Patient-Specific Preoperative Planning for Single-Plate Fixation of Complex Tibial Plateau Fractures: A Scenario-Based Implant Cost Analysis

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Abstract

Background: Complex tibial plateau fractures, particularly Schatzker IV/AO 41B3.3 patterns, may be treated with either single- or dual-plate fixation. Patient-specific preoperative planning may help guide construct selection, but its economic implications remain unclear. This study aims to estimate the difference in implant acquisition costs between single- and dual-plate fixation and between all-locking and hybrid shaft screw strategies in a defined clinical equipoise scenario.

Methods: A scenario-based implant acquisition cost model compared four constructs defined by two factors: plate count (single medial plate vs. dual medial and lateral plating) and shaft screw strategy (all-locking vs. hybrid, with conventional cortical screws in diaphyseal positions).

Results: Estimated implant acquisition costs were $2,700 (Construct A, single plate, all-locking), $2,340 (Construct A′, single plate, hybrid), $5,100 (Construct B, dual plate, all-locking) and $4,380 (Construct B′, dual plate, hybrid). Single-plate fixation was associated with a cost difference of $2,400 per case under an all-locking strategy and $2,040 per case under a hybrid strategy. Projected annual differences ranged from $12,240 to $40,800.

Conclusion: In this scenario-based model, patient-specific preoperative planning was associated with lower implant acquisition costs when single medial plate fixation was considered feasible in selected Schatzker IV fractures. These findings do not demonstrate that planning changes fixation strategy or reduces institutional costs.

Keywords: tibial plateau fracture; patient-specific planning; preoperative planning; finite element modeling; implant cost; single plate; locking screw; value-based care

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Introduction

Tibial plateau fractures represent approximately 1% of all fractures and a disproportionate share of the surgical workload in orthopedic trauma centers[1]. Open reduction and internal fixation (ORIF) remains the standard of care for displaced intra-articular patterns, aiming to restore articular congruity and enable early rehabilitation[2].

The Schatzker IV/AO 41B3.3 fracture pattern—medial condyle fracture with associated lateral depression—sits at a recognized area of clinical equipoise regarding implant strategy. Whether single medial locking plate fixation provides adequate stability, or whether supplemental lateral plating is required to prevent collapse of the lateral articular surface, is a genuine intraoperative decision that varies widely by surgeon experience and institutional practice[3,4]. Several experienced centers achieve satisfactory outcomes with medial-only fixation; others apply dual plating as a precautionary measure in cases with a broader lateral impression zone[5,6].

The financial consequences of this decision are substantial and underappreciated. Material and implant costs constitute a substantial proportion of the total cost of tibial plateau fracture fixation[7]. Definitive fixation implants for tibial plateau ORIF have been reported at approximately $2,968 per case in large US trauma center cohorts[8]. Adding a second plate system with its associated screws imposes a predictable incremental cost burden without a clearly established clinical benefit in the equipoise subset.

Patient-specific preoperative planning has emerged as a strategy for improving implant selection and intraoperative execution in complex articular fractures. Modern planning platforms integrate computed tomography (CT)-based segmentation, three-dimensional fracture reduction, and templated implant positioning to produce a patient-specific surgical plan prior to incision[9,10]. The OrthoPlanner™ platform (CustomSurg AG, Switzerland) is one such patient-specific preoperative planning system, supporting CT segmentation, virtual reduction, and templated screw planning for periarticular fractures. A recent cadaver study using finite element modeling (FEM) as an independent biomechanical readout demonstrated that patient-specific planned single medial plate fixation of selected Schatzker IV fractures achieved significantly superior construct stability versus conventional planning, with reduced surgeon cognitive workload[11]. Critically, both study arms were fixed with the same single medial plate; the cadaver study therefore evaluated the mechanical performance of a single-plate construct under two planning conditions and did not test whether patient-specific planning influences the choice between single- and dual-plate fixation.

A further dimension of cost reduction lies at the screw level. Locking screws command a 3.6- to 5.8-fold price premium over conventional cortical screws[12,13]. The biomechanical rationale for locking screws is strongest at the periarticular and subchondral levels, where angular stability resists metaphyseal collapse. In the diaphyseal shaft portion of a tibial plateau plate, standard bicortical screws anchoring the plate to intact cortical bone provide mechanically equivalent fixation at a fraction of the cost—a principle well established in the AO hybrid construct philosophy[14].

The purpose of this implant-cost analysis study is threefold: (1) to model implant acquisition cost difference achievable with patient-specific planning that may facilitate implant selection toward single-plate fixation versus dual-plate constructs; (2) to quantify incremental differences from hybrid screw strategies substituting cortical screws in shaft positions; (3) to project these differences at the institutional level for a busy Level 1 trauma center. We hypothesize that patient-specific planning may support implant selection toward less extensive fixation in appropriately selected cases and, when combined with rational screw selection, may represent a clinically defensible institutional strategy for value-based care across the periarticular trauma portfolio.

Methods

Clinical context and equipoise rationale

This study is a scenario-based implant cost model. The clinical substrate is provided by a previously published cadaver study demonstrating the biomechanical feasibility of patient-specific preoperative planning over conventional planning, using a single medial locking

plate in Schatzker IV/AO 41B3.3 tibial plateau fractures, with FEM applied as an independent biomechanical validation readout. The FEM findings support the mechanical feasibility of a patient-specific single-plate construct, while the present model aims to estimate implant acquisition cost differences under a hypothetical scenario. The clinical scenario evaluated represents a subset of Schatzker IV/AO 41B3.3 fractures in which the optimal fixation strategy may be uncertain. Although isolated medial plate fixation may provide sufficient stability for selected fracture patterns, certain morphological characteristics, such as a broad lateral articular impaction zone or fracture characteristics approaching a bicondylar configuration, may lead surgeons to consider supplemental lateral plating. However, no validated radiographic, anatomical, or biomechanical criteria currently exist to reliably identify which fractures can be adequately treated with medial-only fixation versus those that may benefit from supplemental lateral fixation. Recent work on bicondylar tibial plateau fracture-dislocations with an intact anterolateral cortical rim further illustrates this clinical uncertainty. Despite substantial lateral articular involvement, medial-only plating was the predominant treatment strategy, and the authors concluded that a medial-only strategy may be appropriate in selected cases, particularly when soft-tissue swelling limits an additional lateral approach[15]. Thus, the presence or extent of lateral articular involvement alone does not establish a need for lateral fixation, and the decision to add a lateral plate remains dependent on individual fracture morphology, reduction, and surgeon judgment. Therefore, dual plating was modeled as a clinically plausible alternative construct in cases where both fixation strategies would reasonably be considered. The specific dual-plate construct modeled reflects a commonly described configuration for bicondylar tibial plateau fractures. Dual-plate constructs are not standardized, and plate length, screw density, and locking-screw proportion may vary with fracture morphology and surgeon preference. The modeled construct is intended to represent a realistic contemporary configuration rather than the full range of dual-plate variants used in practice. Importantly, the present study does not assume that all Schatzker IV/AO 41B3.3 fractures are candidates for single-plate fixation or that dual plating represents the default treatment strategy for this fracture class. Rather, the economic model estimates potential implant-cost differences within this clinical equipoise scenario[3,4].

Implant construct definitions

Four constructs were defined for cost modeling in a two-by-two structure, defined by plate count (single vs. dual) and shaft screw strategy (all-locking vs. hybrid) (Figure 1):

Construct A—Single medial locking plate, all locking screws: 8-hole medial tibial plateau locking plate with 7 periarticular locking screws plus 3 locking screws in shaft positions (reflecting the mean screw count from the parent cadaver study).

Construct A′—Single medial locking plate, hybrid screw strategy: Identical to Construct A but with the 3 shaft-position screws replaced by conventional cortical screws. All periarticular and subchondral screws remain locking.

Construct B—Dual locking plate (hypothetical comparator): Medial tibial plateau locking plate as above, plus a supplemental lateral tibial plateau locking plate (6-hole, 5 periarticular locking screws, 3 locking shaft screws).

Construct B′—Dual locking plate, hybrid screw strategy: Identical to Construct B, with all six shaft-position screws (three medial, three lateral) replaced by conventional cortical screws. All periarticular and subchondral screws remain locking.

This two-by-two structure was adopted so that the effect of plate count and the effect of screw strategy are costed independently, each at a constant value of the other, and can therefore be reported separately rather than summed.

Cost estimation methodology

This analysis estimates implant acquisition cost difference only. It does not include the cost of the planning software platform, CT segmentation, engineering time, surgeon planning time or downstream clinical costs. Unit implant acquisition-costs were estimated from published literature, as vendor pricing is subject to



Figure 1: Schematic X-ray illustrations of the three modeled implant constructs. Construct A (left): single medial locking plate, all-locking screw strategy. Construct A′ (center): identical plate with cortical screws (blue-grey) replacing locking screws in shaft positions. Construct B (right): dual-plate construct with supplemental lateral locking plate. Warm white = locking screws; blue-grey = cortical screws; dashed lines = fracture.

hospital-specific contract confidentiality. The following base estimates were used:

Tibial plateau locking plate: ~$1,200 per plate (published hospital acquisition cost range $800–$1,500)[8,16].

Locking screw: ~$150 per screw (range $100–$200). Multiple analyses report locking screws at 3.6–5.8 times the cost of non-locking equivalents[12,13]; using a $30 cortical screw base and a conservative 5 times multiplier yields $150.

Cortical/non-locking screw: ~$30 per screw (range $20–$40), consistent with published trauma ORIF implant cost data[12,13,17].

All costs represent estimated hospital acquisition costs. A ±25% sensitivity analysis was applied to all unit cost estimates, mirroring the methodology of prior orthopedic implant cost analyses[8]. All unit costs are expressed in 2025 US dollars and represent implant acquisition cost only; they exclude instrument trays, instrument set processing, packaging, sterilization, and unused opened implants. Vendor-contracted pricing was not accessible owing to hospital contract confidentiality.

Model structure and equations

Construct cost is calculated as $C = (n_P \times P) + (n_L \times S_L) + (n_C \times S_C)$, where P is the unit cost of a periarticular locking plate, S_L the unit cost of a locking screw, S_C the unit cost of a conventional cortical screw, and n_P, n_L and n_C the corresponding quantities specified in the study methods.

The per-case cost difference attributable to plate de-escalation is calculated at a constant screw strategy as $\Delta C_{plate} = C_{dual} - C_{single}$. The per-case cost difference attributable to hybrid screw substitution is calculated at a constant plate count as $\Delta C_{screw} = C_{all\text{-}locking} - C_{hybrid}$. These two quantities are reported separately and are not summed, as doing so would double-count the shaft screw substitution already contained within the hybrid comparison. The hybrid screw analysis represents an independent implant-cost scenario and is not considered an economic consequence of patient-specific preoperative planning.

Annual institutional cost difference is calculated as $\Delta C_{annual} = \Delta C_{plate} \times V \times p_e \times p_a$, where V is the annual Schatzker IV case volume, p_e the proportion of cases in genuine clinical equipoise between single- and dual-plate fixation, and pa the rate of planning adoption.

The study perspective is institutional (hospital implant acquisition). The time horizon is per case, aggregated annually; no discounting was applied, as the horizon is less than one year. This analysis constitutes a partial economic evaluation—a cost-comparison of implant acquisition costs—rather than a full economic evaluation, and is reported in accordance with applicable items of the CHEERS 2022 statement with items relating to health outcomes, effectiveness measures and health-state utilities marked not applicable by design.

Case volume, eligibility and adoption parameters

Projections were anchored to the case volume of a single high-volume Level 1 trauma center. Published institutional series of tibial plateau ORIF report annual volumes in the range of 50–100 cases per year at busy Level 1 centers[8,16]. Schatzker IV fractures represent approximately 10%–20% of surgically treated cases[3], yielding an institutional estimate of 6–20 Schatzker IV ORIFs per year, with a base-case estimate of 12. The proportion of these cases meeting criteria for genuine clinical equipoise between single- and dual-plate fixation is not established in the current literature and could not be estimated from available data. Accordingly, the 6–20 case/year range represents the full annual Schatzker IV volume, not a validated estimate of the equipoise-eligible subset. Cost-differences are reported as per-case figures and as annual institutional totals at low (6), base (12), and high (20) case volumes. National or regional population-level analyses were not performed, as implant procurement, value-analysis decisions, and the deployment of a preoperative planning workflow occur at the institutional level. Neither the proportion of cases meeting criteria for genuine clinical equipoise (p_e) nor the rate at which a planning workflow would be adopted for eligible cases (p_a) is established in the literature. Both are therefore treated as free model parameters and varied across scenarios rather than assigned assumed values. Because the proportion of Schatzker IV fractures meeting criteria for genuine clinical equipoise is not established, the full-eligibility, full-adoption scenario ($p_e = 1$, $p_a = 1$) represents an upper-bound, hypothetical ceiling rather than an expected value for a typical trauma center, and should not be interpreted as a projected or expected annual savings figure. In practice, only a subset of Schatzker IV fractures is likely to meet equipoise criteria, and adoption of a planning workflow is unlikely to be immediate or complete. The mid-range and conservative scenarios, in which both p_e and p_a are set below 1, are therefore more

representative of plausible institutional experience than the full-adoption scenario, and are presented alongside the upper bound for this reason.

Sensitivity, scenario and threshold analyses

Three analyses were performed. First, a one-way sensitivity analysis varying each unit cost input across ± 25% of its base value while holding the remaining inputs constant. We note that uniform proportional variation of all unit prices simultaneously—the approach used in several prior implant cost analyses[8]—leaves the relative differences between constructs unchanged by construction and therefore conveys limited information; results of that approach are reported for comparability but are not interpreted as evidence of robustness. Second, a scenario analysis varying case volume, eligibility proportion, and adoption rate. Third, a threshold analysis identifying the per-case planning workflow cost at which the modeled implant acquisition cost difference is fully exhausted.

We did not assign point estimates to planning software licensing, CT segmentation, engineering or technician time, surgeon planning time, training, implementation, or operating room time. No institution-independent inputs for these parameters are available to us, and any values we supplied would be arbitrary. The threshold analysis is presented in their place, allowing readers to apply institution-specific workflow costs against the modeled difference. For the same reason we did not undertake a probabilistic analysis: assigning distributions to parameters for which no empirical data exist would convey a degree of precision that the underlying evidence does not support.

Results

Single-plate implant cost model (Constructs A and A′)

Table 1 presents the itemized cost breakdown for Constructs A and A′. Under base estimates, Construct A costs approximately $2,700/case. Substituting 3 shaft-position locking screws with cortical equivalents (Construct A′) reduces the cost to ~$2,340/case—a difference of $360/case from screw-level substitution alone.

Dual-plate implant cost model (Constructs B and B′)

Table 2 presents the cost breakdown for the dual-plate constructs. Relative to Construct A, the lateral plate adds one locking plate (~$1,200), five periarticular locking screws (~$750), and three shaft screws. With all-locking shaft screws, Construct B totals approximately $5,100 per case. Substituting conventional cortical screws in all six shaft positions (Construct B′) gives approximately $4,380 per case.

Cost-difference summary and sensitivity analysis

Holding screw strategy constant, single-plate fixation was associated with a per-case implant acquisition cost difference of $2,400 relative to dual plating under an all-locking strategy (Construct A vs. B; 47.1% reduction) and $2,040 under a hybrid strategy (Construct A′ vs. B′; 46.6% reduction). The more conservative of these,

Table 1: Implant cost breakdown for single-plate constructs.

Component	Qty	Unit cost	Construct A	Construct A′
Medial tibial plateau locking plate (8-hole, e.g., Stryker Pangea)	1	$1,200	$1,200	$1,200
Periarticular locking screws (articular fixation holes)	7	$150	$1,050	$1,050
Shaft screws—locking (Construct A only)	3	$150	$450	—
Shaft screws—cortical/non-locking (Construct A′ only)	3	$30	—	$90
Total implant cost			**$2,700**	**$2,340**
Cost-difference vs. corresponding dual-plate construct (B for A, B′ for A′)			$2,400/case	$2,040/case

Note: Unit costs are derived from published literature. See Methods for assumptions.

Table 2: Implant cost breakdown for dual-plate Construct B.

Component	Qty	Unit cost	Construct B
Medial tibial plateau locking plate (8-hole)	1	$1,200	$1,200
Lateral tibial plateau locking plate (6-hole)	1	$1,200	$1,200
Periarticular locking screws—medial (7) + lateral (5)	12	$150	$1,800
Medial shaft screws—locking (3)	3	$150	$450
Lateral shaft screws—locking (3)	3	$150	$450
Total implant cost—Construct B			$5,100

Note: Unit costs are derived from published literature. See Methods for assumptions. This construct represents a plausible clinical alternative in Schatzker IV fractures where a broad lateral impression zone prompts consideration of supplemental lateral fixation. Construct B′ substitutes conventional cortical screws in all six shaft positions, giving $4,380 per case.

$2,040 per case, is reported as the primary estimate; it is equivalent to the cost of the omitted lateral plate together with its five periarticular locking screws and three cortical shaft screws ($1,200 + $750 + $90). Holding plate count constant, hybrid screw substitution was associated with a per-case difference of $360 for a single-plate construct and $720 for a dual-plate construct, independent of patient-specific preoperative planning. These effects are reported separately and are not additive within a single comparison, as the comparison of Constructs A′ and B′ already incorporates cortical shaft screws in both arms. Percentage reductions are expressed throughout against a single consistent comparator, the corresponding modeled dual-plate construct; the published benchmark of $2,968 per case[8] is retained in the Introduction as context and is not used as a denominator. Table 3 presents one-way sensitivity results. The primary estimate was most sensitive to the unit cost of the locking plate ($1,740 to $2,340 across a plate cost of $900 to $1,500) and to the unit cost of locking screws ($1,853 to $2,228 across $112.50 to $187.50 per screw); variation in cortical screw cost had minimal effect ($2,018 to $2,063).

Institutional cost-differences at a busy Level 1 trauma center

Table 4 presents projected annual institutional implant acquisition cost difference at three case volume scenarios reflecting a high-volume Level 1 trauma center, assuming single-plate fixation was applied across the entire annual Schatzker IV volume. At the base estimate of 12 Schatzker IV cases annually, Construct A vs. dual plating generates ~$28,800 in annual implant cost difference; Construct A′ generates ~$24,480.

Scenario and threshold analyses

Projected institutional cost differences depend on annual case volume, the proportion of cases in genuine clinical equipoise and the rate of planning adoption. Assuming that every case in the modeled volume is clinically eligible for single-plate fixation and is managed under the planning workflow ($p_e = 1.0$, $p_a = 1.0$)—an explicit upper bound rather than an expected value—projected annual differences ranged from $12,240 at 6 cases to $40,800 at 20 cases, with $24,480 at the base volume of 12. Under a mid-range scenario at the base volume ($p_e = 0.50$, $p_a = 0.75$) the projected annual difference was approximately $9,180, and under the most conservative scenario modeled (12 cases, $p_e = 0.25$, $p_a = 0.50$) approximately $3,060.

Table 3: Sensitivity analysis of implant costs and cost-differences at ±25% unit price variation.

Scenario	Construct A	Construct A′	Construct B	Cost-Difference A vs. B	Cost-Difference A′ vs. B′
Low (−25%)	$2,025	$1,755	$3,825	$1,800	$1,530
Base	$2,700	$2,340	$5,100	$2,400	$2,040
High (+25%)	$3,375	$2,925	$6,375	$3,000	$2,550

Note: Construct B′ costs $3,285, $4,380 and $5,475 under the low, base and high scenarios respectively; the final column reports the like-for-like comparison of Constructs A′ and B′. Uniform proportional variation of all unit costs leaves relative differences between constructs unchanged by construction and is reported for comparability rather than as evidence of robustness.

Table 4: Projected annual institutional implant cost difference at a busy Level 1 trauma center.

Annual Appropriate Schatzker IV cases at L1 trauma center	Cost-Difference A vs. B (~$2,400/case)	Cost-Difference A′ vs. B′ (~$2,040/case)
6 (low)	$14,400	$12,240
12 (base)	$28,800	$24,480
20 (high)	$48,000	$40,800

Note: The table is presented as an upper-bound estimate assuming single-plate fixation across the full annual Schatzker IV case volume; the true equipoise-eligible proportion is unknown.

In threshold analysis, the primary per-case implant acquisition cost difference is fully exhausted at an all-in per-case planning workflow cost of $2,040. At the base volume of 12 cases under full eligibility and adoption, this corresponds to an annual planning workflow expenditure of $24,480. The corresponding threshold for the hybrid screw strategy effect, evaluated independently at constant plate count, is $360 per case.

Discussion

Patient-specific planning as a potential factor in implant optimization

The central premise of this analysis is that, in a fracture pattern where dual plating might otherwise be chosen empirically, patient-specific preoperative planning provides the surgeon with construct-specific mechanical information that may support consideration of single-plate fixation in appropriately selected cases. This study does not claim that single plating is inherently superior; rather, it evaluates the economic implications of using a patient-specific planning workflow, with the potential to reduce implant utilization and associated costs. The mechanical feasibility of a patient-specific, single-plate construct—independent of any cost or utilization outcome—has been evaluated in a parent cadaver study using FEM as an *in silico* validation tool. In that study, FEM served as an *in silico* method to test whether a patient-specific planned single-plate construct would withstand physiological loading conditions before fixation is performed. Twelve fresh-frozen cadaveric knees with reproducible Schatzker IV/AO 41B3.3 fractures were paired by bone mineral density and randomized to conventional vs. FEM-based patient-specific planning ($n = 6$ per group), each construct fixed with the same medial locking plate[11]. Specimens underwent quasistatic loading (10–200 N) followed by cyclic sinusoidal loading until failure, defined as ≥ 5° varus/valgus malalignment or ≥ 3 mm vertical condylar impression. The FEM-planned group demonstrated a significantly higher load to failure (1,050 ± 535 N vs. 442 ± 226 N, $P = 0.041$) and significantly lower NASA-TLX cognitive workload (33 ± 12.4 vs. 49 ± 18.6, $P = 0.043$); initial construct stiffness did not differ significantly (899 ± 445 vs. 650 ± 392 N/mm, $P = 0.370$). These findings provide biomechanical support for the feasibility of individualized single-plate construct optimization but do not establish that patient-specific planning directly leads to reduced use of dual plating or demonstrate equivalence between single- and dual-plate fixation[11].

The patient-specific planning workflow operates by optimizing screw trajectory and orientation prior to surgery, a mechanism evaluated for its structural effect, not its economic effect. In the parent cadaver study, planned constructs used a higher proportion of anteroposterior (AP) screws (mean 1.8 vs. 1.0) and achieved 92.2% adherence to planned screw length and direction[11]. The resulting constructs demonstrated substantially superior mechanical performance under FEM-based loading. The significantly reduced NASA-TLX cognitive workload scores (33 vs. 49) suggest that patient-specific planning may reduce intraoperative uncertainty regarding construct performance; whether this translates into a measurable change in implant selection has not been demonstrated.

Clinical equipoise and the dual-plate decision

The Schatzker IV/AO 41B3.3 fracture pattern represents a key decision between single- and dual-plate fixation strategies. Bicondylar Schatzker V and VI fractures have a more established indication for dual plating[3,6]. Isolated medial plateau fractures with a lateral depression zone sit in a zone of equipoise where single medial fixation—when biomechanically sound—can be the preferred approach. Several systematic reviews have documented wide variation in implant choice for this pattern without demonstrable superiority of dual plating when medial fixation achieves adequate stability[2,5].

The implant acquisition cost differences modeled here apply specifically to this equipoise subset. For fractures where the lateral depression is so broad as to represent a true bicondylar pattern, lateral plating may remain appropriate regardless of preoperative planning—and the planning workflow would in those cases be equally valuable for optimizing that dual-plate construct.

Hybrid screw strategy: rational use of locking technology

The incremental cost difference from hybrid screw use ($360/case) reflects a broader biomechanical principle: locking screws are specifically indicated for periarticular and subchondral fixation, where angular stability resists metaphyseal collapse and cortical purchase may be limited. In the diaphyseal shaft portion of a tibial plateau plate, bicortical screws anchoring the plate to intact diaphyseal bone provide mechanically equivalent fixation at approximately one-fifth the cost[14].

This finding aligns with a growing literature on implant cost optimization in periarticular fracture surgery, with comparable radiographic and clinical outcomes between locking and non-locking constructs reported across multiple anatomic sites[12,13]. Systematic application of locking technology where it offers no incremental biomechanical benefit represents an avoidable and modifiable cost driver.

Institutional implications

Relative to the modeled dual-plate comparator, a per-case difference of $2,040 represents a 47% reduction in implant acquisition cost. For a busy Level 1 trauma center managing 12 Schatzker IV ORIFs per year, this corresponds to approximately $24,480 in annual implant acquisition cost differences at full eligibility and full adoption, and approximately $40,800 at a volume of 20 cases. Even at the low end of the volume range (6 cases), approximately $12,240 is projected. These figures represent a ceiling rather than a point estimate: they assume that every case in the modeled volume is both clinically eligible for single-plate fixation and managed under the planning workflow, neither of which has been established. Projected differences will scale downward with the true proportion of cases in genuine equipoise and the rate of planning adoption; under a mid-range scenario at base volume the projected annual difference falls to approximately $9,180. We further emphasize that these are gross implant acquisition cost differences and not net institutional savings. A complete budget-impact evaluation would require the costs of the planning workflow itself, together with any effect on operating room duration and downstream clinical costs including fixation failure, loss of reduction and revision surgery, none of which are captured here. The threshold analysis indicates that the modeled per-case difference is fully offset at an all-in planning cost of $2,040 per case; institutions can apply their own workflow costs against this figure.

Patient-specific preoperative planning may additionally reduce intraoperative implant waste by templating screw type, length and trajectory before incision, thereby reducing the need to open multiple screws of differing specifications on the back table. Implant waste in trauma ORIF is well documented[18]. However, the published data do not permit reliable estimation of the fraction of that waste attributable to intraoperative uncertainty about screw specification, and we have therefore not modeled this effect. Quantifying it would require a prospective institution-specific implant waste audit conducted under planned and unplanned workflows, which we regard as a valuable direction for future work.

Although this analysis is deliberately anchored to a single institution rather than projected to the national level, the per-case figures are not center-specific and would apply to any Level 1 trauma center managing Schatzker IV fractures with comparable implant pricing. The United States is served by a network of more than 200 ACS-verified or state-designated Level 1 trauma centers, the majority of which manage similar periarticular fracture volumes. Even a partial adoption of patient-specific preoperative planning and rational screw selection across this network would scale the per-institution figures shown here into a population-relevant signal. This has not been modeled explicitly in this study because national projections introduce uncertainties (case mix, contracted pricing, equipoise rate) that the analysis avoids.

Limitations

This analysis has important limitations. First, it is a

scenario-based cost-modeling study; no clinical outcome data are reported. The dual-plate comparator is a hypothetical construct, and the proportion of Schatzker IV cases at genuine equipoise for dual plating is unknown and will vary by center and surgeon. Accordingly, the projected implant acquisition cost difference should be interpreted as only appliable to carefully selected cases rather than the overall Schatzker IV fracture population. Second, unit cost estimates derive from published literature rather than institution-specific contracted pricing—actual differences will vary substantially across institutions. Third, the analysis is anchored to a single high-volume Level 1 trauma center and is not generalized to a national or regional population; readers at smaller-volume institutions should scale projections accordingly. Fourth, the analysis does not account for operating room time costs; any time premium associated with preoperative planning (a non-significant trend of 4 minutes in the parent study) could partially offset implant savings in some institutional cost models. Fifth, the cost differences are framed at the per-case implant level and do not capture downstream effects such as reduced sterilization burden, storage costs, or environmental impact associated with smaller opened trays. Because this model captures implant acquisition cost only, the reported figures represent gross implant-cost differences between fixation strategies, not net institutional cost savings or a complete budget-impact evaluation. Planning-workflow costs (software licensing, segmentation, planning labor, training) and any associated operating-room time were not modeled. Last, this study's central premise bears directly on the commercial interests of the planning platform developer, with whom several authors have direct relationships. We recognize this as a conflict warranting particular transparency, given that it concerns the technology's potential value proposition, and we highlight the specific safeguards taken to limit interpretive bias: implant cost inputs were not drawn from commercial pricing, and the cost model was constructed and subsequently audited independently.

Conclusion

This scenario-based cost analysis models the potential implant acquisition cost difference associated with a hypothetical shift from dual-plate to single-plate fixation in Schatzker IV/AO 41B3.3 tibial plateau fractures, conditional on appropriate clinical selection in cases of genuine equipoise between fixation strategies. Under the modeled scenarios, single-plate fixation is associated with an estimated implant acquisition cost difference of $2,040 per case relative to a modeled dual-plate construct. A hybrid shaft screw strategy was independently associated with a further $360 per case; these two effects are not additive and should be interpreted as separate scenario comparisons. Applied to a busy Level 1 trauma center managing 6 to 20 Schatzker IV ORIFs annually, and assuming full clinical eligibility and full adoption, these correspond to projected annual implant acquisition cost differences of approximately $12,000 to $41,000. These findings do not establish clinical equivalence or superiority of single-plate fixation; rather, they quantify the potential economic impact of a shift toward single-plate fixation informed by patient-specific planning, and provide a cost framework to inform future prospective and comparative-effectiveness research on fixation strategy in complex tibial plateau fractures.

Author contributions

C.L. and A.v.K. conceived the study. L.S. and T.Z. provided resources and reviewed the work. A.v.K. provided supervision. All authors reviewed and approved the final version of the manuscript and agreed to its publication.

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Data availability statement

All unit implant costs used in this analysis were extracted from published peer-reviewed literature and are reported in full in Table 1. No CustomSurg AG pricing, commercial or proprietary data were used at any stage of model construction. All model inputs and equations are reported in the Methods section such that the analysis can be reproduced in full.

Ethics statement

Not applicable.

AI statement

The authors used GPT-5.6 Luna as a language-editing tool to improve grammar, clarity, and readability. The AI tool was not used for data analysis, data generation, image processing, or scientific content creation. All outputs were carefully reviewed and verified by the authors, who take full responsibility for the final content.

Conflicts of interest

A.v.K. is a co-founder, Chief Medical Officer and shareholder of CustomSurg AG (Zürich, Switzerland), the developer of the OrthoPlanner™ platform, and is named on intellectual property relating to patient-specific preoperative planning. L.S. and T.Z. are salaried employees of CustomSurg AG. C.L. declares no competing interests.

The cost model was constructed, calculated and independently audited by C.L., who has no commercial relationship with the platform evaluated. The commercially affiliated authors contributed to the conception of the study and interpretation of the biomechanical literature but did not perform or verify the cost calculations.

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