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# Effects of Cyclic Loading on Abutment Screw Torque Loss when Angulated Screw Channel Single Implant Crowns are attached to Narrow Diameter Implants



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## Statement of Problem

Angulated screw channel (ASC) can improve maxillary anterior screw-retained implant crown esthetics by allowing screw access channel to emerge palatal to the incisal edge. While ASC can be used on narrow diameter implants (NDI), there is no published information on ASC abutment screw torque loss (ASTL) on NDI.

## Introduction

- Nowadays, screw-retained implant crowns are favored because of retrievability and eliminating the need of cements, which can potentially lead to peri-implantitis. However, screw-retained crowns are not recommended if the screw access channel emerges through the facial aspect of the crown. Recently, ASC were introduced allowing correction of the original implant screw access up to 30 degrees.
- NDI are indicated when there is limited residual bone volume and mesiodistal space. Studies have shown comparable implant success rates between NDI and regular diameter implants (RDI).
- Regardless of implant success rate, the stability of the connection between different implant components is important for the overall success of the reconstruction. Abutment screw loosening has been reported as one of the most common mechanical complications in single crowns. Moreover, higher incidence of screw loosening has been detected in NDI as compared to RDI.

## Purpose of the Study

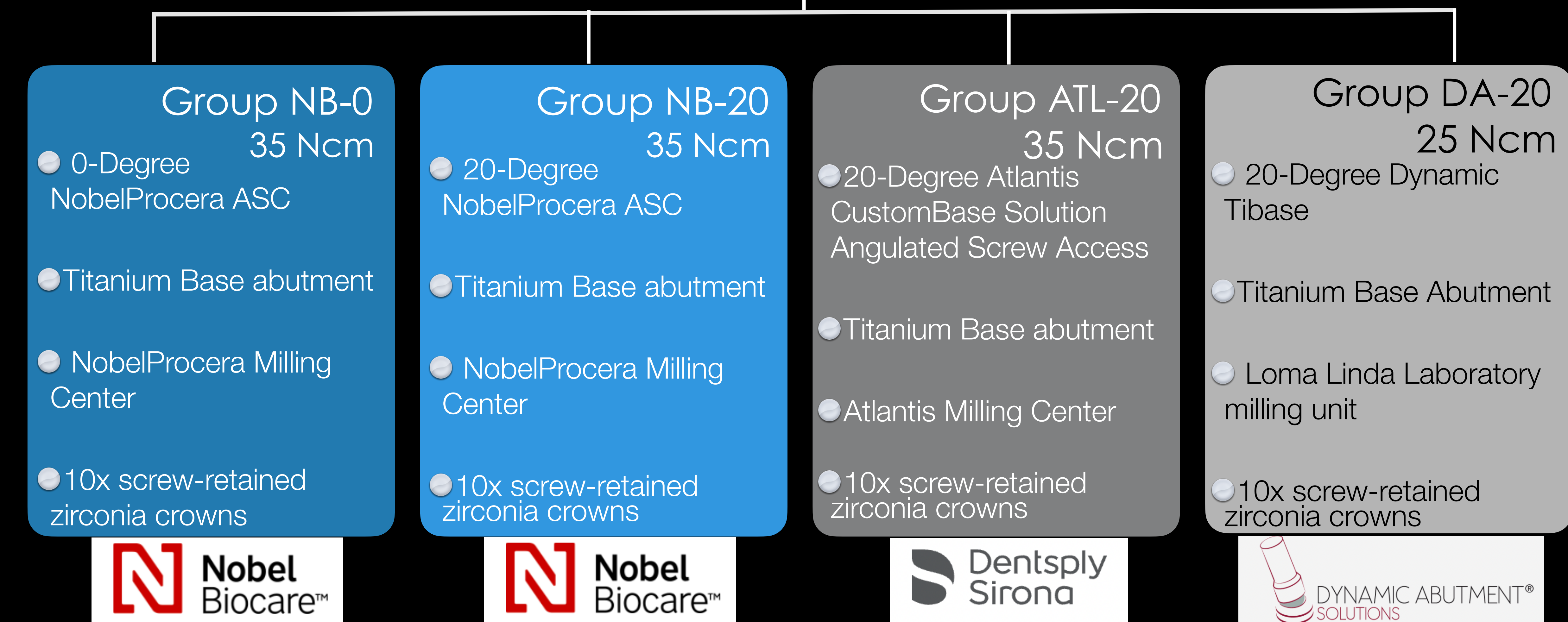
- To compare ASTL after thermocycling and cyclic loading of ASC from 3 different companies connected onto NDI

## Materials and Methods

- A total of 40 NDI (NobelReplace Conical Connection 3.5x11.5 mm; Nobel Biocare AB) were mounted individually in acrylic resin block and divided equally into 4 groups of 10 implants based on ASC abutment systems and access channel angulation. Group 1; NB-0 (Control, 0-degree Angulated Screw Channel Solutions; Nobel Biocare AB); Group 2; NB-20 (20-degree Angulated Screw Channel Solutions; Nobel Biocare AB); Group 3; ATL-20 (20-degree Atlantis Custom Base Solution with angulated screw access; Dentsply Sirona Inc); Group 4; DA-20 (20-degree Dynamic Ti Base; Dynamic Abutment Solutions).

A complete contour wax pattern replicating a maxillary right central incisor crown

Scanned to create STL files





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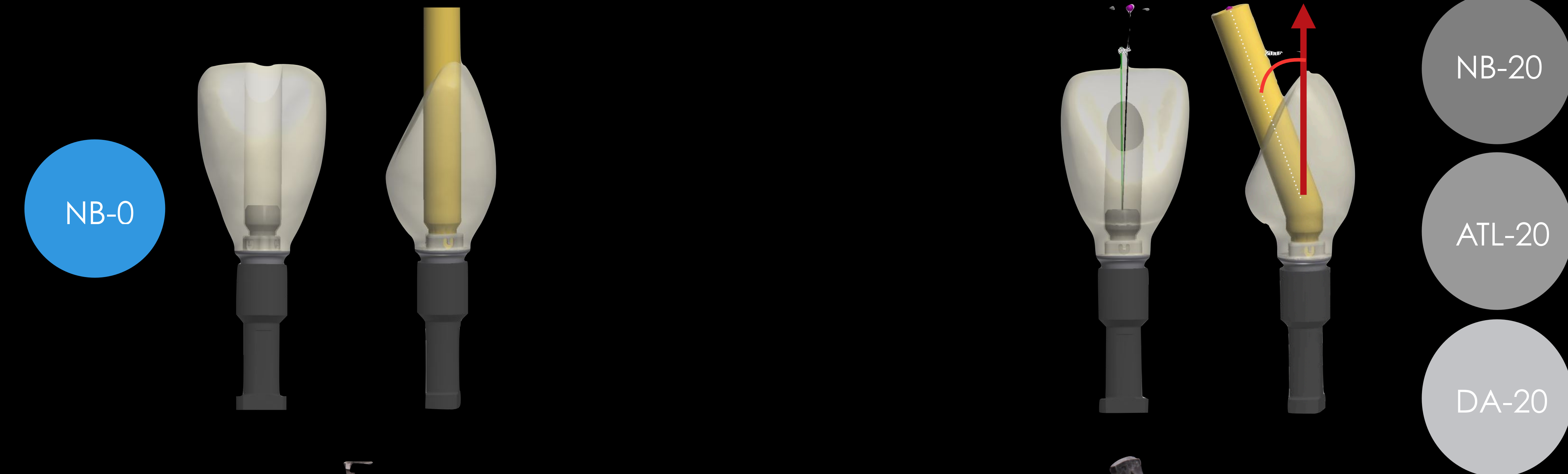
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## Materials and Methods

- The acrylic resin block specimens were prepared by embedding the NDI perpendicularly and centered into custom positioning devices using chemically-activated methyl methacrylate resin. 3mm of the implant platform was exposed according to specification of the ISO14801:2016. (Fig.1)
- A complete contour wax pattern replicating a maxillary right central incisor crown (Fig. 2) was fabricated on a wax-up sleeve that was connected to an implant analog and scanned to create a standard tessellation language (STL) file to enable fabrication of the 40 screw-retained zirconia crowns used in this study (Fig. 3).

Control Group  
0 degree

Test Groups  
20 degrees



Custom positioning

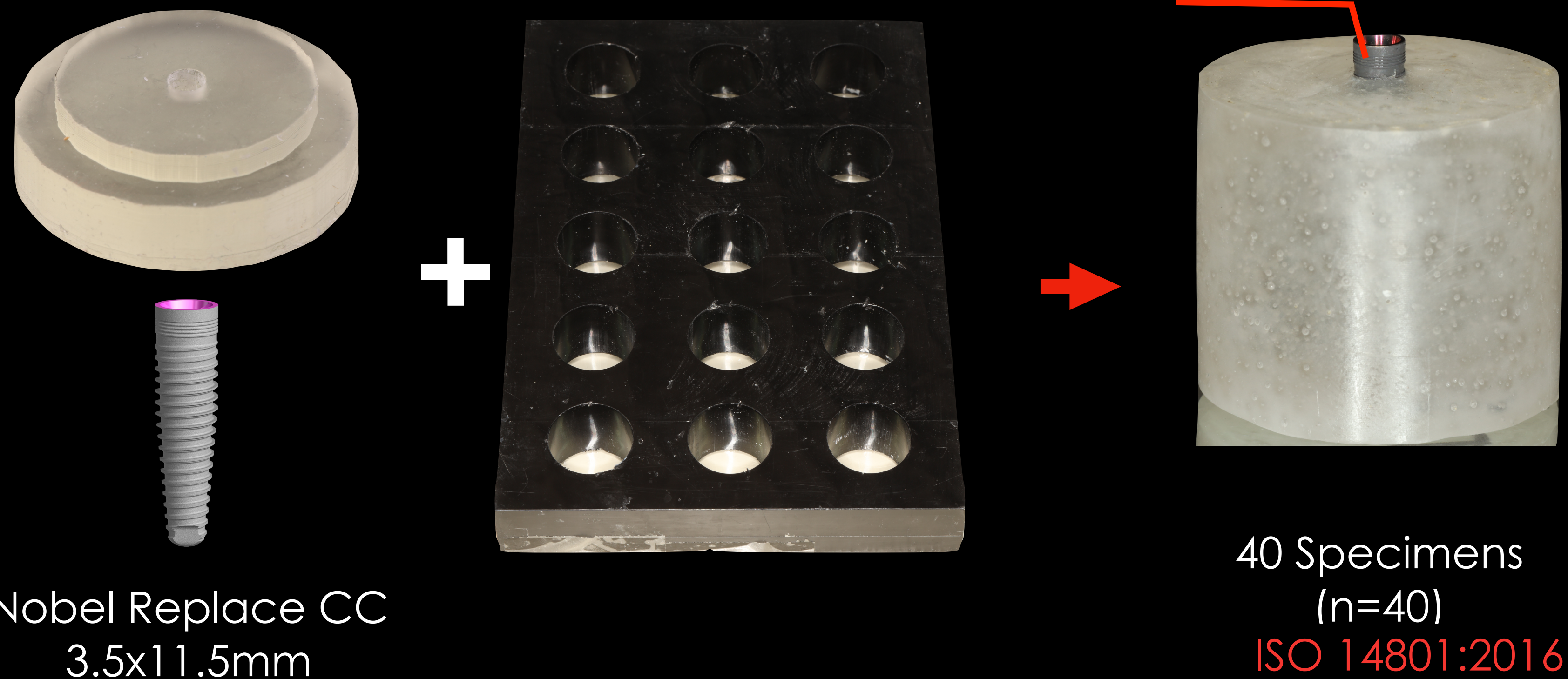


Figure 1. Specimen preparation



Figure 2. Complete wax pattern #8



Figure 3. Process of fabrication 40 screw retained crowns



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## Materials and Methods

- Each crown was secured on the mounted implant with its corresponding titanium base insert and screw (Fig. 4), then tightened to the manufacturer's recommended torque using a digital torque gauge (Fig. 5).
- Initial reverse torque values ( $RTV_I$ ) were obtained and recorded at baseline. Subsequently, a new set of screws were torqued to recommended values, and each specimen underwent thermocycling (Fig. 6) and then was subjected to cyclic loading at 0 to 100N at 10 Hz for one million cycles to simulate one year of functional loading (Fig. 7).
- After cyclic loading, final reverse torque values ( $RTV_F$ ) were recorded and compared to the  $RTV_I$  to evaluate the final percentage torque loss ( $PTL_F$ ).
- Statistical analysis was performed using the Kruskal-Wallis analysis. Rank base ANCOVA and Tukey HSD post hoc comparisons were performed at an alpha level of 0.05.

NB-0 and NB-20

ATL-20

DA-20

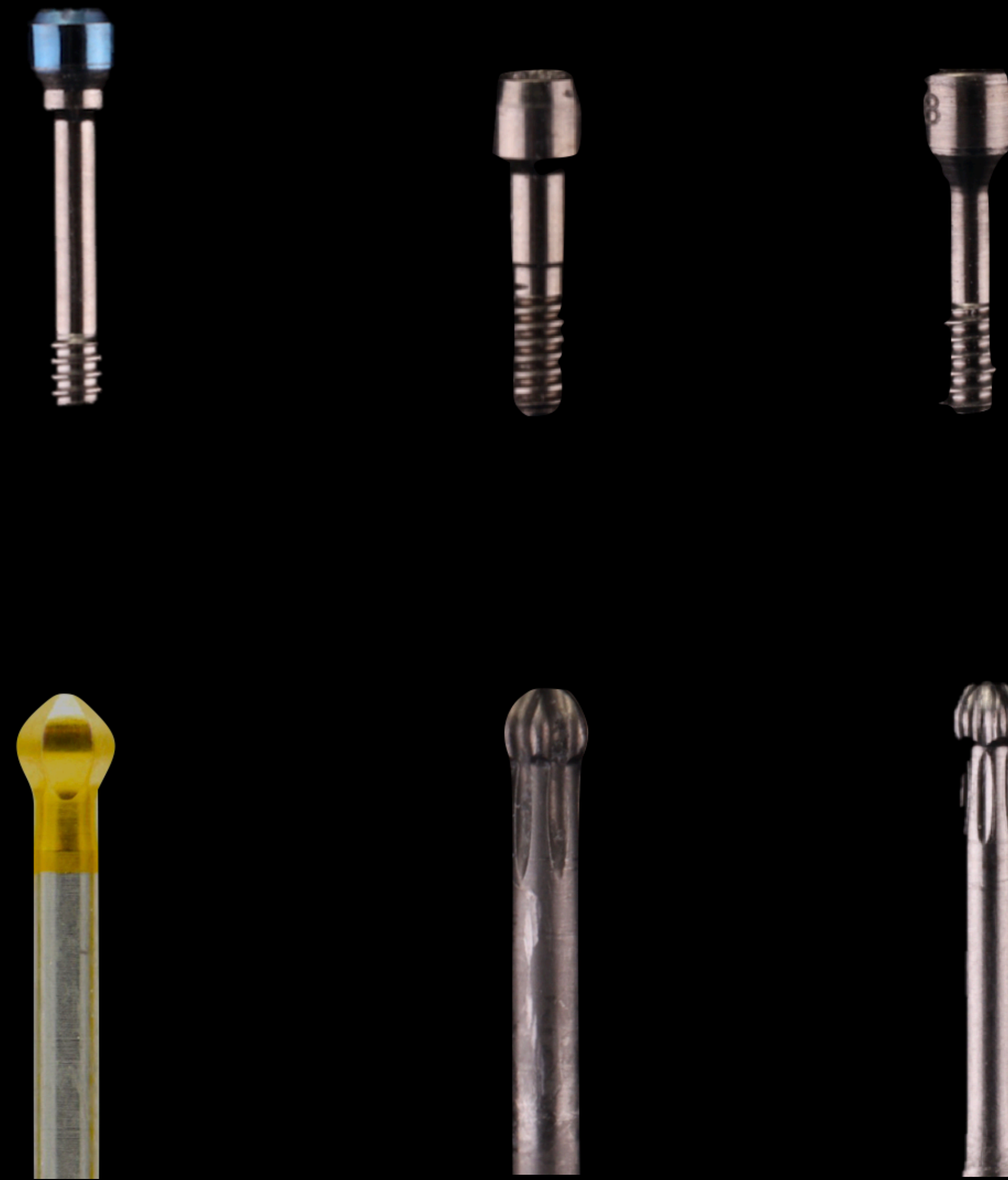


**Figure 4.** Proprietary abutment screws and screwdrivers from different manufacturers



**Figure 5.** Digital torque gauge



**Figure 6.** Thermocycling process

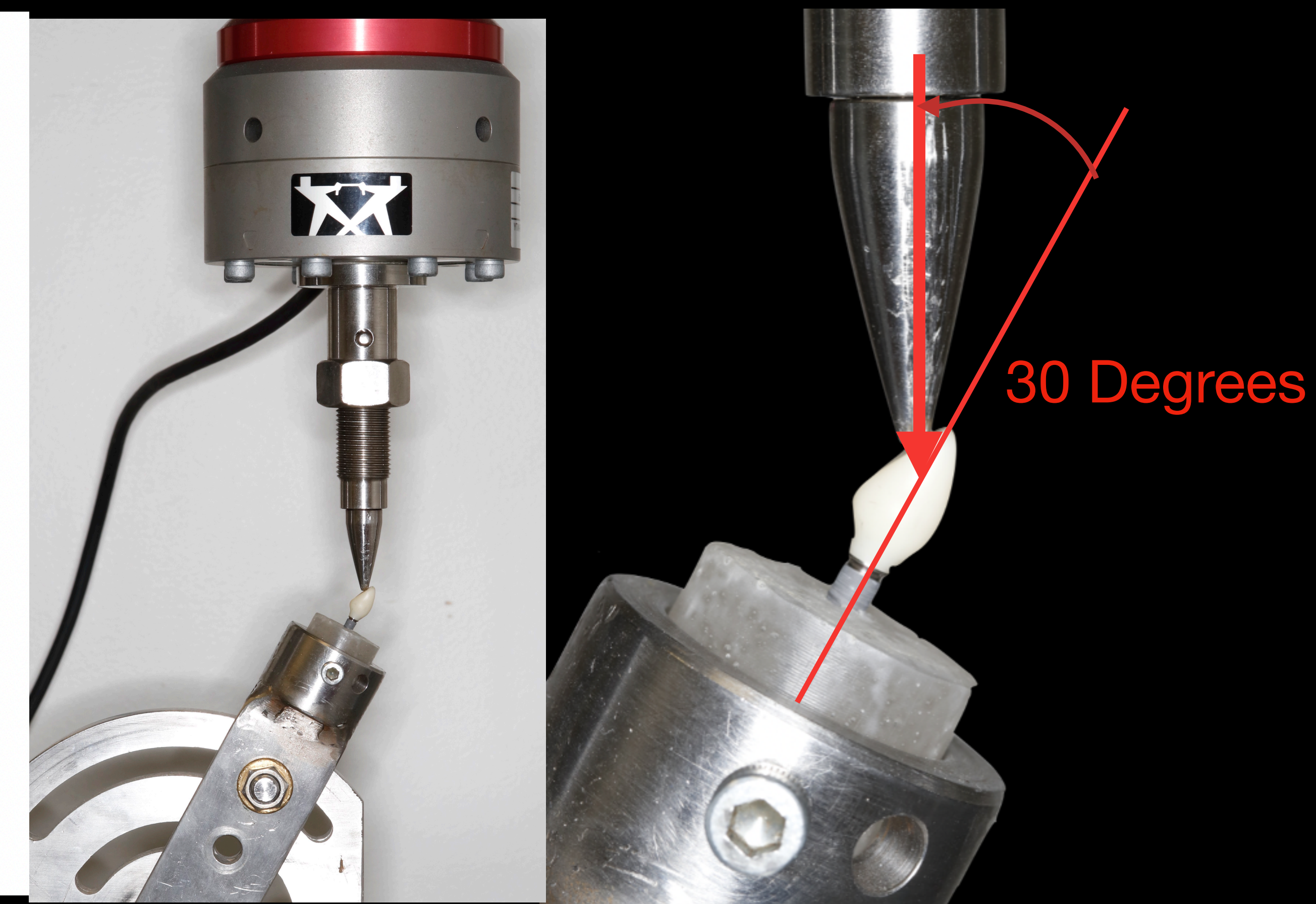
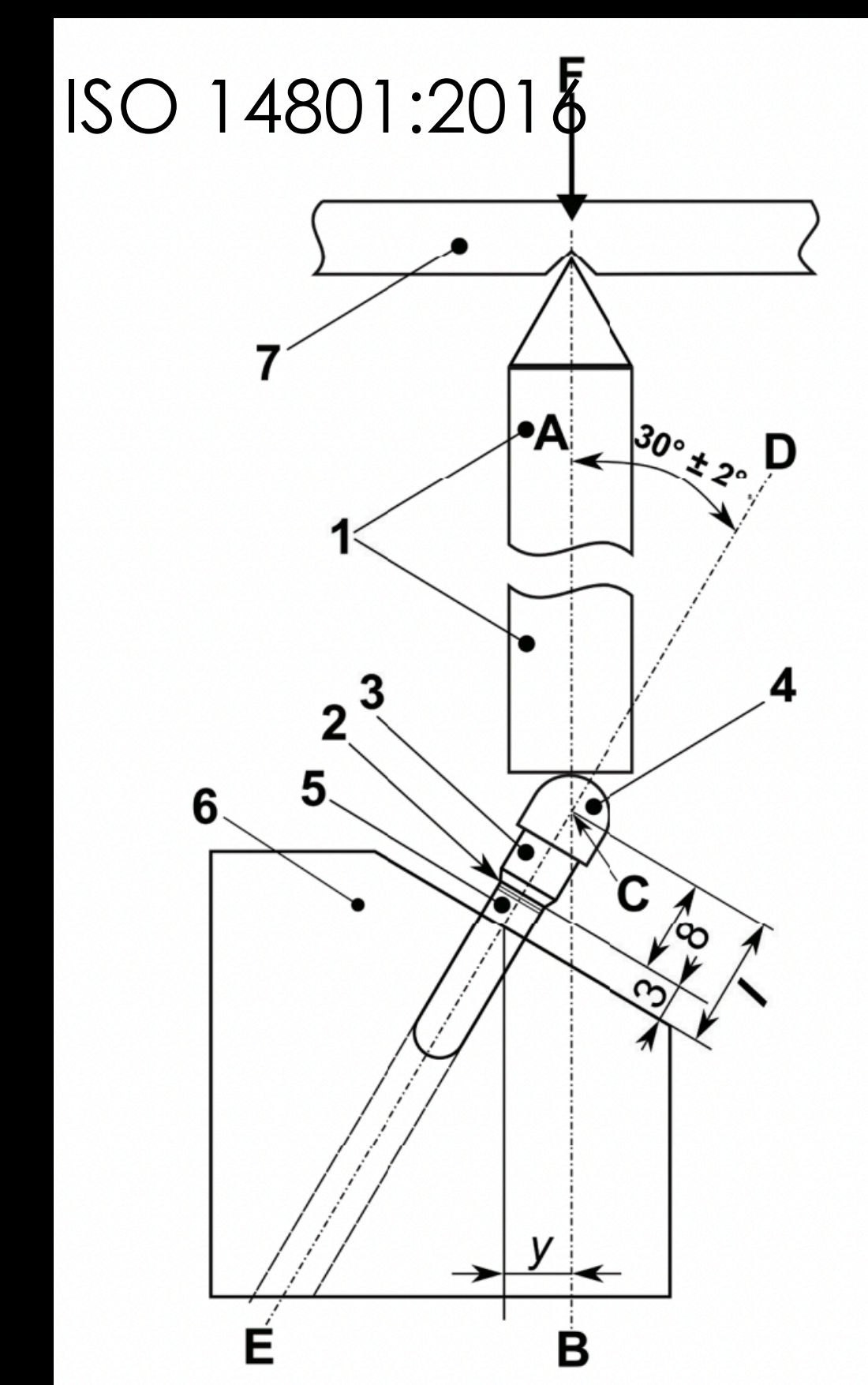


**Figure 7.** Cyclic loading procedure



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## Results

- **Prior to cyclic loading**, significant differences ( $P = .004$ ) were recorded for the initial percentage torque loss (PTL<sub>I</sub>) among all groups (Table 2). The PTL<sub>I</sub> in ATL-20 (26.7%) was significantly higher than those in NB-0 (16.4%) ( $P = .005$ ) and NB-20 (18.8%) ( $P = .037$ ). No significant differences were found in the PTL<sub>I</sub> among other groups.

| Pre – Cyclic Loading |                 |                             |                                                           |                                                                                                              |
|----------------------|-----------------|-----------------------------|-----------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|
| Group                | Mean ± Sd (Ncm) |                             |                                                           |                                                                                                              |
|                      | TV <sub>I</sub> | RTV <sub>I</sub><br>(Range) | ΔTV <sub>I</sub><br>(TV <sub>I</sub> - RTV <sub>I</sub> ) | Initial Percentage Torque Loss<br>PTL <sub>I</sub> = [(ΔTV <sub>I</sub> / TV <sub>I</sub> ) x100]<br>(Range) |
| NB-0                 | 35.2 ± 0.13     | 29.4 ± 2.02<br>(26.0-32.0)  | 5.8 ± 1.94                                                | 16.4 ± 5.57 <sup>a</sup><br>(9.0-25.7)                                                                       |
| NB-20                | 35.1 ± 0.10     | 28.5 ± 1.95<br>(25.6-31.0)  | 6.6 ± 1.96                                                | 18.8 ± 5.58 <sup>a</sup><br>(11.7-27.3)                                                                      |
| ALT-20               | 35.2 ± 0.10     | 25.8 ± 2.74<br>(21.9-30.5)  | 9.4 ± 2.73                                                | 26.7 ± 7.77 <sup>b</sup><br>(13.4-37.8)                                                                      |
| DA-20                | 25.1 ± 0.09     | 18.7 ± 1.63<br>(16.3-21.0)  | 6.4 ± 1.63                                                | 25.4 ± 6.48 <sup>a,b</sup><br>(16.0-35.1)                                                                    |
| P-value              |                 | <.001                       | .015                                                      | .004                                                                                                         |

TV<sub>I</sub> = Initial torque values; RTV<sub>I</sub> = Initial reverse torque values; TV<sub>I</sub> = Initial torque value changes between TV<sub>I</sub> and RTV<sub>I</sub>; and PTL<sub>I</sub> = Initial percentage torque losses.

<sup>a, b</sup> Designated rows with different letters denote statistically significant difference



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## Results

- **Post- cyclic loading**, significant differences ( $P<.001$ ) were found for the final percentage torque loss ( $PTL_F$ ) among all groups (Table 3). The  $PTL_F$  in ATL-20 (47.1%) was significantly higher than those in NB-0 (21.2%) ( $P<.001$ ) and NB-20 (30.7%) ( $P=.01$ ). No significant differences were found in the  $PTL_F$  among other groups.
- No crown mobility, crown fracture, screw fracture, implant fracture or other complications were detected during visual and tactile inspection after cyclic loading

## Conclusions

- Within limitations of this study, it can be concluded that:
- With regards to ASTL among all groups, NB-20 demonstrated the lowest percentage torque loss after cyclic loading.
  - ATL-20 demonstrated the highest percentage torque loss as compared to other groups after cyclic loading.
  - DA-20 had the lowest manufacturer's recommended torque value; however, its percentage torque change after cyclic loading was less than ATL-20, suggesting that other factors play a role in torque loss other than initial torque value.

## References

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## Post – Cyclic Loading

| Group          | Mean $\pm$ Sd (Ncm)            |                                |                                                       |                                                                                        |
|----------------|--------------------------------|--------------------------------|-------------------------------------------------------|----------------------------------------------------------------------------------------|
|                | RTV <sub>I</sub><br>(Range)    | RTV <sub>F</sub><br>(Range)    | $\Delta$ RTV<br>(RTV <sub>I</sub> -RTV <sub>F</sub> ) | Final Percentage Torque Loss<br>$PTL_F = [(\Delta RTV / RTV_I) \times 100]$<br>(Range) |
| <b>NB-0</b>    | 29.4 $\pm$ 2.02<br>(26.0-32.0) | 23.0 $\pm$ 2.78<br>(19.7-29.4) | 6.4 $\pm$ 3.83                                        | 21.2 $\pm$ 12.40 <sup>a</sup><br>(7.3-36.5)                                            |
| <b>NB-20</b>   | 28.5 $\pm$ 1.95<br>(25.6-31)   | 19.7 $\pm$ 2.61<br>(16.2-23.8) | 8.8 $\pm$ 2.69                                        | 30.7 $\pm$ 8.83 <sup>a</sup><br>(15.3-44.5)                                            |
| <b>ALT-20</b>  | 25.8 $\pm$ 2.74<br>(21.9-30.5) | 13.5 $\pm$ 2.27<br>(10.4-18.0) | 12.3 $\pm$ 3.28                                       | 47.1 $\pm$ 10.50 <sup>b</sup><br>(23.3-59.5)                                           |
| <b>DA-20</b>   | 18.7 $\pm$ 1.63<br>(16.3-21.0) | 11.1 $\pm$ 1.70<br>(9.2-14.5)  | 7.6 $\pm$ 2.28                                        | 40.5 $\pm$ 11.00 <sup>a,b</sup><br>(12.7-48.7)                                         |
| <b>P-value</b> | <.001                          | <.001                          | .004                                                  | <.001                                                                                  |

RTV<sub>I</sub> = initial reverse torque values; RTV<sub>F</sub> = final reverse torque values; RTV = reverse torque value changes between RTV<sub>I</sub> and RTV<sub>F</sub>; and  $PTL_F$  = final percentage torque losses.

<sup>a, b</sup> Designated rows with different letters denote statistically significant difference