ISSN:2790-1688 DOI: 10.56028/aetr.4.1.363.2023

Design of easy disassembly abutment system based on elastic connection

Zhaodan Gu

Jiangsu Automation Research InstituteLianyungang, China

gzd2005@126.com

Abstract. The abutment system is a necessity for oral implant repair, traditional abutment systems are mostly of an integrated structure, after oral implant repair, it is difficult to disassemble whether there is implant failure or infection, or daily cleaning and maintenance. Based on the analysis of the problems in the clinical use of the traditional abutment system, this paper proposes a design method of easy disassembly abutment system based on elastic connection. This method changes the traditional abutment integrated mechanism into a two-part structure, and designs an elastic connection device to fix the two-part structure together, which can facilitate the connection and separation. Through performance test and clinical verification, it is proved that the system can meet the clinical requirements in terms of performance and function, and the effect of patients using the system after implant repair is good. In addition, compared with the traditional abutment system, this system has the advantages of convenient installation and disassembly, small occlusal hole of the dental crown, and more beautiful after repair, so, it has good application value.

Keywords: Elastic connection; Two-part structure; Easy to disassemble.

1. Introduction

As the most scientific and popular treatment for tooth loss in the world, dental implants have developed rapidly in the domestic market in recent years, with an average annual growth rate of more than 20%. Since the introduction of osseointegration, longitudinal studies have proved the long-term success of osseointegrated implants. Implants have successfully treated some edentulous patients. Implants and implants supported prostheses have a high success rate and survival rate[1]. Implant supported fixed dental prostheses can be fixed with screws or bone cement, however, both methods have some defects in clinical practice, it may affect the frequency of technical and biological complications. Screw fixation requires high precision to achieve passive coordination. If passive coordination cannot be achieved, residual stress caused by screw tightening may occur between multi unit prostheses and implants. The most common complications after screw fixation are loosening of denture screws, fracture and fracture of denture; The repair of residual bone cement will lead to diseases around the implant, such as peri implant mucositis and peri implant inflammation[2-4]. In the process of removing excess bone cement from the subgingival margin, the abutment may be scratched, and the bone cement is difficult to remove. In addition, when the prosthesis is damaged or needs to be removed for maintenance, it is necessary to remove the denture and abutment as a whole through the removal hole reserved on the upper part of the prosthesis, remove the filler, loosen the connecting screw with a special tool, and then remove the denture and abutment, and then destructively separate the denture and abutment, which is likely to cause damage to the denture or abutment, causing secondary loss or failure.

The easy disassembly abutment system based on elastic connection designed in this paper is a two-stage abutment system[5-6], and an elastic connection device is designed to realize the connection and fixation of the two-stage abutment system. At the same time, it can be easily disassembled, which can effectively solve the problem that the traditional abutment system is difficult to disassemble when removing excess bone cement, implant failure, postoperative infection, and daily cleaning and maintenance.

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2. System composition

An easily removable abutment system based on elastic connection consists of a base body and a cylinder. See the system diagram for specific structure.

The base body is an integrated structure, made of titanium alloy (Ti-6Al-4VELI). The lower end is designed as an internal cone, and is equipped with threads. The connection with the implant system is realized through the threads, which has the advantages of good stability and anti loosening. The upper end is equipped with a retention slot for connection and retention with the cylinder. According to requirements for clinical use, L=1mm - 6mm, B=3.4mm, C=M2.0 * P0.4 are designed. Other dimensions are shown in the dimension diagram.

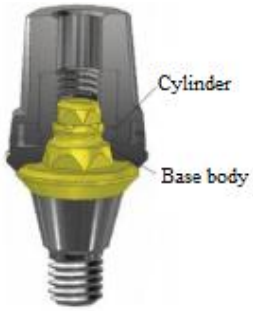

Figure1.Schematic diagram of abutment system

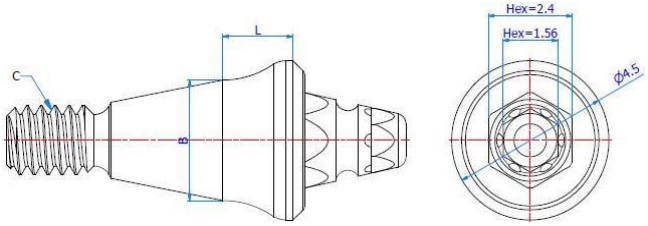

Figure2.Dimension diagram of base body

The cylinder consists of a main body, three balls, a spring and a housing, which are mechanically assembled to form a whole.The features and functions of the cylinder components are as follows:

2.1 Main body:

It is the innermost part of the cylinder, which is made of titanium alloy (Ti-6Al-4VELI). It is a cavity with threads inside. The separation of the base body and the cylinder can be easily realized by using a screw driver; In addition, a plurality of grooved hexagonal containers corresponding to the hexagonal structure of the matrix are provided, so as to prevent the rotation of the subsequently attached dentures. In addition, a plurality of holes are formed, and the radius towards the inner side is gradually reduced so that the ball can be seated.

2.2 Ball:

It is a perfect ball with a diameter of 0.7mm, which is composed of zirconia (ZrO2) and hafnium oxide (HfO2). After the three balls fall, they form 120 ° to each other. When fixed on the matrix, it can directly participate in the retention force by fixing in the retention slot, and prevent the rotation of the shape memory alloy spring.

2.3 Spring:

located on the outside of the alloy ball, with a notch on one side, with a thickness of 0.5 mm and a height of 1.0 mm. The main material is NiTi shape memory alloy. The main function of the spring is to help the alloy ball to easily sit on the retaining groove of the common part of the abutment and undercut it. The method is to combine the super elasticity of nickel titanium alloy with the common part of the abutment. After the spring is engaged, it returns to its original state and exerts a constant external force on the alloy ball.

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2.4 Housing,

it is a part connecting the denture and has a groove to prevent the denture from rotating. The hole on the top allows a special screw driver to pass through, and the dentist can use the screw driver to conveniently separate the matrix from the denture. The housing structure and dimensions are shown in the figure below. According to clinical requirements, L=3.8mm-6.5mm is designed.

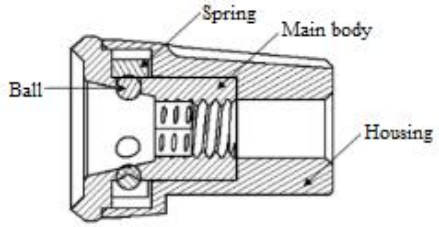

Figure3.Schematic diagram of cylinder

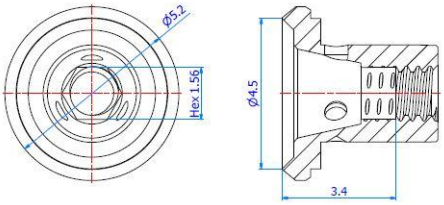

Figure4.Dimensions of main body

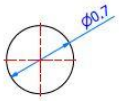

Figure5.Ball Structure Dimension

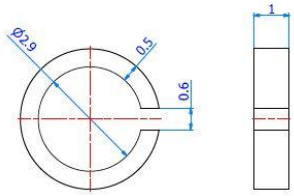

Figure6.Structural dimension of spring

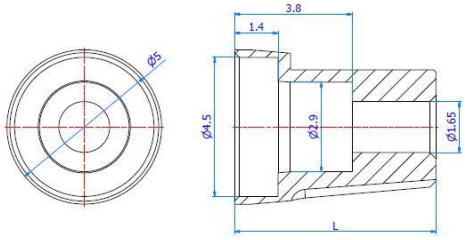

Figure7.Dimension of housing

3. Performance test

3.1 Breaking Strength Test

3.1.1Test Method

Fix the implant on the customized steel support, and the implant axis is at a 30 degree angle with the loading direction. To simulate bone resorption, the implant was clamped 3mm from the nominal bone level to the top. Install the abutment on the implant, make a cobalt chromium alloy hemispherical loading member (simulated denture) with a diameter of 7mm, and install it on the abutment with double curing resin adhesive. Carry out static load test with a testing machine at a crosshead speed of 1mm/min[7], and record the load displacement curve until the implant component is obviously broken, or the displacement of the loading device reaches 5mm.

ISSN:2790-1688 DOI: 10.56028/aetr.4.1.363.2023

3.1.2Test Results

When the force of the loading device exceeds 400N and the displacement of the abutment reaches 5mm, the abutment and the implant do not fracture (if fracture occurs, the load will be reduced to 0), which proves that the two-stage abutment based on elastic connection has good toughness after connecting with the implant.

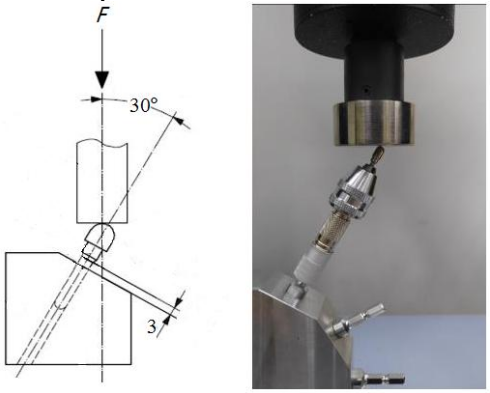

Figure8.Test design and device Diagram

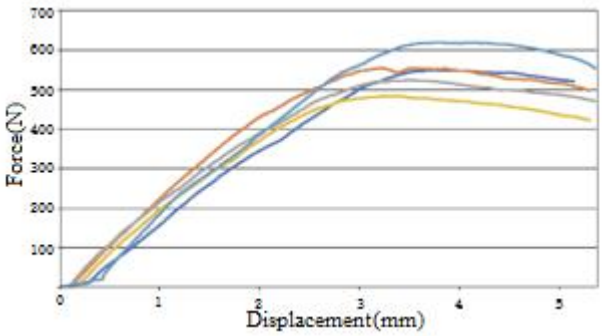

Figure9.Load-displacement curve

Figure10.Test Results of Sample

3.2 Tensile Strength Test

3.2.1Test Method

Select 5 samples, and apply a cyclic load with an inclination of 30 degrees to the samples through the loading machine[8]. The stress is 100N and the frequency is 2Hz. When the loading times are 0, 1000000, 2000000, 3000000, 4000000 and 5000000, carry out the retention force test on the samples. The method is to clamp the samples on the lower clamp of the UTM testing machine, and apply a uniaxial dislocation force to each sample at the crosshead speed of 5mm/min until the cylinder is completely separated from the matrix, Record the retention force and calculate the average retention force of the sample.

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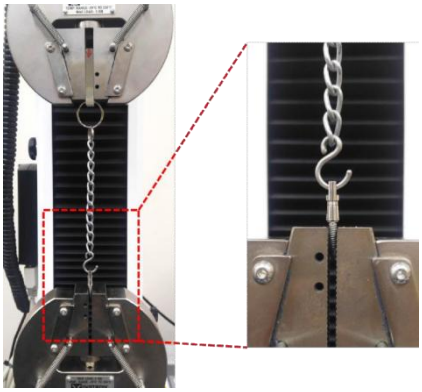

Figure11.UTM testing machine

3.2.2Test Results

Before the cyclic load is applied, the average retention force of the abutment is 29.679N, the maximum value is 31.997N, and the minimum value is 28.193N. With the increase of the times of applying cyclic load, the abutment retention force decreases rapidly with the increase of the times of applying cyclic load during the first 1 million times; During the period from 1 million to 4 million times, the abutment retention force decreases gradually with the increase of the number of times of applying cyclic load, and the downward trend is more and more slow; During the period of 4 million to 5 million cycles, the abutment retention force has little change with the increase of the number of cycles applied; After 5 million times of loading, the average value of the final retention force is 19.709N, the maximum value is 22.464N, and the minimum value is 17.606N. According to clinical experience, the retention force can meet the clinical requirements[9].

Table 1. Test Data of Cycle Retention Force

Retention Force(N)				
Cycle / Sample	0	1000000 4000000	2000000 5000000	3000000
1	28.193	22.996 18.456	20.672 17.832	19.253
2	29.320	22.765 18.189	21.326 17.606	19.431
3	30.337	24.404 18.356	22.808 18.743	22.275
4	28.546	23.934 21.983	23.263 21.898	22.436
5	31.997	25.804 22.858	24.360 22.464	23.354
Average value	29.679	23.981 20.127	22.485 19.709	20.948

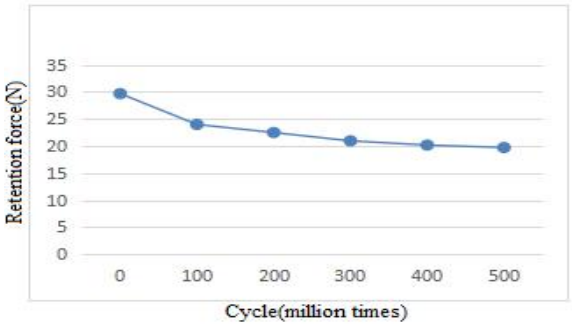

Figure12.Changing curve of retention force

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3.3 Fit Clearance Measurement

3.3.1Test Method

Take the sample of the bench, first block the top hole of the cylinder with wax, prepare five test blocks with self curing acrylic resin in the silicon putty mold, then cut the bench from the middle along the longitudinal axis with a low-speed diamond sawing machine, then polish the cut surface of the sample with sandpaper and grinder, and finally conduct ultrasonic cleaning with water for 5 minutes to remove surface contaminants and complete the sample production.

Observe the cross section of each sample with an electron microscope (magnified by 100 times), measure the fit clearance between the matrix and the cylinder with a scanning electron microscope analysis image system [9], select four measuring points 1, 2, 3 and 4, and measure the vertical distance between the starting points of their edges. In order to improve the reliability of measurement, make three measurements at each observation point and determine the average value.

3.3.2Test Results

The maximum fit clearance of 5 samples is 7.98 μm. The minimum fit clearance is 1.4 μm. No matter the average gap of four observation points at each base station or the average gap of the same position at each base station is less than 5 μm. Meet clinical requirements. The specific data are showed in the measurement data sheet of abutment fit clearance.

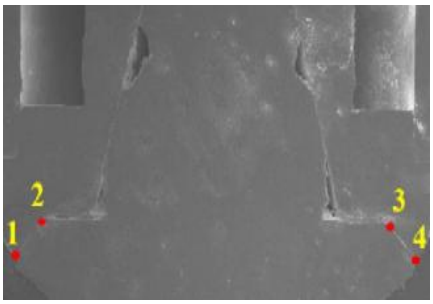

Figure13.Measuring point of sample

Table 2.Measuring data of abutment fit clearance

Fit Clearance(μm)					
Position / Sample	1	2	3	4	Average value
1	7.98	2.52	5.38	3.80	4.92
2	2.94	5.18	2.38	3.22	3.43
3	4.48	4.76	1.40	4.48	3.78
4	2.81	2.81	4.26	3.80	3.42
5	6.53	2.52	5.38	3.80	4.56
Average value	4.96	3.56	3.78	3.82	

4. Clinical validation

4.1 Clinical Implementation Process

A clinical experiment was carried out on a patient with missing posterior teeth. The whole operation process of abutment installation, removal and repair was as follows:

- First, the base body of abutment system was connected with the implant system by hexagon screw tools;
- The cylinder of the abutment system is fixedly connected with the base body;
- Take the mold, make the crown, and then use the cement to complete the bonding with the cylinder;

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- The cylinder and crown were removed integrally with a screw driver to remove residual bone cement;
- Install the crown and fill the occlusal hole.

4.2 Clinical effect

X-ray films were taken after the operation to show that the planting results met the design requirements.

Six months after the operation, the composite resin of the occlusal hole was removed, and the crown was removed with the removal driver. The patient had no discomfort or pain, and the periodontal index had no change compared with the initial installation of the crown. In terms of restoration, there is no movement or fracture of the dental crown, and a stable occlusal contact is maintained. There is no fracture of the implant abutment. The removed crowns, attachments, and abutments show clean surfaces. The soft tissue is healthy, and no clinical symptoms such as periimplant inflammation, edema, ulcer, etc. are found.

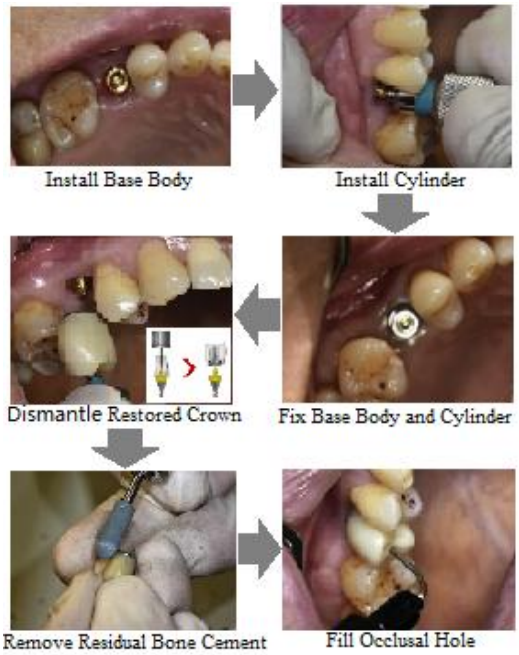

Figure14.Operation process of abutment repair

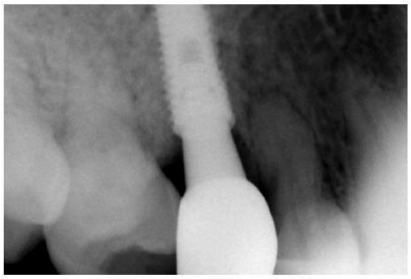

Figure15.Postoperative X-ray

Figure16.Effect picture of 6 months after operation

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Conclusion

This paper creatively designs an easy to disassemble abutment system based on elastic connection. This system changes the traditional one-piece abutment based on screw connection into a two-part structure, and carries out retention connection through elastic connection devices. While realizing the basic functions of the traditional abutment, it has the following four advantages:

- The crown occlusal hole is smaller (1.5mm), which is only half of the traditional one, and is more beautiful after repair[11];
- No screws are used, and no clinical side effects such as screw breakage and loosening occur;
- When excessive masticatory force is applied, these forces are dispersed at the joint of zirconia ball and positioning slot, which can reduce the damage to implant and alveolar bone and should not break;
- It can be installed and disassembled repeatedly. During installation, only pressing hard can realize the fixed connection between the cylinder and the base. During disassembly, the screw driver can be used for convenient removal, maintenance and management.

The performance test shows that the abutment has good fracture resistance, retention and sealing. It is clinically verified that there are no adverse symptoms and it has good use effect.

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