Experimental verification of the test procedure for measuring the retentive force of magnetic attachments as stipulated in DIS 13017(Ed.2)

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Introduction

The international organization for standardization of dental magnetic attachments, ISO 13017, was published in 2012[1)]. ISO 13017 only outlined the test procedure for measuring retentive force. Afterwards, the detailed test procedure was established in 2015 and incorporated into ISO 13017 Amendment 1[2)].

All ISO standards are revised every five years after issuance. Revision meetings for ISO 13017 started in 2017 with amalgamation of ISO 13017 and its Amendment 1, and reconsideration of the test procedure for measuring retentive force of dental magnetic attachments. However, the usefulness of the test procedure as stipulated in the latest DIS 13107(Ed.2) has not been verified.

Objective

The aim of the study was to investigate the effectiveness of the test procedure instructions.

Materials and Methods

1. Participants, samples, and the measuring device

Undergraduate/graduate dental students (A, B, C, D, and E) whose native language is not English, were selected to participate and conduct the experiment for the first time. Three different samples of magnetic attachments were used—two flat types (Gigauss D600, GC; and Hyper Slim 3513, Morita) and one post type (Hicorex post keeper 3513, Morita). The measuring device used (Fig. 1) matched that described in DIS 13107(Ed.2). Measurements were recorded by digital force gauge (ZPS, Imada). The crosshead speed was controlled by a hydraulic check unit (Kinecheck 3022-19-1-1/4, Meiyu Airmatic).

Fig. 1 Device for measuring retentive force

2. Prerequisite conditions for the various stages of the experiment

Measurements were conducted in three stages. The validity of the procedure was estimated by comparing the student obtained values with those of an expert.

Stage 1: Each participant reads the DIS standard test procedure manual alone, before carrying out the experiment. Discussions among participants at this stage are not allowed.

Stage 2: Participants discuss the test procedure instructions among themselves then repeat the experiment.

Stage 3: Participants discuss the test procedure instructions with an expert, and carry out the experiment for a third time.

3. Test procedure instructions for measuring retentive force

Details of the test procedure method are found in the DIS manual. The outline of the test procedure for measuring the retentive force is as follows:

a) Align the centers of upper and lower table.
b) Place the mating face of the magnetic assembly onto the lower-table.
c) Place a drop of the cyanoacrylate adhesive on the top surface of the magnetic assembly. Lower the upper-table until it makes contact with the magnetic assembly.
d) Place the keeper on the mating face of the magnetic assembly and make sure that it is properly aligned to the magnetic assembly.
e) Place a drop of the cyanoacrylate adhesive on the lower-table then move the upper-table down until the bottom surface of the keeper makes contact with the lower-table. If necessary, reinforce the bonding area with a self-curing acrylic resin.
f) The specimens are loaded in tension on the device at a crosshead speed of 2.0 mm/min.
g) The retentive force of the magnetic attachments [C, Fig. 2] is acquired by subtracting the dead weight of the device including its moving friction [B, Fig. 2] from the separation point value [A, Fig. 2].
h) Repeat the retentive force measurements for each of the three specimen is repeated four times to generate five measurements for every stage of instructions per specimen. In this study, the average value is obtained from five measurements.

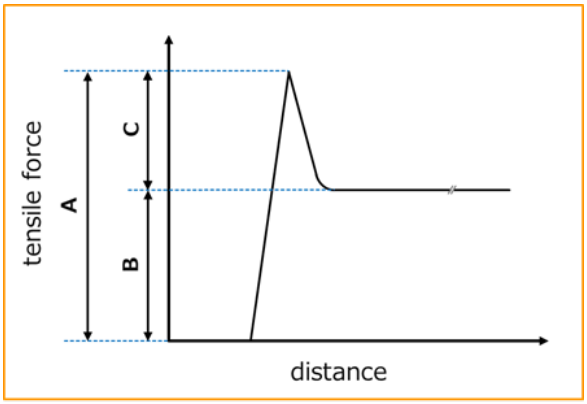

Fig. 2 Retentive force curve

4. Statistical analysis

Generated data was statistically analyzed using ANOVA and Tukey's HSD test (α=0.05).

Results

The retentive forces measured by each participant are shown in Fig. 3. All the values attained during second stage, except in the case of HICOREX by participant A and GIGAUSS by participant B, matched the values measured by the expert. The retentive force values of all the magnetic attachment specimen in the second and third stages was higher than that of the first stage ($p<0.05$). The values for each magnetic attachment sample during the second and third stages were nearly same for all the participants ($p>0.05$).

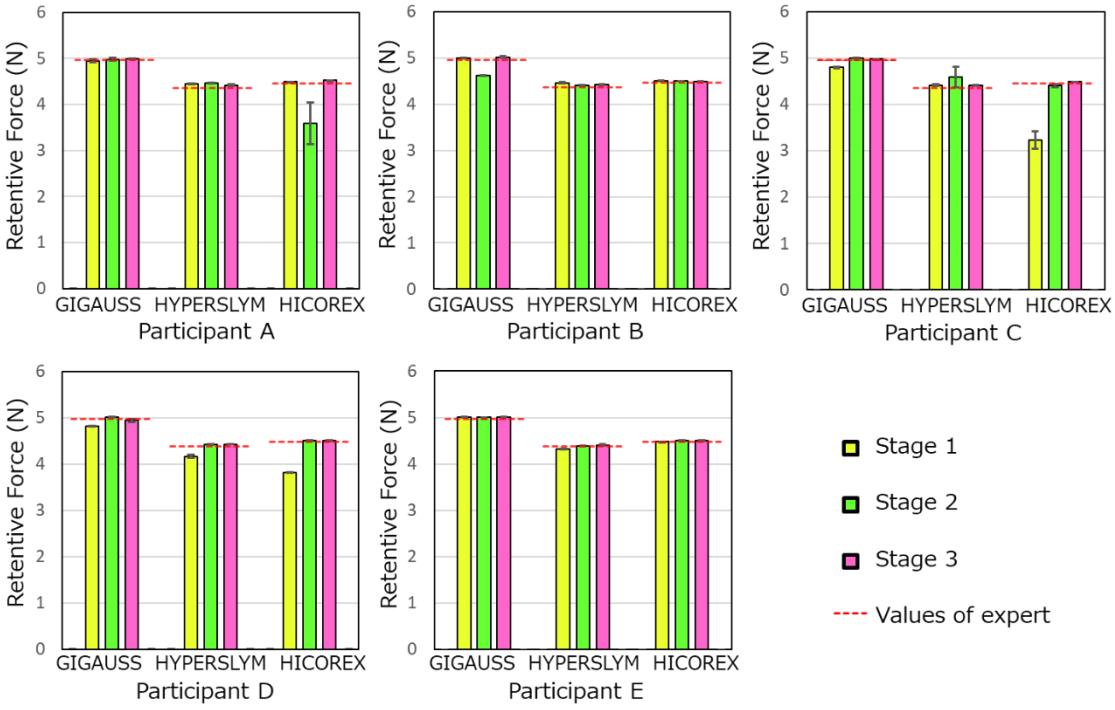

Fig. 3 Retentive forces measured by each participant

Discussions

Retentive force values of the second stage mostly matched those of the expert. This demonstrates that discussing the instructions with other participants aids in understanding of the test procedure and improves the measurement technique. Second and third stage values which were almost the same prove that accurate measurements can be obtained by individuals carrying out the test for the first time without help from an expert.

The values measured by participant C and D during the first stage did not match those of the expert. Differences in carrying out the measurements by the participants involved the factors discussed below.

(i) The type of cyanoacrylate adhesive used

Cyanoacrylate adhesive is available in liquid and jelly formulations. Theoretically, the retentive force does not change based on the formulation used as long as the glue sets completely. However, the setting time is different for the two types. The jelly type being thicker, has a longer setting time, compared to the liquid type. Moreover, the setting reaction of cyanoacrylate adhesives starts from the surface in contact with air and proceeds inwards[3]. Since participant A (stage 2, HICOREX) and C (stage 1, HICOREX) used the jelly type and measured retentive force before the setting process was complete, the values acquired were lower. In order to measure retentive forces accurately, measurement should only be carried out after cyanoacrylate adhesive has set completely.

(ii) Temporary fixation while securing a magnetic assembly on the upper-table

ISO 13017 Amendment 1[2], outlines that the magnetic assembly be attached to the lower-table using an adhesive double sided tape. That description was deleted and does not appear in the current DIS as recent research proved that there was no difference in the retentive force measured if double sided tape is used or not[4]. However, the following sentence remained in the DIS; "*Provisionally place the mating face of the magnet (or magnetic assembly) to the center of the lower-table*". Participant D and E interpreted "*provisionally*" as "temporary adhesion/fixation", and used the double sided tape. The double sided tape did not affect the retentive force a finding that is in agreement with the previous study[4].

(iii) Alignment after fixation of magnetic assembly and keeper

The DIS presumes that the center of the magnetic assembly and that of the keeper are automatically congruent when a keeper is placed onto the mating face of a magnetic assembly that is bonded to the upper-table. However, the centers maybe out of alignment because the placement of the keeper onto the mating face depends on the tactile sensation of the operator doing the experiment and his visual ability to ascertain that the centers are not horizontally displaced. Alignment between the magnetic assembly and the keeper is the most important factor in measurement of retentive forces[5]. Therefore, after fixing the magnetic assembly and keeper on the tables, the alignment should be adjusted confirmed by using X-Y stage. However, the requirement to readjust the alignment is not contained in the DIS. Participant B, C, D, E during the first stage measured the retentive force, without re-adjusting the alignment (see Fig. 4). Since the measured values improved during second stage after addition of the sentence "align the centers of samples after the fixation"; it would be important to append the phrase to the test procedure.

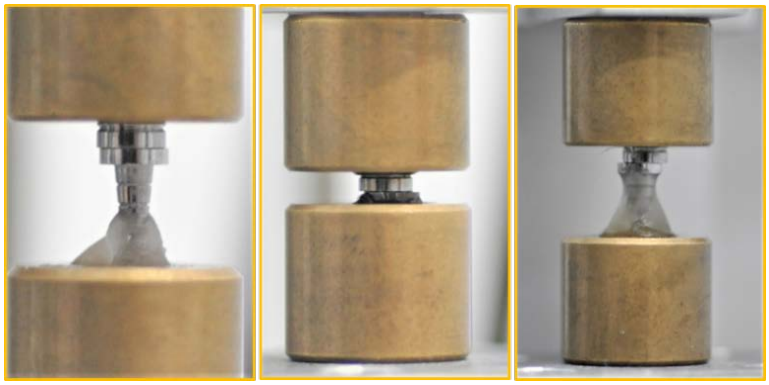

Fig. 4 Possible misalignment between magnetic attachment and keeper

(iv) Fixation technique of the post-keeper type

The participants used different methods to secure the post-keeper onto the table. One participant used a table with a hole for the post, whereas another reinforced the bonding area between the post-keeper and lower-table using self-curing acrylic resin. However, the measured values did not differ significantly among participants. As long as the post-keeper is fixed correctly, the retentive force can be measured with sufficient accuracy, a finding that is in agreement with the previous study[6].

Conclusions

These results indicate that DIS 13017(Ed.2) is a useful guide for measuring retentive force. More accurate measurements can be performed by appending the following clause "align samples after the fixation".

Acknowledgments

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