Effect of changes in the protocol of fixing a magnetic attachment onto the stage of an ISO measuring device on retentive forces

M. Takahashi, K. Numazaki, H. Sakatsume, M. Kanyi, K. Sato, K. Sasazaki and Y. Takada

Division of Dental Biomaterials, Tohoku University Graduate School of Dentistry

Abstract

Retentive forces are an important and sensitive aspect of dental magnetic attachments. The existing ISO 13017/Amd1 on measurements of retentive forces, outlines the method of fixing magnetic attachments on the table which has been reported as complicated. The aim of this study was to establish if the location, method of temporary stabilization and adjustment of the center of magnetic attachments on the table of an ISO measuring device have an influence on retentive forces.

Two types of magnetic attachments GIGAUSS D600 and HYPER SLIM 3513 were mounted on a measuring device connected to a digital force gauge.

The position a magnetic attachment is fixed on the table has no influence on retentive forces, since there was no significant difference between measured values with set up placed on the left, right, back or front compared with the center (reference) position.

Use or avoidance of double-sided adhesive tape to stabilize magnetic assembly did not affect retentive forces since there was no significant difference in measurements for the various styles of temporary fixation.

Gross adjustments using the X-Y stage has a negative effect as some of the retentive forces measured were statistically significantly lower than the reference values for both attachments.

Introduction

One of the most important aspects of dental magnetic attachments is the retentive force. However, retentive force is sensitive to changes involving the test method and conditions. ISO 13017/Amd.1 was published in 2012/2015[1,2] and includes a detailed test procedure method for measuring retentive force which was developed and adopted as an international standard. Repeatability and accuracy of the retentive force data measurements is attainable using the measuring device and method prescribed in ISO 13017. Findings of our previous study proved that the test procedure in the ISO 13017 standard serves as a useful guide for measuring retentive force for first-time users[3,4]. However, participants who contributed in this verification test[4] and members of domestic/international ISO meetings stated that "the method of fixing a dental magnetic attachment on the table is complicated" and that "there is a possibility that the relative location on the table where the sample magnetic attachment is fixed has an influence on retentive force". To improve the clarity of ISO 13017, a revision on the fixation method of a sample magnetic attachment was considered useful.

Objective

The aim of this study was to determine whether the method of fixing a magnetic attachment on the table has an influence on the retentive force measured. This involves; the manner in which temporary stabilization is done, the relative location on the table where specimen are placed and the use of X-Y adjustment table for aligning grossly mismatched magnetic attachment centers. Retentive force of a dental magnetic attachment fixed in various conditions and locations was measured and the relationship between the fixation method and retentive force was evaluated.

Materials and Methods

Dental magnetic attachments

Two dental magnetic attachments were used: GIGAUSS D600 (GC) and HYPER SLIM 3513 (Morita).

Retentive force measuring device

The measuring device used in this study matches the basic description in ISO 13017:2012/Amd.1:2015. This device allows pulling of magnetic attachment when fixed on the table, in a direction strictly

perpendicular to the mating surface without any inclination. This is achievable through incorporation of a linear motion bearing slide guide of low friction resistance (0.02 N). The device was connected to a digital force gauge (ZPS, Imada). The crosshead speed was controlled by use of a hydraulic check unit (Kinecheck 3022-19-1-1/4, Meiyu Airmatic).

Double-sided adhesive tape

Two types of double-sided adhesive tapes were used: thin type (thickness of 110 μm) and thick type (thickness of 400 μm).

Test procedure for measuring retentive force

Retentive forces of dental magnetic attachment were measured in accordance with the test procedure stipulated in ISO 13017. The crosshead speed was set at 4.5 mm/min. Data (retentive force readings) was obtained corresponding to the 9 different conditions of fixation different from the ISO stipulated ones. The standard reference conditions for fixation according to ISO 13017manual are as follows:

1. A magnetic assembly was temporarily secured on the lower table by use of thin type of double-sided adhesive tape on the mating face before transfer and steady fixation of the same assembly on the upper table by use of a cyanoacrylate adhesive applied on the upper surface of assembly.
2. After removal of the double-sided adhesive tape, a keeper was temporarily attached to the assembly in a position in which the center of the assembly and that of the keeper matches and the two are congruent. Thereafter, the keeper is fixed on the lower table by use of a cyanoacrylate adhesive applied on its bottom surface.

Experimental fixation conditions

Several aspects involving conditions of magnetic attachment fixation were varied in this study as follows:

1. Magnetic attachments fixed in different positions of the table (Fig. 1).

a) center (C) –as is specified in ISO standard.
b) back (B)
c) front (F)
d) left (L)
e) right (R)

2. Method of intermediate stabilization of magnetic assembly on the lower table

a) use of thin type of double-sided adhesive tape: 110 μm –as is specified in ISO standard.
b) use of thick type of double-sided adhesive tape: 400 μm
c) no temporary adhesion done using tape. The magnetic assembly was placed on the lower table with the mating surface directly in contact with the table. Glue was applied onto the free surface before lowering the upper table so as to transfer and firmly attach the assembly.

3. Centering of the magnetic attachment specimen on the tables (Fig. 2).

The magnetic assembly was at the time of fixation deliberately set in positions that involved gross displacement of the center of the keeper on a horizontal plane along the X or Y or combined XY axis away from that of assembly. This resulted in a surface overlap of both assembly and keeper that covers about 1/3 diameter. Afterwards, the X-Y stage was used to adjust the setup making the center of assembly and keeper congruent. Retentive forces after each adjustment were measured.

a) Initially shifted along X-axis direction
b) Initially shifted toward the Y-axis direction
c) Initially shifted toward the X + Y axis direction

Statistical analysis

The data generated was statistically analyzed using ANOVA and Tukey's HSD test ($\alpha = 0.05$).

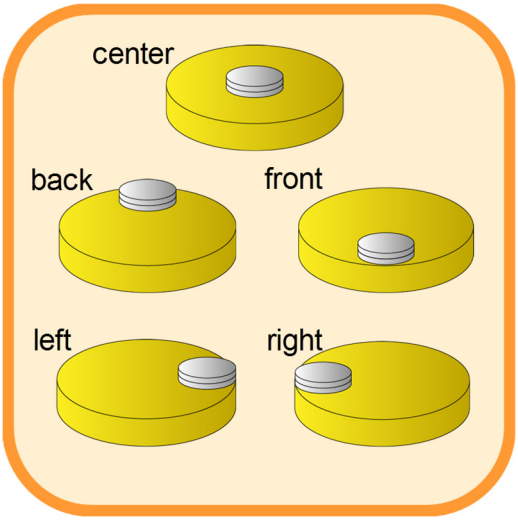


Fig. 1 Different locations on the table

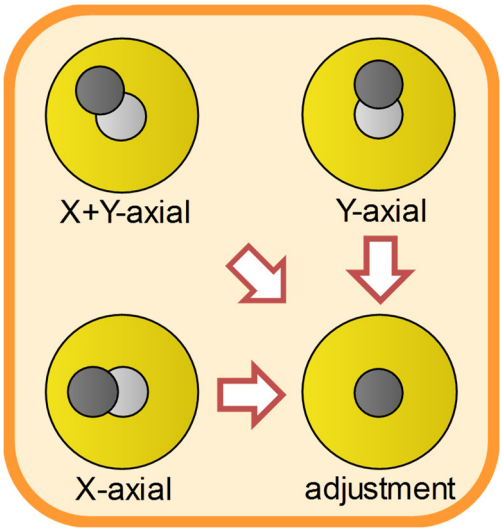


Fig.2 Center displacement /overlap positions before adjustment

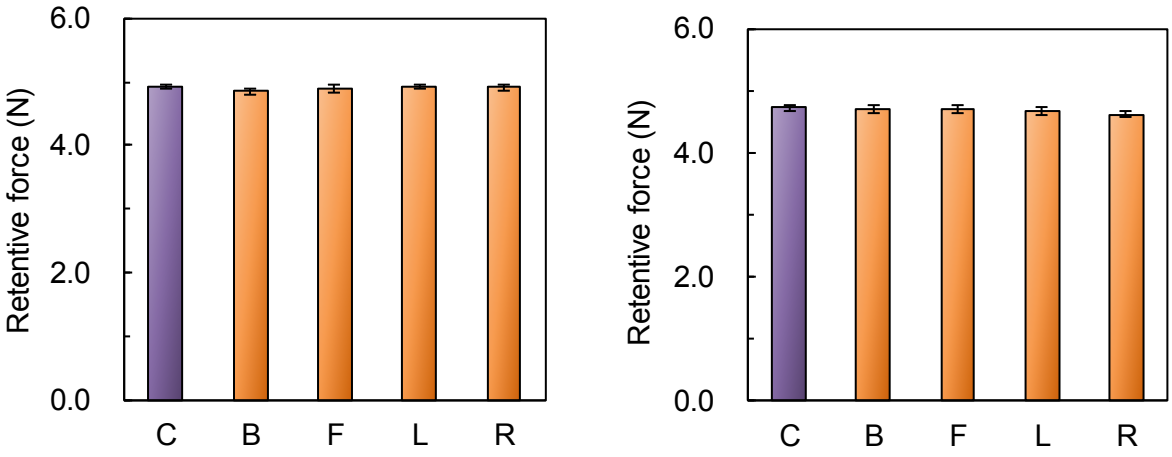
Results

1. Retentive force measured in accordance with the test procedure stipulated in ISO 13017 (reference values)

The retentive force values of both GIGAUSS and HYPER SLIM measured in accordance with the test procedure in ISO 13017 were more than 85% in absolute value when compared with the figures quoted in the manufacturer's literature accompanying the package.

2. Influence on retentive force associated with placement of assembly on different relative locations on the table

The retentive force values measured with the assembly in different positions on the table are represented in Fig. 3. There were no significant differences in both GIGAUSS and HYPER SLIM data compared with the reference value (p>0.05).

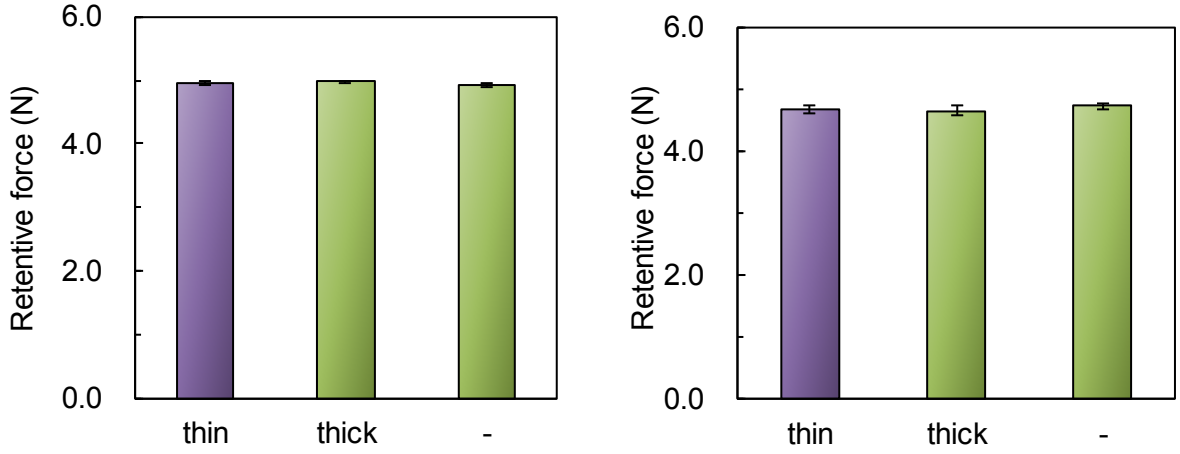


(a) GIGAUSS (b) HYPER SLIM

Fig. 3 Retentive forces for magnetic attachments fixed on different relative positions on the table

3. Influence of intermediate fixation conditions on retentive force

The retentive force according to the varying temporary conditions of fixation are shown in Fig. 4. All the data for both GIGAUSS and HYPER SLIM did not show any significant difference from the reference value (p>0.05).

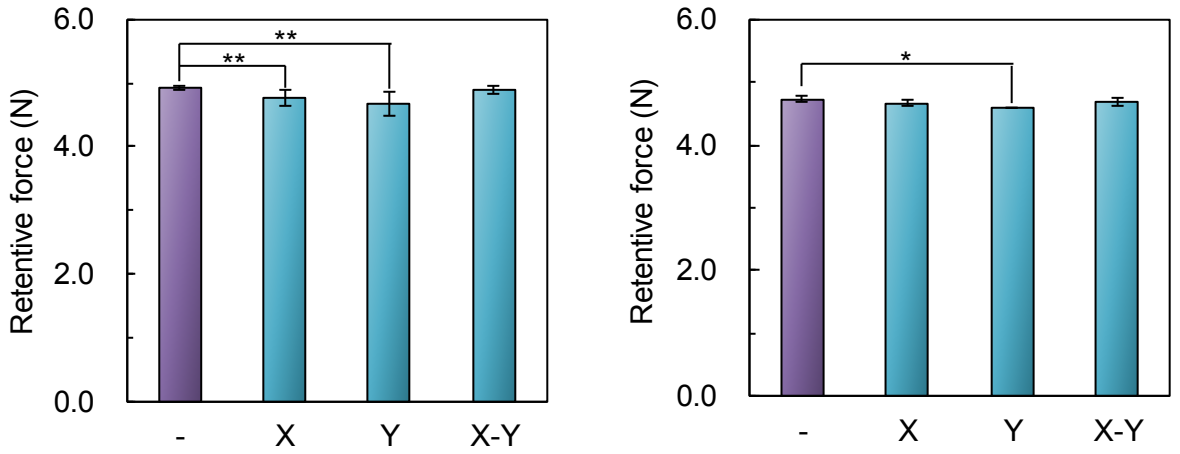


(a) GIGAUSS (b) HYPER SLIM

Fig. 4 Retentive force according to the various conditions of temporary fixation.

4. Influence that gross adjustments of the center of the magnetic assembly and keeper has on the retentive force

The retentive forces measured when initial deliberate mismatch of the center of magnetic assembly away from that of keeper along various directions on the horizontal axis and consequent adjustment done is shown in Fig. 5. In GIGAUSS, the values measured after displacement along the X-axis and Y-axis directions were significantly lower than the reference value (p<0.01). In HYPER SLIM, the values measured after displacement along the Y-axis direction were significantly lower than the reference value (p<0.05).



(a) GIGAUSS (b) HYPER SLIM

Fig. 5 Retentive force of magnetic attachments after adjusting for gross displacement along various axis on the horizontal plane (* and ** indicate p<0.05 and 0.01, respectively)

Discussion

1. Retentive force measured in accordance with the test procedure stipulated in ISO 13017 (reference values)

ISO 13017 prescribes that the measured figure should be of a value that is more than 85% of that quoted in the manufacturer's literature accompanying the package. The measured retentive force values of both dental attachments done in this study under ISO stipulated conditions fulfilled the requirement. Therefore , figures acquired under ISO compliant conditions (center of assembly placed at the center of the table, temporary stabilization done using thin double-sided tape and centers of magnetic attachment congruent) were considered as the reference values in this study.

2. Influence on retentive force associated with placement of assembly on different relative locations on the table

It was demonstrated that the relative location in which a magnetic attachment is fixed on the table has no influence on the retentive force, since there was no significant difference between values representing any of the locations (B, F, L, R) and the reference values (C). The slide guide (linear motion bearing) whose inclusion in retentive force measuring devices is specified in ISO 13017 is highly efficient and contributed to this stable result.

3. Influence of intermediate fixation conditions on retentive force

The choice to use or avoid transient stabilization of magnetic attachment using double-sided adhesive tape did not affect the retentive force because there was no significant difference in measured values corresponding to the various temporary fixation conditions. Ordinarily, the double-sided adhesive tape is used to secure the position of the magnetic assembly at the center of the table and avoid movement before further stabilization with cyanoacrylate glue. However, as the findings proved no difference in retentive force despite placement of magnetic attachment on various locations of the table, we consider the temporary fixation step irrelevant.

Although not shown in the results above, some of values of retentive force attained when either thick tape or no tape was used, were lower (statistically insignificant) than the reference values. This is because the process of dislodging the attachments from the tables which is done several times as in this experiment, may leave the surface of assembly and keeper that are fixed onto the tables by use of glue slightly damaged. Damages on the bottom surface of assembly may have a negative effect on the precise alignment of the mating surfaces which interferes with the accuracy. However, ISO 13017 does not deal with scenarios of multiple use of a magnetic attachment. This observation does not have a direct impact on usage of dental magnetic attachments but serves as a caution when conducting repetitive measurements like for experimental or research purposes.

4. Effect of gross displacement and consequent adjustment involving the center of magnetic attachment on the retentive force

When deliberate shift to mismatch center of the magnetic assembly from that of keeper and consequent readjustment was done, some of the retentive forces measured were statistically significantly lower than the reference values for both GIGAUSS and HYPERSLIM. Ideally, when the X-Y stage is moved along the horizontal plane, to correct minor displacements after fixation of the magnetic assembly set with centers matching as much as visibly possible, there should be no effect on the retentive forces. However, in situations of gross displacement resulting in overlap, lateral movements on the table could result in tipping or movement of the magnetic attachment elements at an inclined angle which may negatively interfere with the adhesion leading to weak results. Therefore, although the center of the elements of the magnetic attachment (assembly and keeper) can be adjusted to correspond by use of X-Y stage after fixation on the tables, it is highly advisable to align the set up correctly as much as possible at the fixation stage.

5. New proposal for the fixation method

The test procedure in the current standard specifies that a magnetic assembly or magnet is first fixed on upper table, and then a keeper or a magnet is fixed on a lower table. We propose that the reverse procedure could be more useful. It involves fixing of a keeper or magnet onto the lower table first, then a magnetic assembly or magnet to the upper table. The proposed method would eliminate the need to use double-sided adhesive tape and make the process that involves matching the center of a magnetic assembly to that of keeper before fixation easier.

Conclusion

Retentive forces can be measured almost accurately using the ISO 13017 test procedure, as long as the magnetic attachment is not fixed in a position where the center of magnetic assembly is grossly displaced from that of the keeper.

Acknowledgments

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