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## From facial surface acquisition to digital orthopedic support

Lisandro Gonçalves and Heilo Hisasshy Terada • Digital Sky Hook technical note

### Supplementary Table S1. Expanded digital workflow controls and validation-oriented documentation.

| Workflow stage | Documented control | Relevance |
|---|---|---|
| Facial acquisition | Non-contact multi-camera photogrammetry; patient at rest; no external compression of chin-support region | Reduces distortion of the soft-tissue surface used for support design |
| Scanner setup | Cloner/dOne 3D booth; approximate working distance 55 cm; acquisition time approximately 0.4 s | Provides standardized acquisition geometry and rapid capture |
| Calibration | Manufacturer-guided calibration target and software-guided camera alignment | Supports consistency of facial acquisition |
| Original file package | OBJ, MTL and JPEG components; working mesh handled in STL format | Preserves geometry and texture-related records while enabling CAD/manufacturing workflow |
| Digital traceability | Original records, converted files, prototypes and final design files preserved as distinct workflow stages | Supports auditability and potential remanufacturing |
| Design environment | Mesh-based support delineation; extrusion, duplication and Boolean operations | Converts resting facial topography into support geometry |
| Wire-retention architecture | L-shaped negative channels incorporated into printed components | Guides metallic framework adaptation and reduces freehand variability |
| Slicing and printing | FlashPrint; DLP printing; vertical orientation at approximately 90°; automatic supports | Documents additive manufacturing controls |
| Iterations | Three design/printing iterations before final standardization | Shows refinement rather than single-print assumption |
| Post-processing | Alcohol-based washing, complete drying, UV post-curing, support removal, finishing and polishing | Supports clinical handling of printed biocompatible resin |
| Assembly | Printed components joined after wire adaptation using chemically activated acrylic resin | Clarifies the hybrid digital-laboratory nature of the workflow |
| Quality control | Visual inspection, absence of visible warpage, laboratory fit and clinical passive seating | Provides practical verification while acknowledging absence of formal metrological validation |
| Regulatory traceability and material handling | Transparent biocompatible resin selected from supplier operating under Anvisa AFE; washing, drying, UV post-curing, finishing, polishing, cleaning instructions and clinical soft-tissue monitoring documented | Supports sanitary traceability and safe clinical handling while reserving device-specific prolonged skin-contact testing for future validation |
| Digital data governance | Original facial files, converted meshes, prototypes, final manufacturing files and documentation screenshots stored as versioned workflow stages; identifiable biometric files restricted | Improves auditability, remanufacturing potential and privacy-aware management of patient-specific digital records |

**Supplementary note.** This expanded table is intended to support methodological transparency without overloading the main manuscript. It describes the technical decisions used in the present proof-of-concept and identifies the steps that remain operator-dependent or require future validation. It is not intended to imply full inter-operator, inter-scanner, inter-software or inter-printer reproducibility.

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**Supplementary Table S2. Recommended next validation endpoints.**

| Validation layer | Recommended metric | Purpose |
|---|---|---|
| Pressure mapping | Thin-film sensor pressure peaks and pressure-distribution area | Quantify soft-tissue contact behavior under clinical load. |
| CAD-to-print metrology | Best-fit alignment, color-coded deviation maps, mean absolute deviation, RMS error, and percentage of surface points within tolerance | Quantify whether the printed component reproduces the final design geometry. |
| Force behavior | Inline dynamometer or calibrated tension gauge at placement and after time in use | Quantify force decay and working elastic behavior. |
| Structural durability | Fatigue loading, thermal cycling, moisture exposure and repeated insertion/removal | Test the resin-wire-acrylic assembly under simulated clinical conditions. |
| Computational biomechanics | Finite element analysis with support geometry, hook position and force-vector scenarios | Estimate stress concentration and rotational tendency. |
| Clinical follow-up | Comfort scores, adverse events, objective wear time, adjustment burden and orthodontic outcomes when clinically justified | Move from feasibility toward prospective clinical evidence. |

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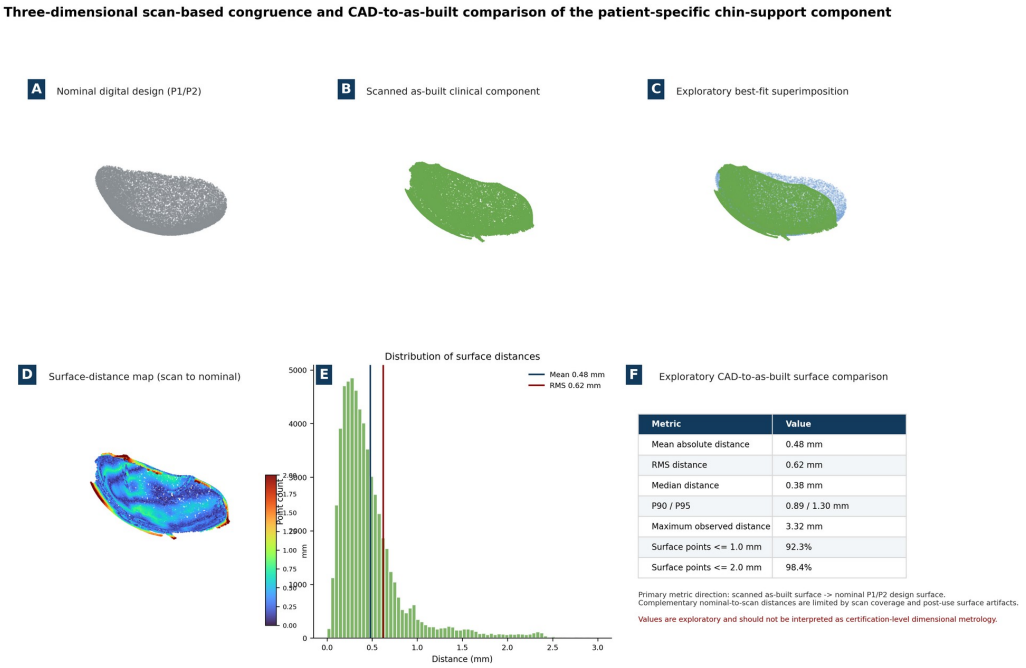
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## Supplementary Table S3. Exploratory CAD-to-as-built surface-congruence metrics.

The primary comparison was calculated from the scanned as-built clinical component to the nominal P1/P2 design surface after exploratory best-fit alignment. Values are intended as research-level congruence descriptors and should not be interpreted as certification-level dimensional metrology.

| Metric | Value |
|---|---|
| Primary comparison | Scanned as-built component -> nominal P1/P2 design surface |
| Mean absolute distance | 0.48 mm |
| RMS distance | 0.62 mm |
| Median distance | 0.38 mm |
| P75 | 0.57 mm |
| P90 | 0.89 mm |
| P95 | 1.30 mm |
| P99 | 2.23 mm |
| Maximum observed distance | 3.32 mm |
| Surface points <= 0.5 mm | 67.6% |
| Surface points <= 1.0 mm | 92.3% |
| Surface points <= 1.5 mm | 96.4% |
| Surface points <= 2.0 mm | 98.4% |
| Surface points <= 3.0 mm | 99.9% |




***Supplementary Figure S1.*** *Exploratory CAD-to-as-built congruence figure supplied as high-resolution image file.*

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