Development of a Simple Measuring Device of the Attractive Force with Magnetic Attachment — part 2 —

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Abstract

The most effective attractive force measuring method of a dental magnetic attachment is considered to be a combination of biaxial jig and high sensitivity tension testing machine. The biaxial jig device was developed at the Aichi Gakuin School of Dentistry. The high sensitivity testing machine presently serves as the standard testing device for magnetic attachment ISO measurements. Although this device permits high accuracy measurements, it has a complex structure and high cost.

The Japanese Society of Magnetic Applications in Dentistry has developed an improved testing jig device to improve upon the problems of the biaxial jig testing device. This improved jig design was simplified from a biaxial measurement design to a uniaxial type which has also lowered the overall cost.

As the existing device measuring system utilizes the jig together with a high performance tension testing machine, high versatility and performance are required for both jig and the tension testing machine.

The use of multiple devices required simplification and design improvements for efficiency of measurements and reduction of cost. A simplified attractive force measuring device was thus developed that includes both jig and tension testing machine into a single unit. This paper reviews the measurement accuracy and testing of the new device. The results demonstrate the utility and efficiency of this new attractive force measurement device.

Introduction

The character of retentive force of magnetic attachments used in dentistry requires specialized methods of evaluation to determine the relative quantitative performance different magnetic attachments. Relative retention is a comparative measurement a magnetic attachment to the metallic keeper. Various studies have been conducted on magnetic attachment attractive force measurement techniques at the Department of Removable Prosthodontics, School of Dentistry, Aichi-Gakuin University. An effective dental magnetic attachment attractive force measuring technique has been recently developed. This new technique utilizes a device that combines the a biaxial jig, previously devised at Aichi-Gakuin, and an EZ test high-performance tension testing machine, which presently serves as an approved ISO standard testing device.

Although independently the biaxial jig design itself permits high-accuracy of measurement, its complex structure and high cost precludes ease of use. An improved jig device (hereafter “uniaxial jig”) has been developed by the group, Japanese Society of Magnetic Applications in Dentistry, to improve upon biaxial jig design. The improved jig was simplified from a biaxial to uniaxial design which simplified design and cost factors, increasing versatility.

While previous attractive force measuring systems rely on the compatibility and standardization capacity of the high-performance tension testing machine utilized. The inclusion of a standardized tension testing machine apparatus with a uniaxial jig device was devised to improve upon standardization and compatibility concerns.

Objective

The purpose of the present study was to develop a simplified attractive force measuring device that combines the an axial motion limiting jig device and tension testing machine. The combination device design permits simplified manufacture while maintaining accurate capacity for attractive force measurements, specifically useful for the uniform evaluation of different dental magnetic attachments. The purpose of this study was to evaluate and test the measurement accuracy of such a new attachment measuring device.

Material and method

1. Simplified attractive force measuring machine

The following shows a simplified attractive force measuring machine including a jig and tension testing machine developed in the present study.

a. Device dimensions

The simplified attractive force measuring machine weights 5 kg, and is 120 mm in width, 105 mm in depth, and 370 mm in height. This is less than half the size and weight of a conventional EZ-test tension testing machine (Fig. 1).

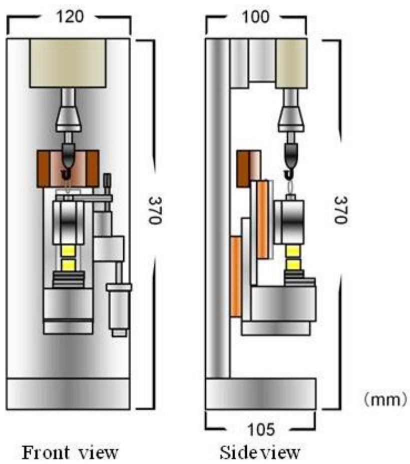


Fig1 Device dimensions

b. Components

The uniaxial jig device was embedded into the measuring machine and fabricated using several pre-manufactured products (Fig. 2).

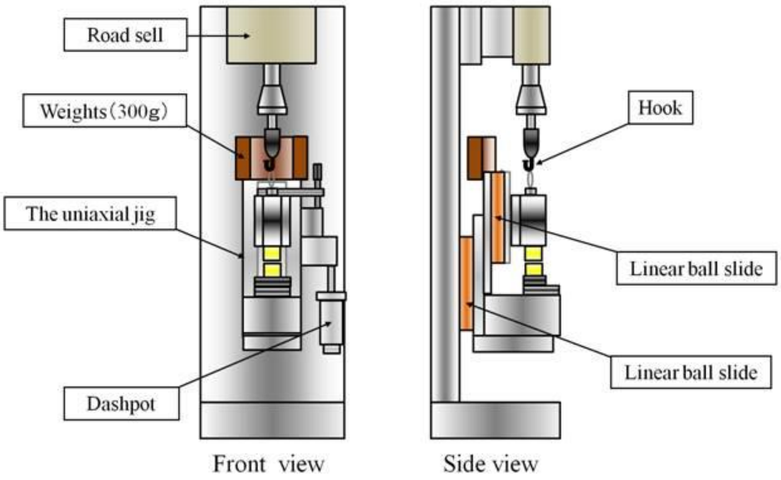


Fig2 Components

The crosshead speed can be set, and a dashpot (KINECHEK, Meiyu) was installed to maintain the speed (Fig. 3). Figure 4 shows the inner structure of a dashpot. When the plunger rod is pushed in, speed is maintained constant by oil pressure, and the rod is returned to its original position by the return action of a stretched spring. The size of the inner oil droplet can be changed by adjusting the bottom scale to change the speed.

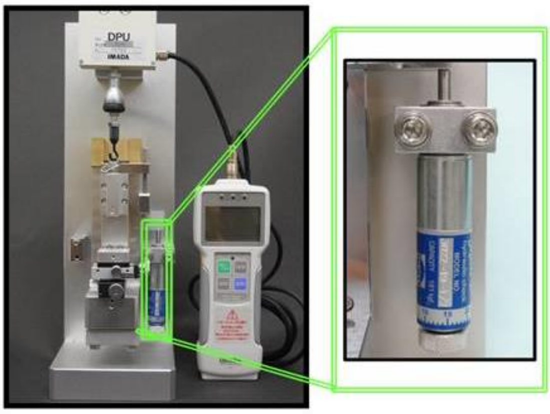


Fig3 Dashpot (KINECHEK,Meiyu)

Fig4 Inner structure of dashpot

Measurement value is displayed on the Digital Force Gauge (Imada) at the maximum load of 50 N and ±0.2% FS measurement accuracy (Fig. 5).

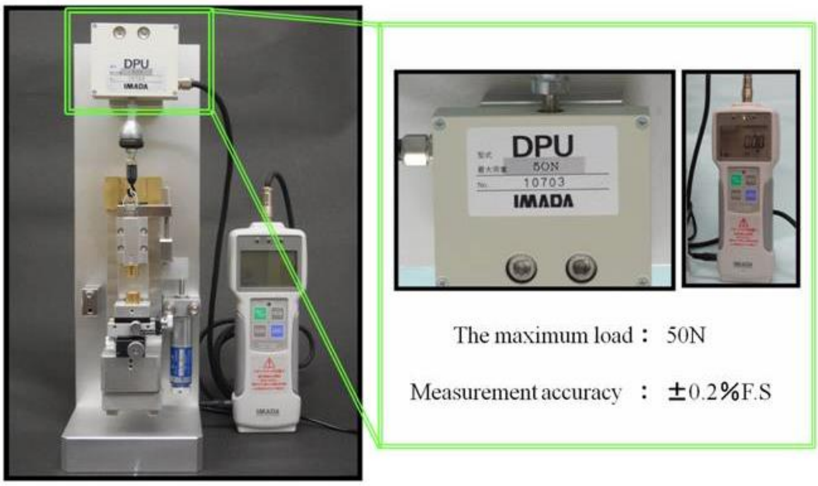


Fig5 The Digital Force Gauge (Imada)

c. Measuring mechanism

The measuring mechanism of a simplified attractive force measuring machine is shown in Figure 6. The bottom right screw is a switch, and the lower jig assembly begins movement downward with its own weight when the stopper is first unlocked. Speed is then controlled by a dashpot preventing acceleration, and measurement is therefore performed at constant speed. A certain minimum weight is required and applied for appropriate descent movement.

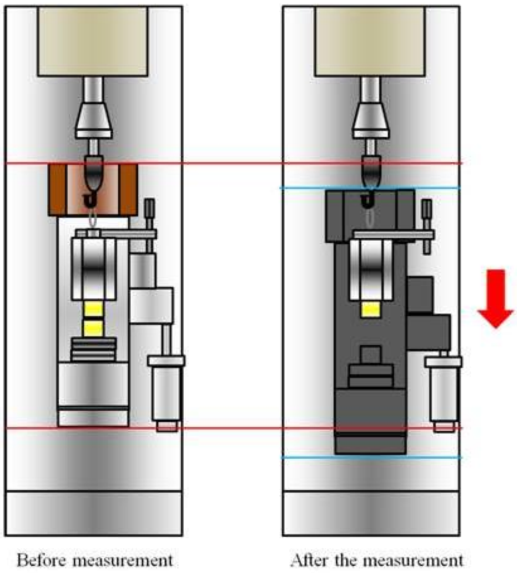


Fig6 Measuring mechanism

d. Crosshead speed setting

The crosshead speed of the machine was set. Based on the previous studies, the crosshead speed is specified at under 5 mm/min in ISO 13017. The time required for the jig to descend 5 mm was measured, and the crosshead speed was calculated. The crosshead speed was 4.4 mm/min at 18 on the scale, and, therefore, the scale was set at 18 in the present study.

2. Attractive force measurement
   a. Measurement samples: A magnetic attachment (GIGAUSS C 600, GC) was used as a sample (Fig. 7).

Fig7 A magnetic attachment (GIGAUSS C600,GC)

   b. Measurement conditions

Measurement was performed 10 times, and the average was taken as the final measurement. One sample was used to avoid inter-product errors. The crosshead speed was 4.4 mm/min.

   c. Measurement result verification of a simplified attractive force measuring machine

3. Testing

The results between the conventional system using biaxial jig and tension testing machine and the new system using uniaxial jig and tension testing machine were compared to evaluate the measurement accuracy (Fig. 8).

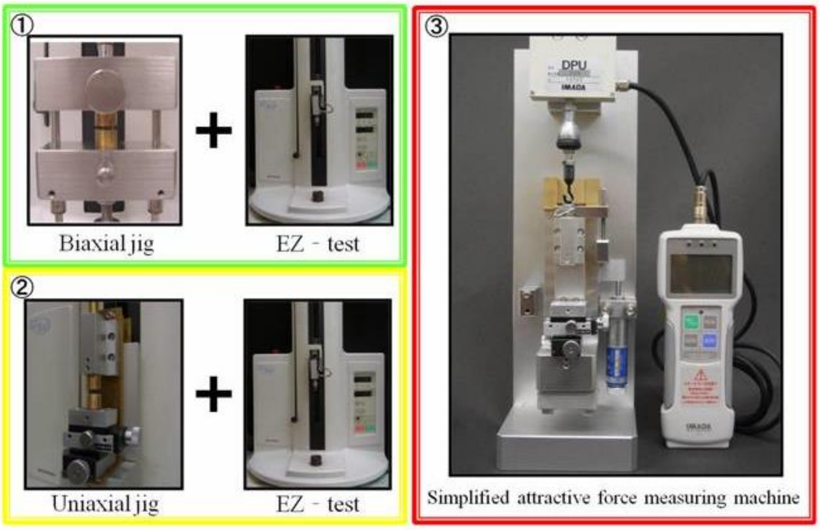


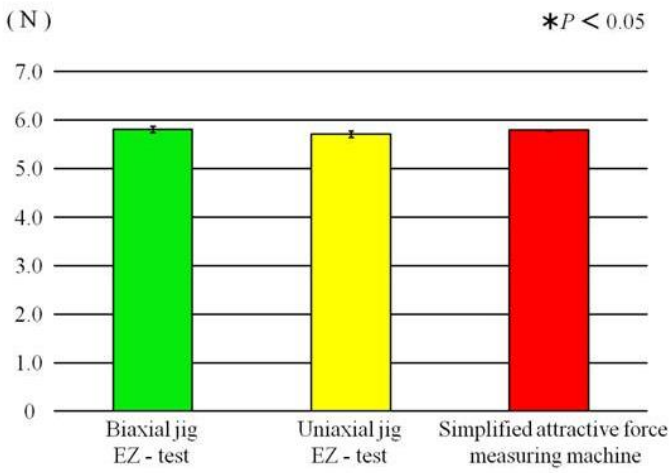
Fig8 Testing

Statistical Analysis was performed. Measurement results were evaluated using one-way analysis of variance and Scheffe Multiple Comparison Method.

Results

Table 1 shows the measurement results. The results were 5.81 N in the measuring method using a biaxial jig, 5.71 N in the method using a uniaxial jig, and 5.79 N in the method using a newly-developed simplified attractive force measuring machine. Statistical analysis demonstrated no significant difference between the three groups.

Table1 Attractive force



Discussions

Prior to the development of the new testing device evaluated, a separate measurement jig and high-performance tension testing machine were necessary for the measurement magnetic attachment attractive forces. The uniform testing of devices in a global environment requires improved standardization and of both measuring devices and measuring frame. A measurement jig was previously accepted for a global standards was developed by the Japanese Society of Magnetic Applications in Dentistry.

The use of the accepted measurement jig was found to be dependent upon testing machine standardizations. A designed inclusion of the tension testing machine components within the measurement jig was designed and developed at the Aichi-Gakuin School of Dentistry. The new attractive force measuring machine that includes both jig and tension testing machine has been shown to provide high accuracy and versatility combined with easy of manufacture and low cost. This measuring design has been determined to be a suitable replacement for the previous conventional measuring system.

The newly-developed measurement machine was produced by combining pre-manufactured components. The prior conventional method utilized a vertical direction pull using a separate high-performance tension testing machine. The newly developed device drops the lower portion components along the guide frame to exert the separation power of a magnet (approximately 1.5 kg) and measures attractive force. The conventional tension-testing machine requires complicated and precise mechanism to pull the machine in an elevated vertical direction using constant speed. The new machine utilizes normal gravity to permit lowering of the machine which is resisted by the attachment device to be measured.

Both measurement techniques use vertical upward and downward movements. The new device manages strong magnetic attachments by adding weight to the top part of the bearing for to increase separation force. The simplified attractive force measuring machine developed in the present study is thus considered to meet all conditions necessary for the magnetic attachment attractive force measurement. The new machine is reduced in size and overall costs compared to conventional tension testing machines. Virtually identical attractive force measurement values can be more easily obtained under any worldwide environment, and thus facilitates inter-laboratory testing.

Conclusion

A simplified attractive force measuring machine including both jig and tension testing machine have been developed. Comparative testing has demonstrated measurement accuracy and reproducibility, suggesting acceptability and consideration as a uniform method and device for attractive force measurement.

The uniformity of access, small size, and availability of components, the new testing device presented as a simplified attractive force measuring device appears to facilitate and enable inter-laboratory testing of attractive force measurements world wide.

References

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