Development of a Simple Measuring Device of the Attractive Force with Magnetic Attachment

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Introduction

The establishment of the attractive force measurement and measurement method is considered important to quantitatively describe the characteristics of dental magnetic attachment products. Various studies have been conducted to obtain accurate attractive force measurements since the development of magnetic attachments. The combination of Aichi-Gakuin testing jig and high-performance tensile tester is considered the most effective method of attractive force measurement of a dental magnetic attachment. The method meets ISO standards. Although Aichi-Gakuin testing jig allows high accuracy measurement, it lacks versatility due to its complicated biaxial structure and high cost.

An improved jig was devised by ISO task force of the Japanese Society of Magnetic Application in Dentistry to solve problems of Aichi-Gakuin testing jig. The improved jig expanded versatility by simplifying the structure from biaxial to uniaxial, and lowering the cost. Although the versatility of a jig was improved, it still requires a high-performance tensile tester. Since the ISO measurement system requires an expensive tensile tester, it lacks versatility due to difficulty in installing the device in institutions, introducing worldwide, and its difficult portability.

Objective

The purpose of the present study was to develop a simple measuring system of the attractive force introducing a tensile tester with a built-in jig to expand the versatility of the conventional ISO measurement system, and to evaluate the measurements using the system. The new system is designed to be cost effective, easily fabricated, and compatible with the round-robin test in each country.

Material and method

The following figures show a simple measuring system of the attractive force introducing a tensile tester with a built-in jig developed in the present study. The total weight of a device is 5 kg, and the size is 120 mm in width, 105 mm in length, and 370 mm in height (Fig. 1).

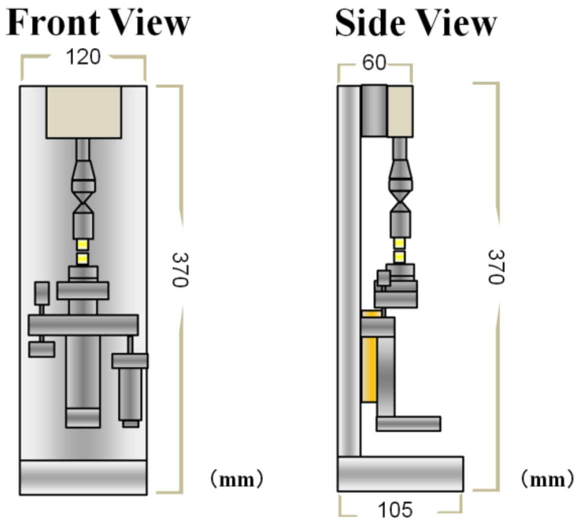

Fig.1 a simple measuring system of the attractive force

The measurement value was displayed by the Imada digital force measurement gauge up to 50 N with measurement accuracy of ±0.2% FS (Fig. 2).An uniaxial linear ball bearing is embedded in the device so that the friction resistance can move minimally in the longitudinal direction during measurement (Fig. 3). A magnetic assembly was embedded in the mold bonded with a digital force gauge by a movable joint in the upper part of a magnet assembly, and a keeper was installed in the lower mold with X-Y stage. The lower part of the device with a keeper starts free-fall movement by a measurement start screw (Fig. 4).

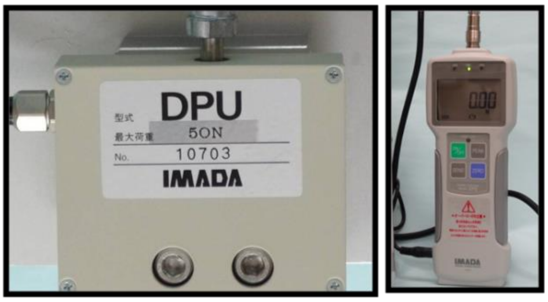

Fig.2 Digital Force Gauge (IMADA)

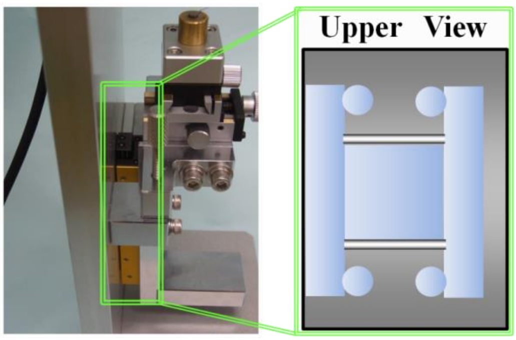

Fig. 3 linear ball bearing

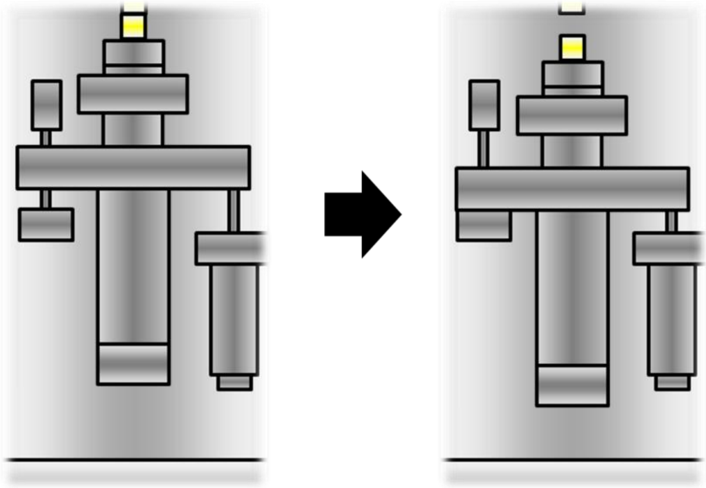

Fig. 4　measurement system

The lower part of the device was supported using a dash-pot (KINECHECK, Meiyu Airmatic Co., LTD) to maintain a constant speed (Fig. 5).

The Fig. 6 shows the inner structure of a dash-pot. The falling velocity was maintained at a constant speed by oil pressure during indentation, and the piston was returned to the original position by the restoring force of the spring. The velocity can be changed by altering the size of oil aperture (Fig. 6).

Fig.5　Dashpot (KINECHEK, meiyu)

Fig.6　the inner structure of a dash-pot

Oil pressure of a dash-pot was controlled, and a scale at a cross head speed of 5 mm/min or less was confirmed in the preliminary experiment. The amount of time before the device sank by 5 mm was measured to calculate the measurement speed (mm / min).

The cross head speed was determined at 4.8 mm / min (13 on the scale) based on the measurement results of oil pressure scale (Table 1).

Table1　The cross head speed was determined by screw Hydraulic

Dashpot
Screw Hydraulic Control

Hydraulic Scale	Speed(mm/min)
5	90.0
10	10.0
15	3.3
20	1.4
25	0.8

Verification of ISO Standard(5mm/min or less)

Hydraulic Scale	Speed(mm/min)
11	7.5
12	6.0
13	4.8
14	4.0

The measurement results of a tensile tester with a built-in jig, a simple measuring device of attractive force, were compared with the results obtained by conventional two systems including the combination of Aichi-Gakuin testing jig and tensile tester and improved ISO jig and tensile tester (Fig. 7).　Measurement samples were (GC) (Fig. 8).

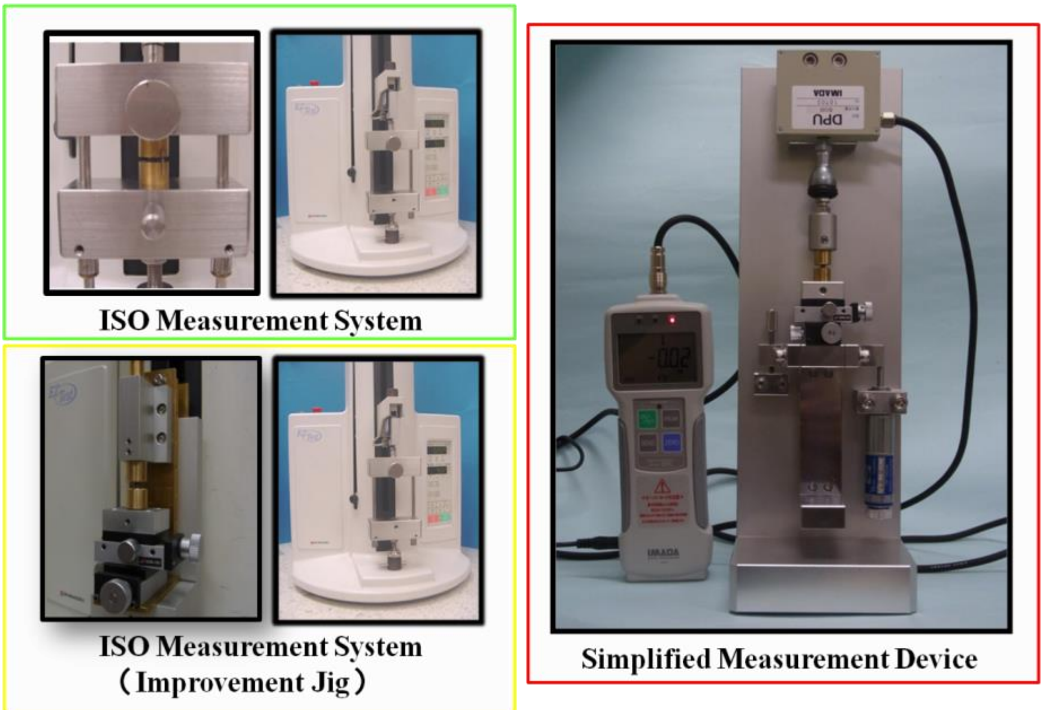

Fig.7　Comparison of measuring methods

Fig.8　Measurement samples(GIGAUSS D600 and C600)

Results

The attractive force measurement of GIGAUSS D600 using a simple measuring device was 4.04 N on average. The results showed significantly smaller attractive force compared with the other two measurement methods, and large standard deviation (Fig. 9).GIGAUSS C600 demonstrated the similar results with attractive force measurement of 4.57 on average (Fig. 10).

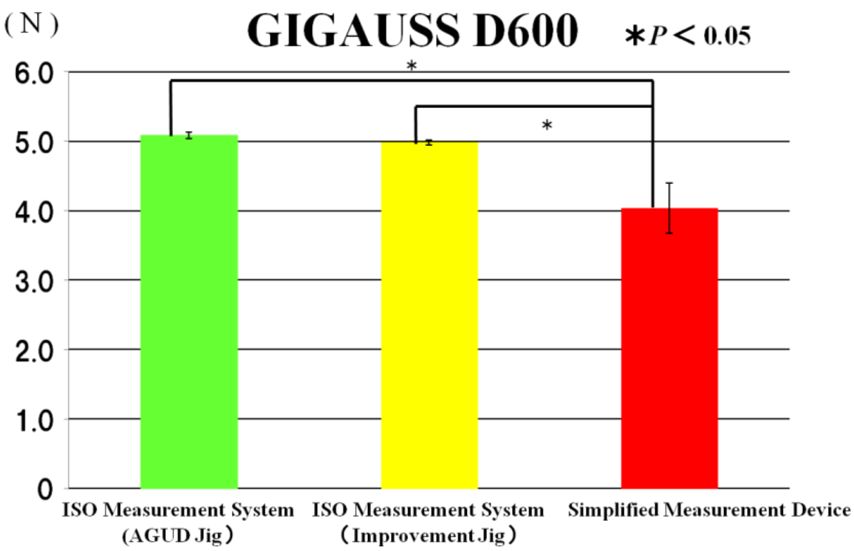

Fig. 9　Results GIGAUSS D600

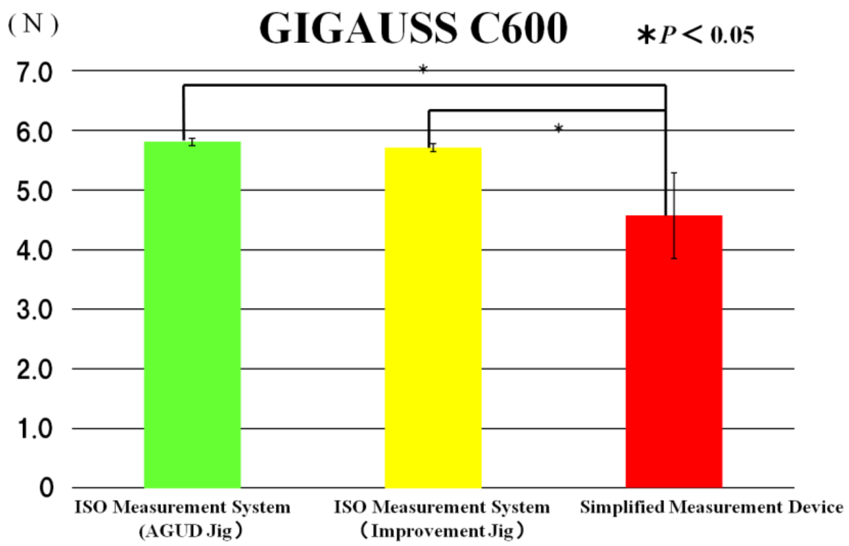

Fig.10 Results GIGAUSS D600

Discussions

The attractive force measurement using a tensile tester with a built-in jig confirmed that the crosshead speed during measurement can be controlled by a simple device. Fall velocity was controlled at a constant speed to avoid acceleration by a dash-pot, and vertical and horizontal directions were regulated by linear ball bearing. The crosshead speed under 5 mm/min (ISO standard) was accurately reproduced. The detaching movement between a magnetic assembly and a keeper, which is considered the most important element of attractive force measurement, was controlled. The previous studies showed that the most challenging part of attractive force measurement was to control the unique movement of magnets, and to transmit the attractive force to the load cell in the vertical direction. Therefore, overcoming these challenges was considered the biggest achievement of the present study. Although the simple measuring device used in the present study controlled the detaching movement between a magnetic assembly and a keeper, vertical and horizontal direction could not be controlled since the movable joint was used during accurate transmission of the attractive force to the load cell. As a result, measurement values were small, resulting in poor reproducibility. This problem is considered to be solved by incorporating ISO jig into the simple measuring device.

Another achievement of the present study was that the device is portable and mailable due to its size and weight. Therefore, the same device can be used for the measurement domestically and internationally to compare the results. The device can be fabricated at various institutions due to its simple structure and low cost, and the measurement procedure is simple.

Conclusion

The simple measuring device was designed and the prototype of the device was fabricated. The present study using the prototype device established the foundation of more cost-effective and versatile attractive force measurement system, and elucidated improvement points. Further improvements of the device are being pursued to increase availability of the present system.

References

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