The Effect of Restoration Height on the Strength of the Implant-Abutment Complex in a Single Tooth Rehabilitation

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Introduction

Missing teeth particularly in the anterior part of the jaws often lead to special prosthodontic problems. Osseointegrated implants in this area act as single root forms and highlight the differences in the biomechanical and aesthetic demands for this treatment modality compared to the multiple implant restoration. The single implant is exposed to a different magnitude and combination of masticatory forces. As a result the possibility for technical or biological complications and failure can be increased.

The restriction placed by the anatomical presence of adjacent teeth and the pattern of bone resorption related to single tooth loss has led to the development of fixtures of varying dimensions and numerous components aimed at increasing the indications for treatment.

To overcome the limitations of space often encountered in the mandibular incisor and maxillary lateral incisor regions (Fig.1), implants with a narrower diameter, commonly 3 to 3.5 mm, have been introduced by various companies. The reduced diameter can lead to modifications in both the external and internal specifications of the implant together with the possibility of a smaller abutment screw. These implants are reportedly weaker and there is no published data relating to the potential strengths or mode of failure of such implants.

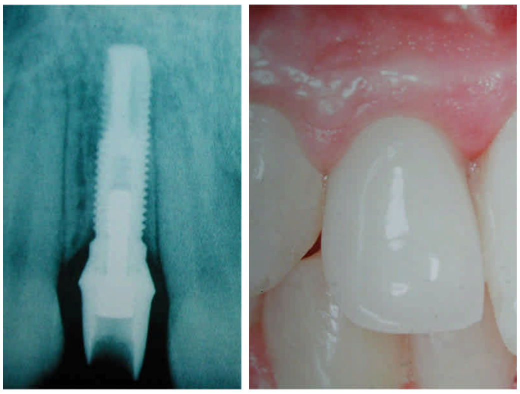

Figure 1.

Narrow diameter implant restoration in the maxillary lateral incisor region.

In the mandibular incisor region, it is possible to be confronted, with clinical situations where due to marginal bone loss; the proposed level of the head of the fixture may give rise to restoration lengths in excess of 15 mm (Fig. 2,3). In the absence of predictable vertical bone regeneration procedures, the whole implant pillar could be therefore be subjected to axial loads and bending moments that may be deleterious to component strength and marginal bone integrity. It would of use to know how a variance in restoration height can affect the performance of such an assembly.

Figure 2.

Narrow diameter implants can offer an improved emergence profile for the restoration.

Figure 3.

Mandibular incisor region showing implant retained restorations on narrow diameter implants. Restoration heights in excess of 15mm can occur.

The need for implant designs to offer some degree of biomechanical security can be considered to be essential with many inter-related factors inextricably linked to achieve long-term stability. Notwithstanding the biological and host response, the design characteristics of the implant assembly and its performance at the abutment-implant interface and bone-fixture level in response to loading and function can be considered to be of prime importance.

Aims of the Study

The aims of this study were therefore to investigate the factors that affect the performance of a narrow diameter implant under bench test conditions and to analyse these with regard to the clinical relevance of the suggested use of these implants in the mandibular incisor sites.

Materials and Methods

Test samples were assembled by mounting 3.3mm diameter Narrow Platform fixtures (Branemark System, Nobel Biocare AG) into custom-built aluminium alloy holders up to the level of the first screw thread apical to the platform of the fixture (Fig.4). The placement was assisted with an optical microscope (Meiji Binocular Stereo Zoom Light Microscope, Meiji Labax Co. Ltd., Tokyo, Japan).

Figure 4. ***Aluminium Holder (above). Mounted Implant (below).***

Abutments were fabricated using the AurAdapt abutment (DCA 1085-0, Nobel Biocare). The required abutment height was constructed from a wax pattern conforming to the hemi-spherical shape suggested by the International Organisation for Standardisation.

Three abutment heights were constructed at 8, 13 and 18 mm (Figure 5).

Figure 5.

The mounted implants were placed in a custom-made jig designed to support the specimens at 30-degrees to the vertical axis. The custom abutments were secured to the implant with a gold abutment screw (DCA 1044-0, Nobel Biocare) to the manufacturer's recommended torque of 20 N-cm using a hand-operated contra-angle torque driver and torque controller (CATDB, CATC2, 3i Implant Innovations, West Palm Beach, FL., USA). The samples were re-tightened ten minutes after the initial application of torque. No effort was made to standardise the hex alignment of the implant.

The investigation analysed each abutment height by subjecting new components to compressive loading testing at a thirty-degree off-axis inclination.

The custom-made jig was rigidly fixed to the baseplate of an Instron 1195 testing machine with an Instron Tension Load Cell (Type 2511-318) with a maximum capacity of 50 KN (Instron UK Ltd, High Wycombe, UK), and the specimens secured within the jig and aligned to a stainless steel probe with a diameter of 1cm attached to the crosshead (Fig. 6). The crosshead of the testing machine was aligned with the specimen.

Four samples for each abutment height group were then randomly tested within the testing machine with a crosshead speed of 0.5 mm/minute under scrutiny. The load applied was registered by means of a force-displacement curve on graph paper with a chart speed of 50 mm/minute (Fig.7)

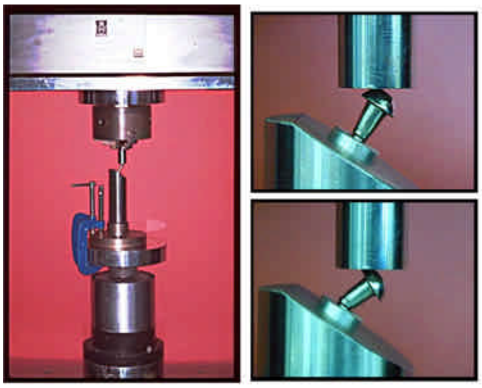

Figure 6.
Compressive loading test set up (above left) with 8mm abutment intact (above right)and following testing (bottom right).

As this investigation was a study of implant components tested at various lengths and not a materials test, traditional methods of analysing a stress-strain curve were modified to apply to this study. The force-displacement curves for the tests were analysed and for the purposes of this study the reading for the yield point was classified as the failure force.

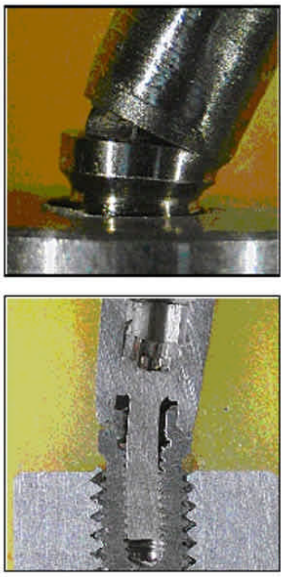

Figure 7.

Summary of Results

In static conditions the 18mm abutment has 50% of the strength of the 8mm abutment. The 13mm restoration would show a corresponding strength value of 65% when compared to the 8mm abutment.

Conclusion

Increased restoration height creates a greater challenge on the clamping force of the joint and preload of the screw. This may have negative effects on the stability of the implant/abutment assembly. Further investigations are necessary to evaluate the full effect of varying restoration height on the long-term success of single implant units.

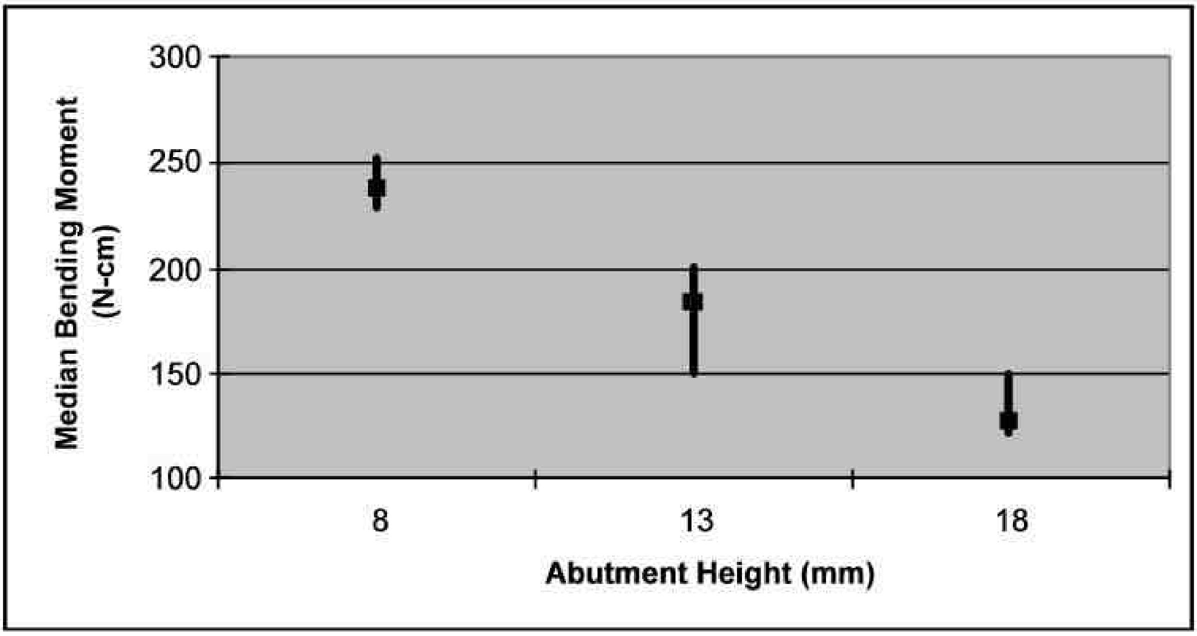

Figure 8. ***Median Bending Moments with Associated Confidence Intervals.***