

# Zimmer® Angled Tapered Abutments

## Restorative Solutions for Tilted Implant Protocols

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### Introduction

Dental implants are often used to rehabilitate edentulous patients.<sup>1</sup> Compromised bone in the posterior regions of the mouth, the presence of the sinus antrum in the maxilla, and the presence of the alveolar nerve canal and the mental nerve loop in the mandible limit the ability to place implants in the posterior.<sup>1-2</sup> Techniques such as bone grafting of the maxillary sinus or transpositioning of the mandibular nerve may be utilized, although these procedures add time and complexity.<sup>2</sup> The tilting of implants toward the posterior eliminates the need for such techniques by placing implants in the available bone.<sup>3</sup> Tilted implants allow for an increased degree of implant-to-bone contact area and implant primary stability, since longer implants may be used. They also allow for a longer distance between implants, which helps to eliminate cantilevers in the prosthesis for better load distribution.<sup>1-3</sup>



**Figure 1.** Zimmer Angled Tapered Abutments.

Zimmer® Angled Tapered Abutments (Zimmer Dental Inc., Carlsbad, CA)\* have been designed for use with angled implants. The components are engineered to align the coping screw for a common path of insertion and draw in the fabrication of multi-unit restorations. Once connected to the implant, the abutment extends through the soft tissue to create a common screw-receiving platform for a prosthesis. A coping screw passes through the restorative superstructure to secure it in place.

The implant, multi-unit abutment, and coping assembly are subjected to compressive loads during use. Consequently, mechanical strength is a major concern when angled abutments

diverge from the long axis of the implant.<sup>4</sup> Prosthetic screw stability is also a major concern with screw-retained restorations.<sup>5</sup> As a coping screw is tightened into an abutment, the applied torque results in a force with a line of action parallel to the surface of the thread. This force can be resolved into two orthogonal components, the first of which acts parallel to the long axis of the screw and results in screw preload. The second component, opposite in direction to the torque, with a line of action tangent to the circumference of the screw thread, is a result of friction between the screw and the mating thread. Preload provides the compressive force that holds the screw connection together.<sup>5</sup> The magnitude of the preload on a screw is the greatest immediately after the screw is tightened.<sup>5</sup> As time progresses, plastic deformation of the thread (creep) will cause a reduction in preload and retention torque.<sup>5</sup> If a screw connection is exposed to a time-varying load, an additional loss of preload and retention torque can occur.<sup>5</sup> If not addressed, loss of screw torque can result in component loosening and fracture, crestal bone loss and eventual implant failure.<sup>5</sup> This article reports on the mechanical strength and retention torque evaluations of the *Zimmer Angled Tapered Abutments* and several of its competitors.

Description	Implant	Abutment Screw Torque	Coping Screw Torque
Zimmer Angled Tapered Abutment, 30°	Tapered Screw-Vent	30 N-cm	20 N-cm
Nobel Biocare®, 30° Multi-unit Abutment*	NobelActive	15 N-cm	15 N-cm
Biomet 3i™, 30° Low Profile Abutment*	Certain Tapered	20 N-cm	10 N-cm

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**Table 1.** Test part descriptions and torque values.

### Materials and Methods

Mechanical testing was conducted according to ISO standard 14801:2007 Dentistry – Implants – Dynamic Fatigue Test for Endosseous Dental Implants. Implants and components from three (3) manufacturers were used: *Tapered Screw-Vent*® Implant and 30° Angled Tapered Abutment (“Zimmer”), NobelActive™ Implant and 30° Multi-unit Abutment (“Nobel”) (Nobel Biocare, Yorba Linda, CA)\* and NanoTite™ Tapered Certain Implant and 30° Low Profile Abutment (“3i”) (Biomet 3i, Palm Beach Gardens, FL).\*

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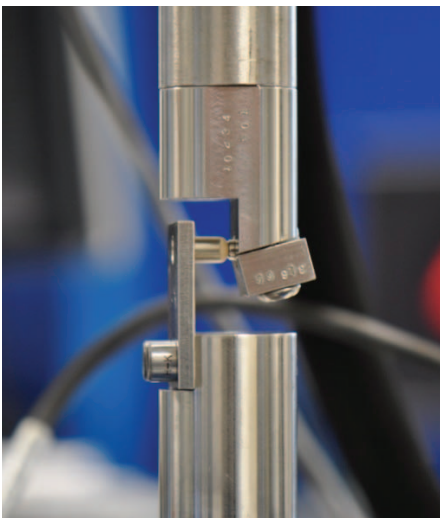
To test the abutment assemblies in compression, each assembly was clamped in a fixture 40° off-axis, and force was applied until failure of the assembly occurred. Fatigue testing was conducted with the assembly clamped in the same fashion, and a cyclic force was applied at a frequency of 14 Hz until failure of the assembly occurred, or the assembly withstood 5,000,000 cycles. If three (3) assemblies withstood 5,000,000 cycles at a specific force value, this was considered the assembly's endurance limit. The assemblies were tested with a range of force values in order to determine the endurance limit.

Testing was also conducted to determine coping screw torque retention over time. Each abutment was torqued into an implant, per the manufacturer's Instructions for Use, to the appropriate abutment torque value. A temporary titanium coping was secured to the abutment with a titanium coping screw, and the coping screw was torqued to the appropriate coping torque value specified by its manufacturer (see Table 1).



**Figure 2.** Coping screws for BIOMET 3i, Zimmer, and Nobel (respectively).

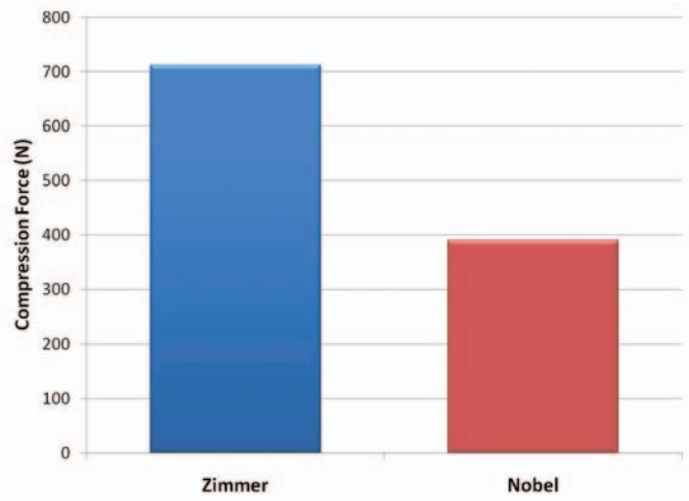
A test cap was cemented to the coping, and the assembly was clamped to a fixture such that the test cap was positioned to experience lateral forces. A cyclic force was applied at a frequency of 10 Hz for a total of 100,000 cycles. The reverse torque value of the coping screw was measured after testing, and torque retention values were recorded.



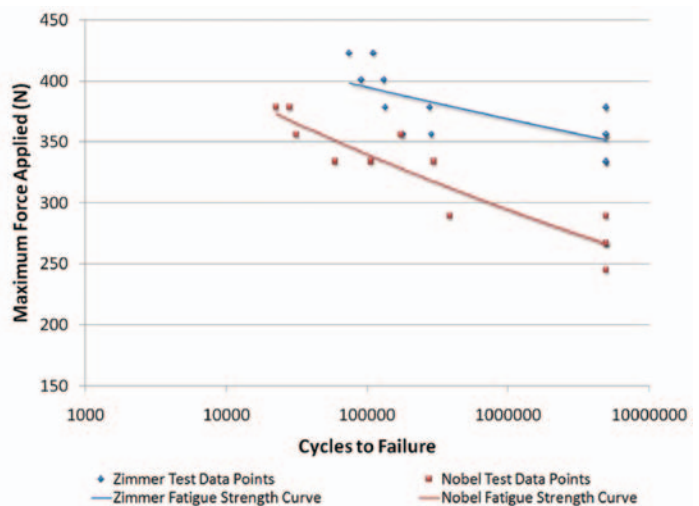
**Figure 3.** Dynamic torque retention test set-up.

## Results

Compressive strength testing of the Zimmer abutments demonstrated an average compression value of 712 N. Compressive strength testing of the Nobel abutments demonstrated an average compression value of 390 N (see Figure 4). During fatigue strength testing, Zimmer abutments exhibited 334 N of strength. In contrast, Nobel abutments achieved 267 N of strength (Figure 5).<sup>6-7</sup>

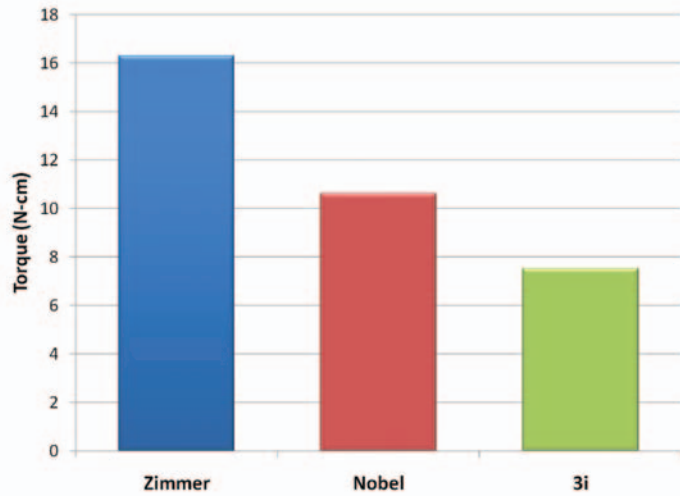


**Figure 4.** Compressive strength testing.

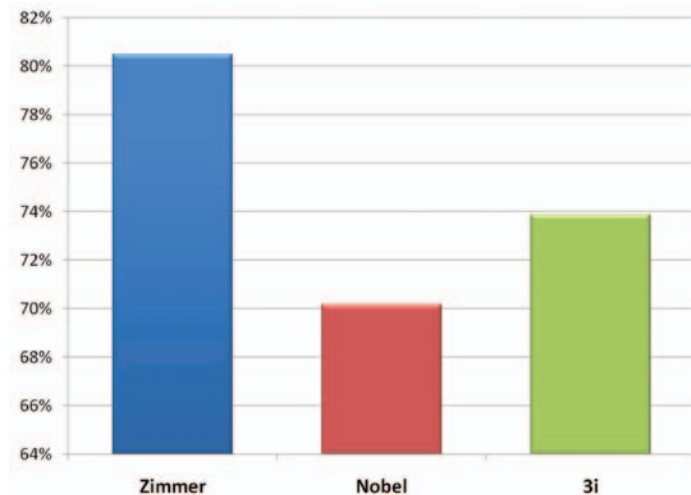


**Figure 5.** Fatigue strength testing.

In torque testing, Zimmer abutments achieved 16.3 Ncm of resistance, as compared to 10.6 Ncm for Nobel abutments and 7.5 Ncm for Biomet 3i abutments (Figure 6). The percentage of the original torque that was retained for each abutment was calculated by dividing the difference between the final and initial torque by the initial torque, and multiplying by 100. Zimmer abutments retained 80.5% of their original torque, followed by Biomet 3i (73.9%) and Nobel (70.2%) (Figure 7).<sup>8-9</sup>



**Figure 6.** Torque after dynamic retention testing.



**Figure 7.** Percent torque retained after dynamic retention testing.

## Discussion

The *Zimmer* Angled Tapered Abutments performed approximately 82% better than the Nobel Multi-unit Abutments in compression strength testing, and 25% better than the Nobel abutments in fatigue strength testing. In retained torque value, Zimmer abutments were approximately 54% higher than the Nobel abutments and exhibited a torque value approximately 117% higher than the Biomet 3i abutments after dynamic retention testing. *Zimmer* Angled Tapered Abutments retained 10.3% more of their original torque than Nobel abutments, and 6.6% more of their original torque than Biomet 3i abutments.

## Conclusions

The *Zimmer* Angled Tapered Abutments outperformed the Nobel Multi-unit Abutments in compression and fatigue strength testing, and both the Nobel Multi-unit Abutments and the Biomet 3i Low Profile Abutments in torque retention testing.

## References

- <sup>1</sup> Bellini CM, Romeo D, Galbusera F, Taschieri S, Raimondi MT, Zampelis A, Francetti L. Comparison of Tilted Versus Nontilted Implant-Supported Prosthetic Designs for the Restoration of the Edentulous Mandible: A Biomechanical Study. *Int J Oral Maxillofac Implants.* 2009;24:511-517.
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- <sup>3</sup> Aparicio C, Perales P, Rangert B. Tilted Implants as an Alternative to Maxillary Sinus Grafting: A Clinical, Radiologic, and Periotest Study. *Clin Impl Dent Relat Res* 2001;3:39-49.
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- <sup>5</sup> Vogel RE, Davliakos JP. Spline™ implant prospective multicenter study: interim report on prosthetic screw stability in partially edentulous patients. *J Esthet Restor Dent.* 2002;14:225-237.
- <sup>6</sup> Data on file. Zimmer Research Report ZRR\_ZD\_00099\_01.
- <sup>7</sup> Data on file. Zimmer Research Report ZRR\_ZD\_00071\_01 Addendum E.
- <sup>8</sup> Data on file. Zimmer Research Report ZRR\_ZD\_00109\_00.
- <sup>9</sup> Data on file. Zimmer Research Report ZRR\_ZD\_00111\_00.