1,9,10}

Parameter	HTO correction target	DFO correction target	Safety limits and cautions
HKA	183°-186° (mild valgus overcorrection) ^{4,8,16}	177°-179° (neutral to minimal varus) ^{7,17}	Undercorrection HKA <183° post-HTO: independent predictor of failure ^{8,18}
MPTA	90°-93° ¹³	Not modified by DFO	ESSKA hard limit: post-HTO MPTA ≤94°; if planned >94°, add DFO or DLO ¹⁹
mLDFA	Not modified by HTO	88°-92° ^{9,17}	Preoperative LDFA >90° signals need for femoral-level correction ¹⁹
WBL/MAD	Fujisawa point: 62% lateral tibial width ⁸	Slight lateral to neutral axis ⁷	Confirm fluoroscopically hip-to-ankle intraoperatively
JLO	≤5° (ESSKA limit) ²⁰	≤5°	Planned JLO >5° → isolated HTO contraindicated; escalate to DLO ²⁰
PTS	Preserve native slope ±3°; intentional reduction for ACL-deficient/reconstructed knees ^{11,12}	Not directly affected	Opening wedge HTO increases slope +1°-4° by default; PSI with slope-specific guide controls this; conventional technique does not reliably ^{10,14}
Implant (3D-Cut) accuracy	PSI achieves significant improvement in HKA with no significant differences between planned target value and postoperative correction value ¹⁰	PSI improves coronal accuracy vs conventional: SMD 0.52, <i>P</i> = 0.004 ¹	Conventional freehand technique: alignment accuracy is “limited”; navigator reduces outliers but does not reliably control tibial slope ^{10,19}

Note: Intraoperative fluoroscopic WBL confirmation (hip-to-ankle) remains mandatory regardless of preoperative planning accuracy. Fujisawa target: WBL at 62% of tibial width from medial plateau.⁸

Preoperative Planning Parameters

All coronal measurements derive from standardized long-leg standing AP radiographs (full-limb, weight-bearing). Posterior tibial slope is measured on a true lateral tibial radiograph. For patient-specific guide design, 3D CT-based planning is required and provides the highest accuracy for multiplanar deformity assessment.^{9,10}

Priority Legend

- ★★★ Primary: Drives osteotomy level and correction amount
- ★★★ Secondary: Influences planning; derived or confirmatory
- ★★★ Tertiary: Document; minor planning relevance for isolated HTO/DFO

Parameter	Abbreviation	Normal value	HTO context	DFO context	Planning role	Priority
Hip-knee-ankle angle (global alignment)	HKA	177°-180°	<177° (varus) → target 183°-186° ^{9,13,21}	≥183° (valgus) → target 177°-179° ^{7,17}	Primary global alignment. Determines procedure selection. Corrected by osteotomy. Undercorrection (HKA <183° post-HTO) is independent predictor of failure. ⁸	★★★
Mechanical lateral distal femoral angle	mLDFA	85°-90°	Normal (<90°) → HTO indicated; abnormal (>90°) → DFO or DLO ²⁰	<87° = primary DFO indication; target: 88°-92° post-DFO ^{7,17}	Identifies femoral vs tibial source of deformity. Drives DFO vs HTO decision. ESSKA: abnormal LDFA >>90°. ²⁰	★★★
Medial proximal tibial angle	MPTA	85°-90°	<85° = tibial varus; HTO target: 90°-93°; ESSKA limit: ≤94° post-HTO ^{13,20}	Remains unchanged by DFO (tibial correction not performed)	Quantifies tibial contribution. Drives HTO correction amount. Postoperative MPTA is leading predictor of WOMAC success after HTO. ¹³	★★★
Joint-line convergence angle	JLCA	0°-2°	>2° = intra-articular component; partially reduces with load redistribution post-HTO ^{13,20}	JLCA >3° suggests intra-articular valgus; DFO indicated for femoral source ^{7,17}	Separates intra- from extra-articular deformity. JLCA >6° signals significant intra-articular disease. ²⁰	★★★

Parameter	Abbreviation	Normal value	HTO context	DFO context	Planning role	Priority
Mechanical axis deviation/weight-bearing line	MAD/WBL	<10 mm medial to tibial spine	Fujisawa WBL target post-HTO: 62% of tibial width (lateral plateau). ⁸	Slight lateral to neutral WBL; confirmed by fluoroscopy hip-to-ankle ¹²	Direct load expression used intraoperatively. Undercorrection of WBL is a primary failure predictor. ^{5,8}	★★★
Posterior tibial slope (critical: sagittal)	PTS	7°-10°	ALERT: Opening wedge HTO increases slope +1°-4° by default. ACL load increases with each additional degree. Target: preserve native slope or intentionally reduce if ACL deficient. ⁹⁻¹¹	Not directly affected by DFO	Primary sagittal parameter for HTO. Uncontrolled slope increase risks ACL failure and tibial subluxation. PSI is evidence-based tool for slope preservation. ⁹⁻¹²	★★★
Joint-line obliquity (post-op limit)	JLO	≤5°	ESSKA: contraindicated if planned JLO >5° or MPTA >94°. ²⁰	Monitor post-DFO for balanced joint line	Post-op safety limit. Excessive obliquity risks mediolateral instability and early revision. ¹³	★★★
Tibial extra-articular deformity %	TEAD%	N/A	High TEAD% (>50%) = strong isolated HTO candidate. Outcome predictor for sport return in AKUMA cohort. ^{13,22}	Not applicable to DFO planning	AKUMA deformity attribution. Higher TEAD% = stronger isolated HTO application. Drives DFO/DLO discussion. ^{13,22}	★★★
Femoral extra-articular deformity %	FEAD%	N/A	High FEAD% (>50%) → DFO or DLO. Software-driven detection improved DFO identification in 28% of HTO candidates. ²⁰	High FEAD% is the key DFO application ^{7,17}	AKUMA deformity attribution. FEAD% >50% triggers level reassessment. ^{13,20,21}	★★★
Patellar height (Caton-Deschamps index)	CDI	0.8°-1.2°	Opening wedge HTO can reduce patellar height. Monitor with corrections >10°. ²²	Less affected; monitor with large corrections	Tertiary sagittal parameter. Relevant for PF symptom screening, particularly post-DLO. ²²	★★★
Tibial torsion	TT	20°-40° external	Not corrected by HTO alone. Flag for concomitant derotational osteotomy if >2 SD from normal.	Not corrected by DFO	Low priority for isolated HTO/DFO. Document; flag if derotational correction planned.	★★★
Limb length discrepancy	LLD	<10 mm	Opening wedge HTO creates minor effective lengthening. Document pre-op baseline. ²²	Minimal effect; document pre-op	Low priority for isolated HTO/DFO unless significant preexisting LLD (>15 mm).	★★★

Note: Tibial torsion and LLD are tertiary for isolated HTO/DFO. Significant preexisting LLD (>15 mm) should be documented preoperatively and may prompt discussion of staged correction.

Posterior tibial slope is elevated to primary (sagittal) because opening wedge HTO systematically increases slope by 1°-4°. ^{9,10} In ACL-deficient or post-ACL reconstructed knees, uncontrolled slope increase substantially raises anterior tibial subluxation risk. PSI with a slope-specific guide is the evidence-supported intervention for slope management. ^{11,12}

Patient Selection Summary

AKUMA gray-zone patients (overlapping intra- and extra-articular deformity, Ahlbäck classification II-III) represent the most complex decision point. HTO in this group provides reliable pain relief and functional improvement (72% WOMAC success) but limited sport recovery (6.8% Tegner ≥ 5).¹³ Osteoarthritis burden, not deformity magnitude, is the primary predictor of pain/function outcomes.^{13,21}

Criteria	HTO (varus/medial OA)	DFO (varus/lateral OA)
Age	<65 years; younger age improves survivorship: 87% at 10 years for <55 years vs 63% for ≥ 55 years ¹⁸	Active patients <65 years; younger preferred ^{7,17}
BMI	<30 kg/m ² preferred; BMI ≥ 30 is independent predictor of TKA conversion ^{5,18}	<30 kg/m ² preferred ⁷
HKA (global alignment)	Varus HKA <177°; mean preoperative HKA ~173° in literature ^{5,13}	Valgus HKA >183°; exclude if HKA >195° (valgus >15°) ^{7,17}
Tibial deformity (MPTA)	MPTA <85° confirms tibial source: HTO preferred ^{13,20}	MPTA typically normal; femoral correction targeted ⁷
Femoral deformity (mLDFA)	Normal mLDFA (85°-90°) → isolated HTO; abnormal (>90°) → DFO or DLO ²⁰	mLDFA <87° = primary DFO application ^{7,17}
OA grade	Ahlbäck I-II ideal; meta-analysis confirms acceptable outcomes even in Ahlbäck ≥ 2 (96.3% 5-year survival) ⁶	KL III-IV acceptable if lateral compartment isolated ^{7,17}
Knee stability	Stable or stabilizable (concomitant ACL reconstruction acceptable) ¹³	Stable or stabilizable
ROM	Full extension, flexion $\geq 120^\circ$	Full extension, flexion $\geq 120^\circ$
Posterior tibial slope (HTO)	Preserve native slope; avoid increasing PTS >12°; in ACL-deficient knee: target slope reduction ^{11,12}	Not a primary DFO selection driver

Additional Considerations

When to Escalate From Isolated HTO to DLO

- › Planned post-HTO MPTA >94° (ESSKA contraindication for isolated HTO)¹³
- › Planned JLO >5° post-HTO¹³
- › Preoperative mLDFA >90° (significant femoral contribution)^{13,20}
- › FEAD% >50% (femoral deformity exceeds tibial contribution)^{13,21}

Posterior Tibial Slope (HTO-Specific Alert)

- › Standard opening wedge HTO increases PTS by 1°-4° by default^{11,12}
- › ACL-deficient/reconstructed knees: avoid slope increase; reduce if possible¹²
- › ContourLock™ A/P sloped wedge or iBalance® sagittal control are the only systems with engineered slope management
- › PSI with slope-specific guide is evidence-supported for PTS control^{11,12}

iBalance System vs ContourLock System Decision Points

- › The iBalance system may be best for patients with a preference for no metal and a surgeon more concerned with soft-tissue impacts than plate prominence and who may need a step-by-step technique.
- › The ContourLock system may be preferred for large corrections (>12 mm gap) that require maximum (2.2 kN fatigue strength)¹⁴; for intentional slope modification with A/P sloped wedge; and for DFO applications (ContourLock DFO system only).
- › Both are compatible with Arthrex orthobiologics.
- › iBalance system is designed for slope-preserving osteotomies.

Survivorship Evidence Summary

HTO Survivorship

- Systematic review of 69 studies (4557 patients) establishes isolated HTO survival at 92.4% (5 years), 84.5% (10 years), 77.3% (15 years), and 72.3% (20 years),¹⁸ with modern improved technique and selection showing 5-year survival up to 96.3% even in advanced OA.⁶
- A 20-year cohort series (n = 100) found a 44% overall survival rate, with the best outcomes in people ages <55 with a BMI of <30.16. Independent failure predictors include a BMI ≥30, FTA of <185° (undercorrection), and Ahlbäck of ≥3.^{5,18}
- AKUMA gray-zone HTO (n = 84, 8-year follow-up): 72% WOMAC success; postoperative MPTA is leading outcome predictor.¹³

DFO Survivorship

- Systematic review of opening- and closing-wedge DFO (372 osteotomies, 16 studies): showed a mean 10-year survival rate of 80%.⁷ A meta-analysis of opening-wedge DFO found a 90.5% survival rate at mean 4.5-year follow-up.¹⁷
- A UK DFO cohort study (n = 81; 99-month mean follow-up) found an 89% 10-year survival rate; other studies found a 64-82% rate at 10 years and 45% at 15 years, which was consistent across all technique variants.²³

References

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