Additive manufacturing in titanium a novel implant abutment: assessment of strength and torque as a precursor for clinical evaluation

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INTRODUCTION

Scientific interest has been focused on refining the components and processes for predictable implant temporary restorations as (1) implant provisionals restore gingival health, provide esthetics and function, but may apply stress causing soft-tissue inflammation and (2) poorly fitted removable dentures can cause forces & may lead to failure of the implant.

A novel abutment and temporization process (Figure 1) has been developed, with specific advantages, but fabrication was unpredictable (Figure 2A). A workflow was developed to use additive manufacturing (AM) to fabricate the abutment (Figure 2B).

This investigation assessed the torque and pin strength of the additive manufactured (AM) novel abutment against that of a conventionally manufactured (CM) abutment, providing data to determine if the abutment could tolerate (1) tightening within an implant body and (2) the process of temporization.

METHODS & MATERIALS

Abutment Production

CM abutments were fabricated by utilizing a titanium regular neck closure cap and 0.60 mm diameter titanium pins, that were laser welded through a commercial dental laboratory.

The AM abutment was developed through a novel workflow, was additive manufactured in dental-grade titanium (Ti-6Al-4V) and were post-processed.

The CM and AM abutments were evaluated for fit and suitability with a dental implant through visual, tactile and radiographic assessment.

Figure 1. QR Code: Provisionalization Animation

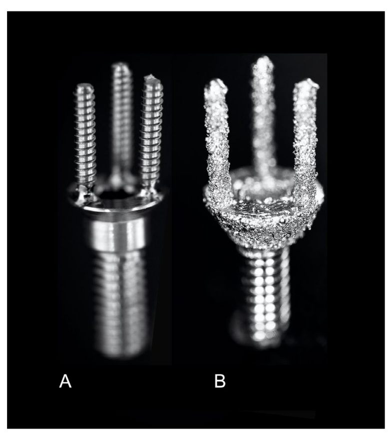

Figure 2A. CM abutment.
Figure 2B. AM abutment.

Assessment of Pin Strength

Five custom jigs were fabricated (Figure 3) with light cured resin with an embedded implant. Jigs fit within the metal housing of the universal loading machine. Twenty-five (25) CM abutments and twenty-five (25) AM abutments were placed into the implants and torqued to 25 Ncm. The jig was inserted into a universal loading machine with an axial load, perpendicular to the abutment, generated at a maximum cross head speed of 0.5 mm/min until failure occurred. The corresponding value was recorded.

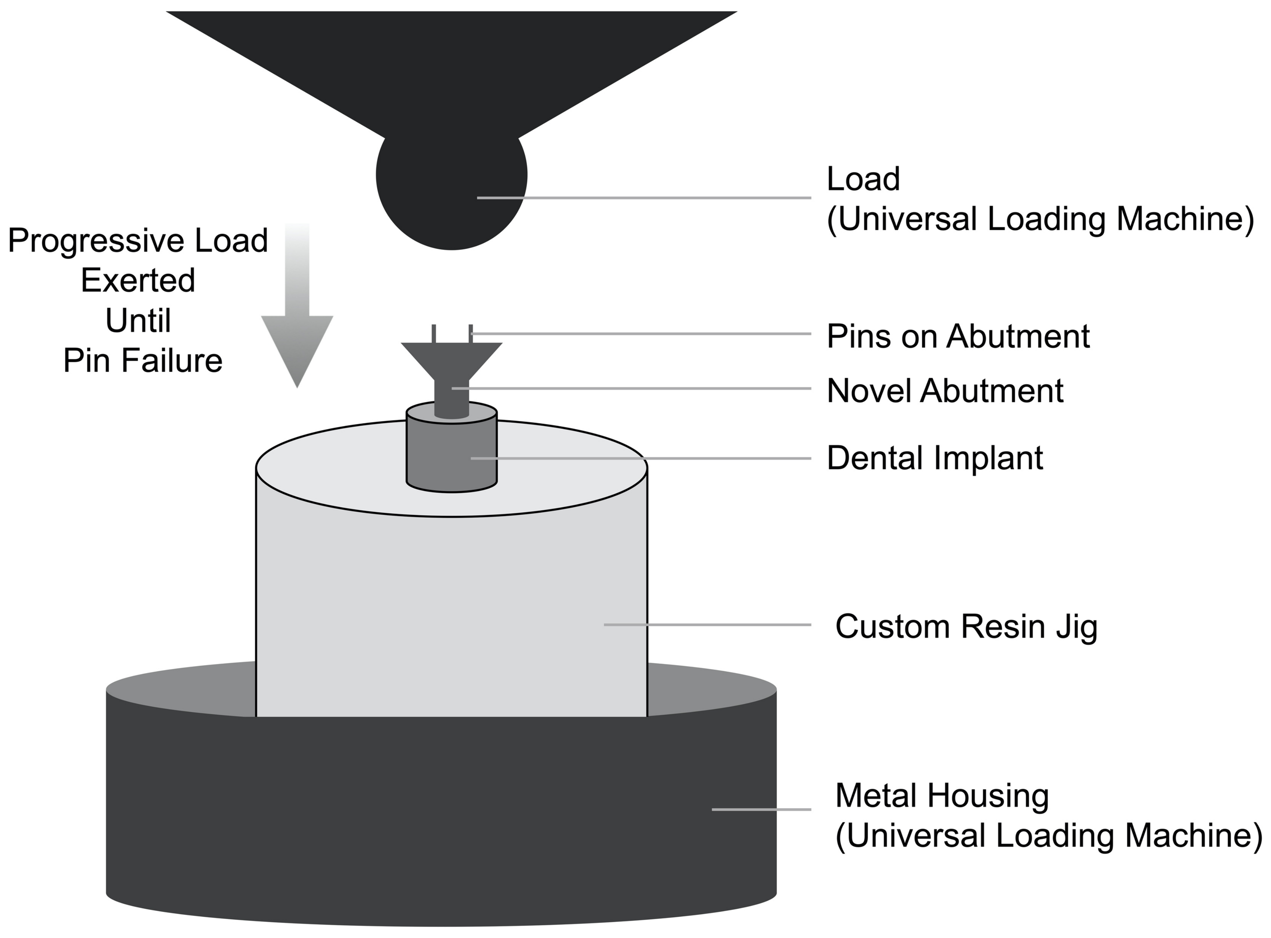

Figure 3. Assessment of pin strength.

Assessment of Torque

A modified torque measurement protocol (Figure 4) used fifty (50) dental implants that were placed into artificial bone blocks. Twenty-five (25) CM abutments and twenty-five (25) AM abutments were threaded into the implants. Bone blocks were placed into a custom jig, abutments were tightened with standard torque wrenches. Torque was continuously measured by a sensor secured at the base and the maximum torque was recorded.

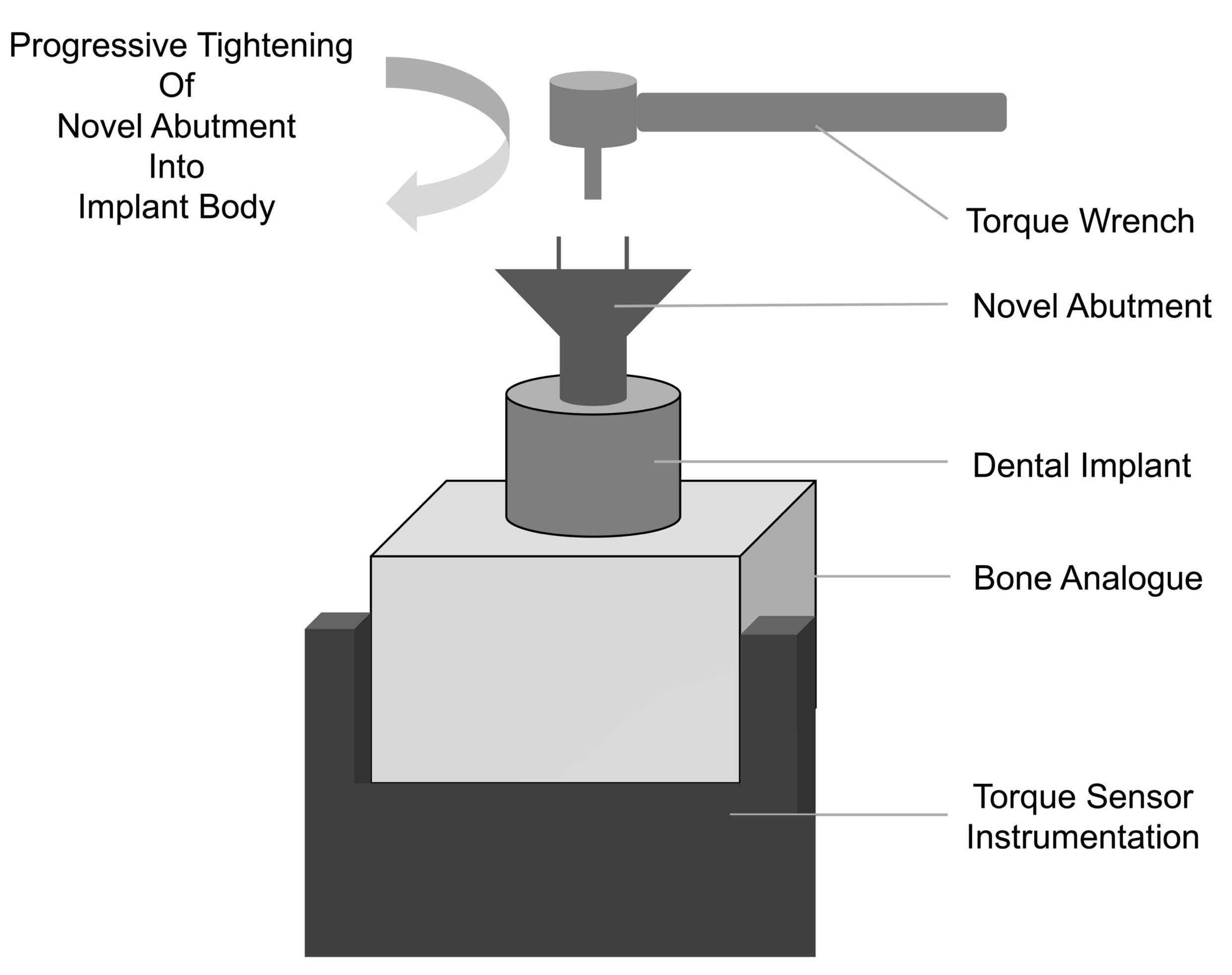

Figure 4. Assessment of torque.

RESULTS

Results 1

Figure 5 illustrates the data from the assessment of pin strength.

The maximum axial load that the pin projections on the abutment could tolerate (i.e., fracture resistance), before breakage or bending, was recorded.

Average pin strength for AM abutments: 364.4 N and for CM abutments: 62.5 N. AM maximum pin strength: 468.9 N, AM minimum pin strength: 278.3 N. CM maximum pin strength: 146.9 N, CM minimum pin strengths: 12.1 N.

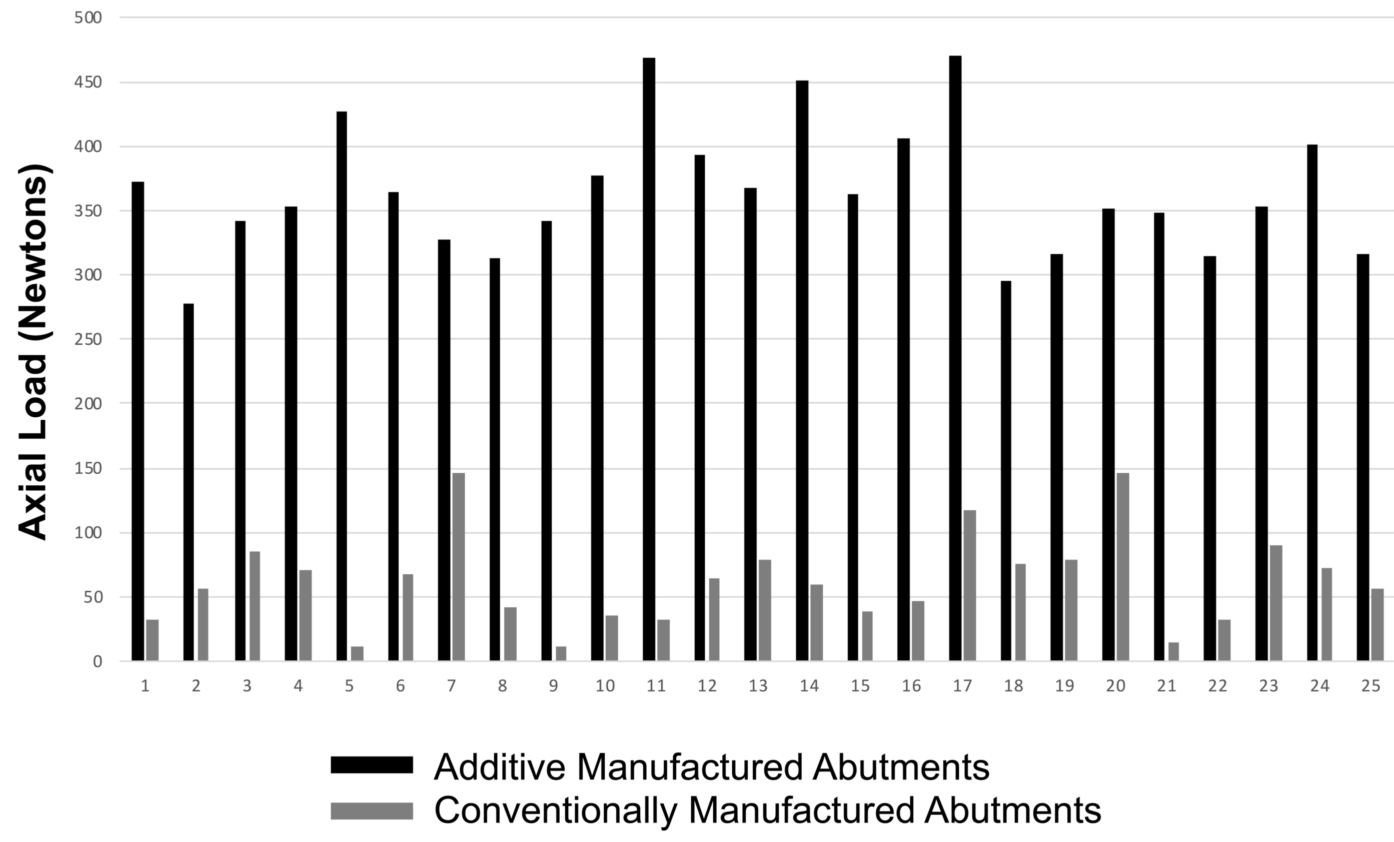

Figure 5. Pin strength of novel abutments.

Results 2

Figure 6 illustrates the data from the assessment of torque of novel abutments. Maximum torque of the abutment into the implant body was recorded.

Average torque for AM abutments: 49.9 Ncm and for CM abutments: 62.9 Ncm. AM maximum torque: 83.1 Ncm, AM minimum torque: 34.1 Ncm. CM maximum torque: 93.1 Ncm, CM minimum torque: 48.9 Ncm.

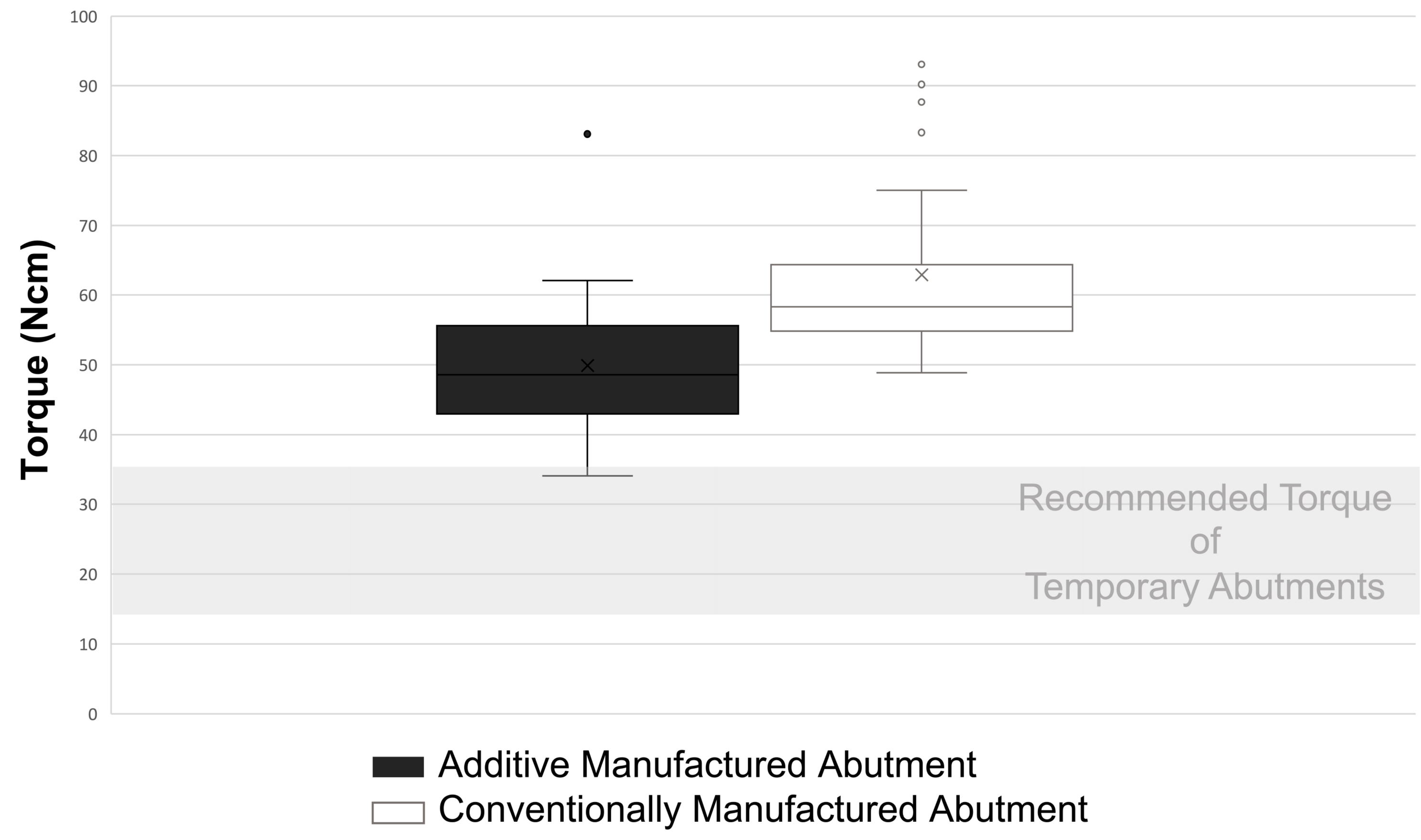

Figure 6. Assessment of torque of novel abutments.

DISCUSSION

Strength of CM abutment pins were low, due to the unpredictability of titanium welding. AM abutments had higher pin strength. Pin strength assessment was to estimate if the abutment could tolerate the temporization process. The author inferred that pin strength would be suitable.

CM abutments had higher torques than the AM abutments, attributed to the torque wrench slipping within the abutment receptacle. Literature recommends torqueing of a metal temporary abutment from 15 to 35 Ncm (Figure 6); data suggests that AM abutments could be utilized for temporization.

Cost to manufacture the CM abutment was $225 CDN/unit, took several weeks & 50% of the CM abutments were inadequate due to quality. AM abutment cost was cost $13 CDN/unit, required one week for fabrication & 100% of the abutments were adequate. Further clinical testing is required and planned.

CONCLUSIONS

Based on this limited investigation, the additive manufactured novel abutment seems suitable as a temporary abutment option. Additive manufacturing with titanium using SLM, provides a predictable, cost-effective, efficient and customizable approach for the fabrication of a novel dental implant abutment.

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