Economic-Time Feasibility of 3D-Printed Crowns in Young Permanent Molars

John Gavel DDS; David Ciesla DDS, MS, MAS; Safaa Ahmed BDS, DrPH; Katelyn Parker

OU Pediatric Dental Specialty Clinic

OU Health | College of Dentistry
The UNIVERSITY of OKLAHOMA

Abstract

Permanent first molars are disproportionately vulnerable to caries and enamel defects, frequently requiring full-coverage restoration prior to adulthood. Although stainless steel crowns (SSCs) remain the gold standard, their limited esthetics along with rising patient expectations have increased interest in esthetic alternatives. Despite growing enthusiasm for additive manufacturing, the time and cost feasibility of chairside 3D-printed crowns in pediatric dentistry has not been well characterized. The purpose of this study is to explore the time and costs associated with 3D printing permanent restorations for molars,

Introduction

Permanent first molars erupt around age six and are frequently affected by developmental enamel defects such as molar–incisor hypo mineralization (MIH). These defects increase the risk of rapid structural breakdown and early caries development. Full-coverage restorations are often required to preserve compromised permanent molars in pediatric patients.

SSCs remain the clinical gold standard due to durability and ease of placement. However, SSCs present esthetic limitations that may reduce acceptance in older children and adolescents.

Advances in digital dentistry, including intraoral scanning, CAD design, and additive manufacturing, allow the fabrication of customized crowns through 3D printing. Although these technologies show promising mechanical properties and marginal accuracy, their time and cost feasibility within pediatric clinical workflows remains unclear.

Understanding the time requirements and associated costs of a fully digital workflow is critical in pediatric dentistry, where appointment length, behavior management and finances are major clinical constraints.

Methods

A market-based, deterministic feasibility analysis was conducted to evaluate the time and cost of a fully digital, chairside 3D-printed crown workflow for permanent first molars. The model used a clinic-level perspective relevant to private, group, and academic pediatric dental settings, with a primary 12-month horizon and projections at 36 and 60 months to assess the impact of capital depreciation.
The workflow included intraoral scanning, CAD design, 3D printing, post-processing, and final cementation. Cost inputs were derived from publicly available sources. Capital equipment (scanner, printer, ancillary units) was annualized using straight-line depreciation, while variable costs included resin, consumables, and material waste. Per-crown cost incorporated capital allocation, materials, and active labor. Workflow time was divided into active (clinician-dependent) and passive (machine-dependent) components using published estimates. A base-case utilization of 250 crowns/year was modeled. Break-even and sensitivity analyses assessed feasibility across key variables. No IRB approval was required.

Results

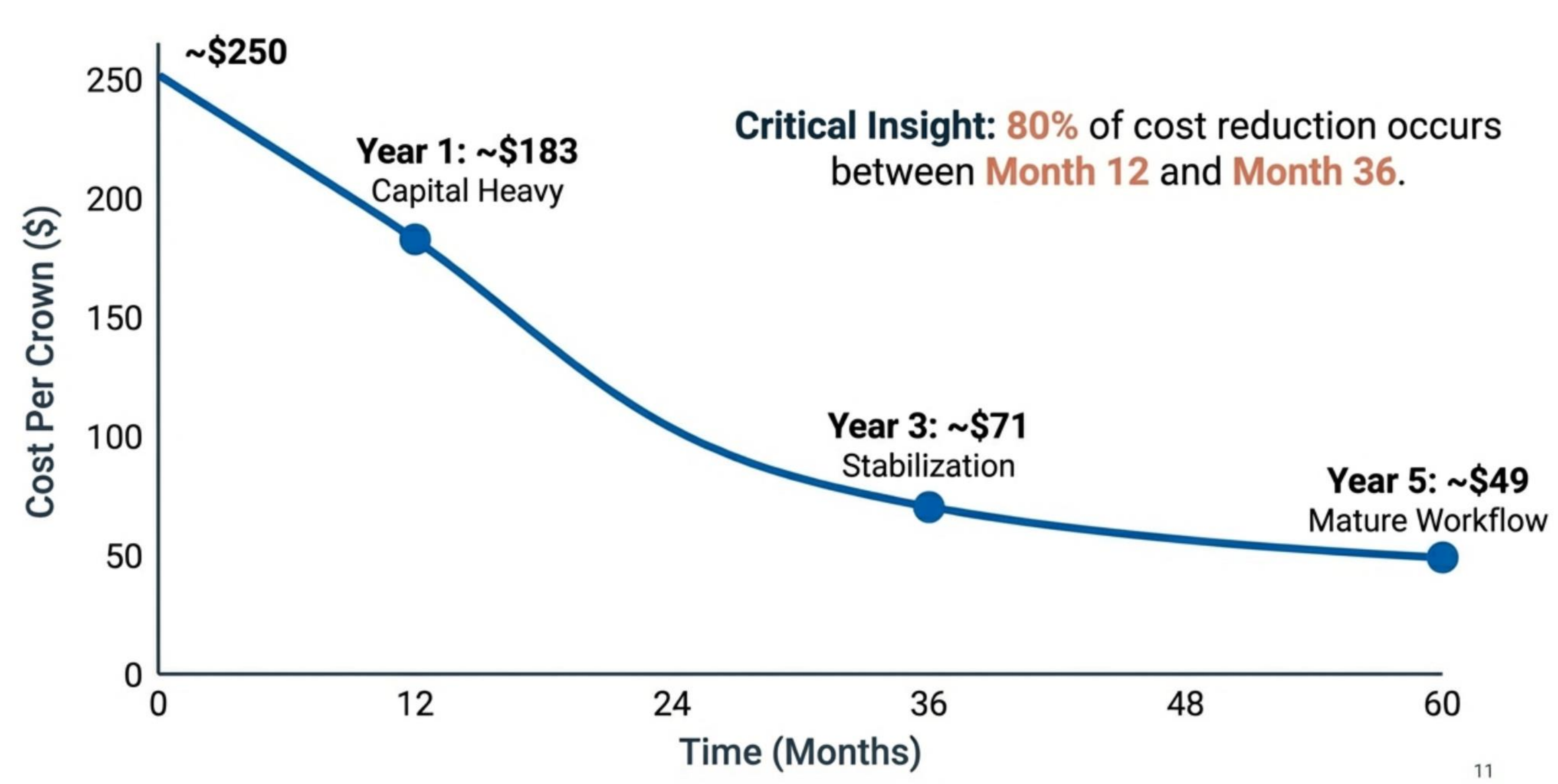
Predictive Workflow Time Model by Provider Experience

Provider type	Operator experience multiplier	Operator-dependent time (min)	Machine-dependent post-processing time (min)	Predicted total elapsed time (min)
Students / limited experience	1.25	~56	~40–120	~96–176
Residents / some experience	1.00	~45	~40–120	~85–165
Experienced clinicians	0.85	~38	~40–120	~77–158

Notes

1. **Operator-dependent time** includes scanning, design oversight, finishing, and cementation; scales with clinician experience.
2. **Machine-dependent time** reflects **post-print washing and UV-curing**, based on PubMed evidence:
   - Washing: ~5–30 min depending on resin and protocol (PMID: 37178635).
   - Curing: ~30–90 min depending on material and desired mechanical properties (PMIDs: 33238528, 40540636).
3. **Total elapsed time** represents the sum of operator-dependent and largely unattended post-processing steps; actual duration varies by case complexity, number of units, and resin selection.

Surviving the First Year: The Depreciation Curve



Depreciation-Driven Capital and Non-Labor Cost per Crown Over Time

Time horizon	Depreciation period	Annualized capital allocation (USD)	Capital cost per crown (USD)	Total non-labor cost per crown (USD)*
12 months	1 year	42,000	168.00	~183
36 months	3 years	14,000	56.00	~71
60 months	5 years	8,400	33.60	~49

**Includes resin and consumables (~$15); excludes labor to allow separation of staffing effects.)*

Key finding: *More than 80% of the reduction in per-crown cost occurs between the 12- and 36-month horizons, illustrating that feasibility improves rapidly once capital costs are spread beyond the first year.*

Medicaid and Private Insurance Reimbursement Comparison (USD)

Dental code	Oklahoma Medicaid	Kansas Medicaid	Texas Medicaid	Missouri Medicaid	Arkansas Medicaid	Private (50% NDAS)
D2394	173.79	130.51	131.63	312.80	226.50	453

Significance

- Per-crown cost decreased from ~$183 (12 months) to ~$49 (60 months), with >80% of cost reduction achieved by 36 months (~$71)
- Capital costs dominated early economics, with intraoral scanners ranging from $5,000–$54,000 (median ~$21,900)—the single largest cost driver
- 3D printer startup costs were lower and more flexible (~$7,500–$18,500), offering multiple feasible entry points compared to scanners
- Active clinician time averaged ~30–45 minutes, despite total workflow times of ~78–176 minutes due to largely unattended printing and post-processing
- Break-even occurred at ~35–42 crowns, while economic stability was achieved at ~250 crowns/year utilization
- Medicaid reimbursement ranged from ~$130–$313, creating variable or negative margins early, while private reimbursement (~$453) consistently exceeded costs

Conclusions

A fully digital, chairside 3D-printed crown workflow for restoring compromised permanent first molars appears economically and operationally feasible under realistic utilization and depreciation assumptions. Per-restoration cost is driven primarily by capital investment structure and utilization rather than consumable materials. Although total elapsed fabrication time exceeds that of stainless-steel crowns, active clinician time is comparable to existing esthetic alternatives, with much of the workflow occurring during automated, non-chairside phases that align with pediatric practice constraints. When integrated as part of a shared digital infrastructure, 3D-printed crowns represent a viable esthetic full-coverage option for permanent teeth in pediatric patients and warrant further preclinical and clinical evaluation.