Comparison of the Micro-Gap of Original and Non-Original Abutment Platforms in Conical Connections

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Abstract

The aim of the study is a comparative assessment of the quality of hermeticity of the conical connection of original and non-original abutments used in implantation systems (Nobel Biocare CC, Strauman BL, BioHorizons Tapered internal). We studied 18 implant/abutment connections, six from each manufacturer, three were original compounds and three non-original compounds. In each group, the screw was twisted with a force of 35 N/cm2, after which longitudinal sections were made to study the quality of the conical connection, the tightness of which was evaluated using scanning electron microscope. The original abutments showed the best connection, where there was practically no micro-gap throughout the conical connection. BioHorizons Tapered Internal implants showed the best connection, with almost no gap, among the original abutments. The best quality among non-original abutments was found in Strauman BL implants.

In general, the implant/abutment connection, in the case of original and non-original prosthetics, is quite acceptable and requires further research related to load modeling.

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Introduction

The implant/abutment connection is a relevant problem of dental implantology, since the hermeticity of the connection, the penetration of microbes, and, as a result, the maintenance of chronic inflammation and bone resorption, depend on the tightness of the connection. The most promising and consistent connection is the conical connection because of the load perception and its distribution to the surrounding tissues[1-4].

The data on the hermeticity of the conical connection are contradictory: some authors support the idea of the complete tightness of the cone, explaining it by the "cold welding" effect[5,6]. Recent studies do not reflect this idea and consider its insufficient hermeticity, the authors studied the conical connections for the penetration of bacteria, and it was found out that the cone was not tight[7-9]. Therefore, according to the literature, there are no unambiguous solutions to this issue. It depends on the abutments and screws used, and the tightening force of these screws, if this micro-gap is critical or acceptable. It is known that the lateral dynamic load leads to the highest pressure, which negatively affects the implant/abutment connection[10-13].

As a result, the abutment/implant/locking screw connection system should contribute to increased reliability. Otherwise, there is a violation of the connection's density, which leads to mechanical[14] or biological complications[15]. However, currently, on the market of dental materials there is a large number of non-original abutment platforms, which have the appropriate certificate for their use. Thus, the use of non-original prosthetics in conical connections and the study of its reliability is an important problem of orthopedic dentistry.

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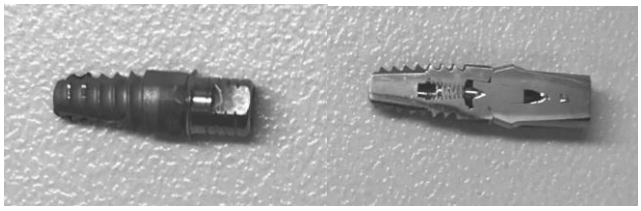
Materials and methods

We used a variety of implants (Nobel Biocare CC, Strauman BL, BioHorizons Tapered internal) in our research, an all-conic connection with an internal hexagon (Nobel Biocare CC, BioHorizons Tapered internal), and an octagon (Strauman). An original and non-original abutment platforms were used for each implant, the delivery was carried out once and the screw was tightened by 30N/cm^2 (Fig.1a). Flat longitudinal sections (Fig.1b) were prepared on abutment/implant/fixing screw platforms using the automatic grinding and polishing machine BuehlerVector using abrasive paper and diamond suspensions with a grain size from 3 to 0.25 microns. The slates were examined in a scanning electron microscope (SEM) JEOLJSM 7001-F (Japan), equipped with an energy-dispersive spectrometer INCAPentaFETx3. The surface morphology was studied in secondary electrons at magnifications of x30, x70, 100, x1500, x5000, x10000. The elemental analysis of the implant surface was carried out by energy-dispersive X-ray spectroscopy (EDX).



a b

Figure 1. General view of the platform abutment/implant /fixing screw (a) and the flat longitudinal section of the platform (b).

The microhardness was determined by pressing a diamond tetrahedral pyramid into the abutment and implant material under a load of 0.005 N on the PMT-3M tester.

Results

The Nobel Biocare CC implants with a non-original abutment platform showed a uniform adhesion over the entire length of the conical implant/abutment connection at magnification of x30, but at magnification of x70, an absence of adhesion of the implant/abutment connection can be observed (Fig.2a, b).

The x1000 magnification revealed areas of loose fit of the implant to the abutment throughout almost the entire conical connection (Fig.2c, d). The micro-gap in these areas is 7.59 ± 3.40 microns. In areas of tight fit (magnification x1500), there is no micro-gap (Fig. 2d).

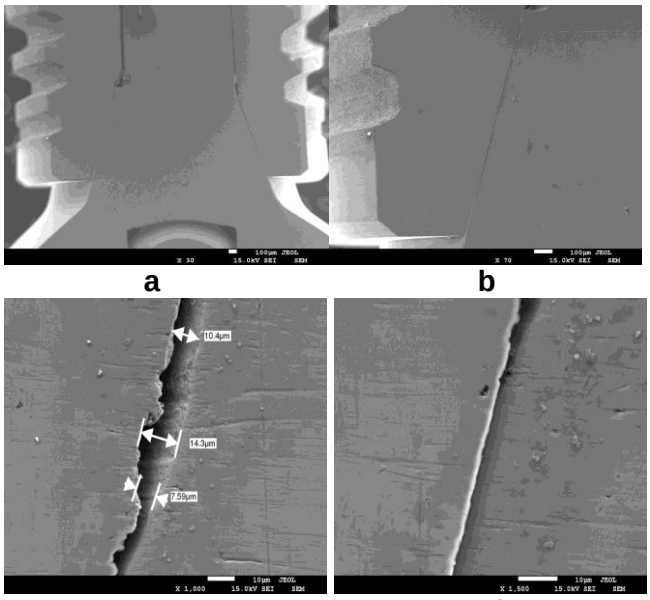


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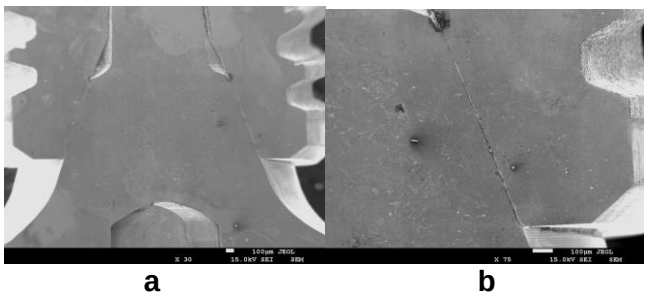
Figure 2. SEM image of the implant/abutment non-original connection (Nobel Biocare) at the magnifications of: a – x30; b – x70, c – x1000, d – x1500.

The analysis of the structure of the connection of the implants with the original abutment platform of the Nobel Biocare CC showed a uniform adhesion and no micro-gap at the x30 magnification. (Fig.3a). At magnification of x75, a micro-gap is not observed throughout the connection (Fig. 3b). At magnification of x1500, there is also a tight fit throughout the cone and the absence of a micro-gap. (Fig. 3c). At one site, an insignificant micro-gap of 1.26±0.18 microns was detected at the x5000 magnification (Fig. 3d).



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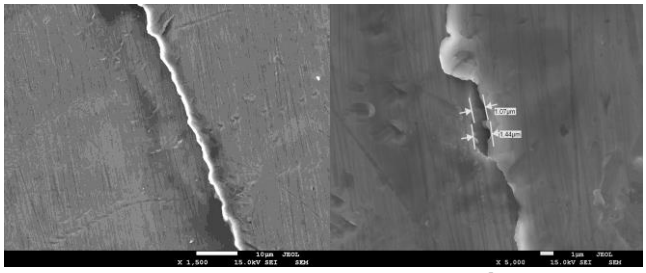

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Figure 3. SEM image of the implant/abutment original connection (Nobel Biocare) at the magnifications of: a – x30; b – x75, c – x1500, d – x5000.

Strauman BL implants with a non-original abutment platform in the area of the conical connection showed an adhesion to the implant abutment at an x30 magnification, no micro-gap was detected (Fig. 4a). At a magnification of x100, the adhesion of the micro-gap is not observed in some areas (Fig. 4b). At the magnification of x1500, the areas where there is no adhesion revealed, the micro-gap is 1.7±0.1 microns (Fig.4c, d).

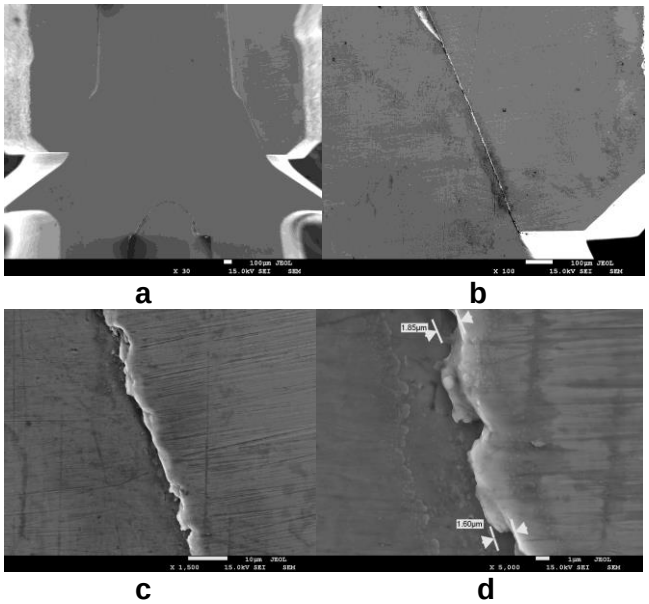

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Figure 4. SEM image of the implant/abutment non-original connection (Strauman) at the magnifications of: a – x30; b – x100, c – x1500, d – x5000.

The surface of the connection of the implants with the original abutment platform (Strauman) at a magnification of x30 shows an adhesion throughout the conical connection and the absence of a micro-gap (Fig. 5a). At a magnification of x100, the micro-gap is observed throughout the entire connection (Fig. 5b). Areas with a non-tight fit and the presence of a small micro-gap are observed only at a magnification of x1500 (Fig. 5c). At one site at a magnification of x10000, it was possible to detect a micro-gap of 0.78±0.17 microns (Fig.5d).

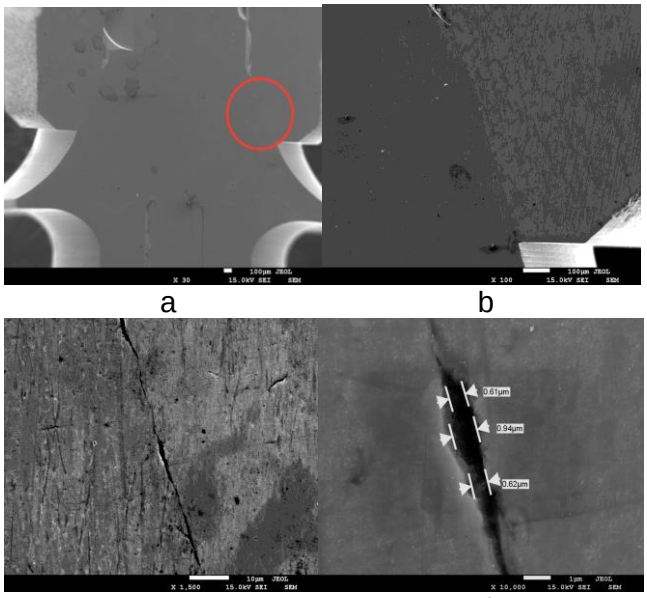

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Figure 5. SEM image of the implant/abutment original connection (Strauman) at magnifications of: a – x30; b – x100, c – x1500, d – x10000.

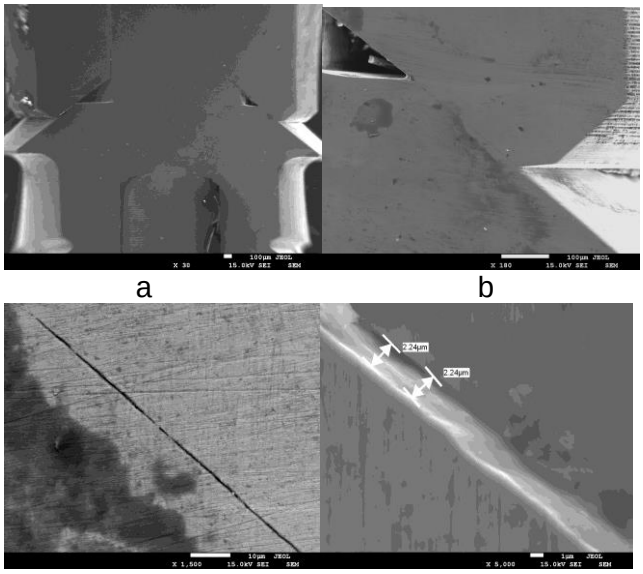

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Figure 6. SEM image of the implant/abutment non-original connection (BioHorizons) at the magnifications of: a – x30; b – x180, c – x1500, d – x5000.

Studies of the micro-gap of BioHorizon implants with a non-original abutment platform showed an adhesion over the entire length of the conical implant/abutment connection at a magnification of x30. At the x180 magnification, several sites with a non-tight fit of the implant/abutment were identified (Fig. 6a, b). Almost throughout the entire connection, the micro-gap is observed at a magnification of x1500 (Fig. 6c). The micro-gap was determined at a magnification of x5000, it was 2.37±0.13 microns (Fig. 6d).

The BioHorizons implants with the original abutment platform showed an adhesion over the entire length of the conical implant/abutment connection at a magnification of x30. At a magnification of x150, a high adhesion of the implant/abutment connection is also observed (Fig. 7a, b). There is no micro-gap and there is an adhesion of the implant to the abutment throughout the entire conical connection and at magnifications x1500 (Fig. 7c) and x10000 (Fig. 7d).

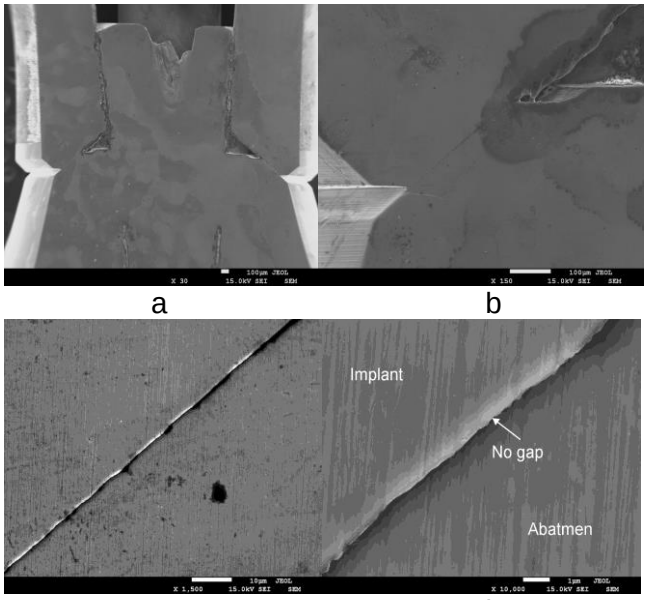

Figure 7. SEM image of the implant/abutment original connection (BioHorizons) at magnifications of: a – x30; b – x150, c – x1500, d – x10000.

The microhardness of abutments and implants is shown in Fig. 8c graphically. The microhardness of BioHorizons implants, original and non-original abutments made of the same alloy, is almost the same and is 32.9±1.7. While Nobelbiocare implants made of pure titanium have a microhardness of 25.7±2.0, which is slightly lower than that of original and non-original implants made of a titanium-based alloy, the microhardness of which is 32.2±2.0. Strauman implants and original abutments are 34.95±2.25, implants and non-original abutments – 32.7±2.6. Thus, a high-quality conical connection of the implant-abutment is possible in the presence of a close microhardness of the connected parts.

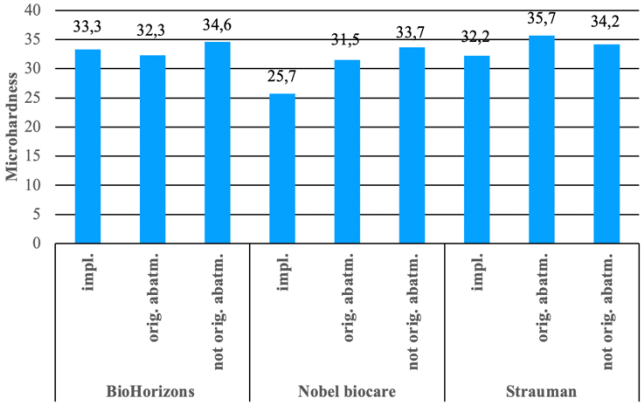

Figure 8. Microhardness of original and non-original implants and abutments.

The chemical composition of abutment and implant materials was determined using the energy-dispersion microanalysis method(Table 1).

Manufacturer		Composition, wt.%					
		Al	Ti	V	Zr	Nb	Total
BioHorizons	non-original abutment	6,66	90,09	2,49	–	–	100.00
	original abutment	5,78	90,53	3,69			100.00
	implant	6,15	90,70	3,16	–	–	100.00
Nobelbiocare	non-original abutment	6,13	90,22	3,65	–	–	100.00
	original abutment	6,06	89,19	4,75	–	–	100.00
	implant	–	100,00	–	–	–	100.00
Strauman	non-original abutment	5,97	91,04	2,99	–	–	100.00
	original abutment	5,59	88,07	–	–	7,33	100.00
	implant	–	81,38	–	18,62	–	100.00

Table 1. Chemical composition of implants and abutments.

The composition is the same as the alloy used for the BioHorizons implants, as well as the original and non-original abutments used in the platforms with BioHorizons and Nobel Biocare implants, and the non-original abutments used in the platforms with Strauman implants (Table 1). The Nobel biocare implant is made of pure titanium, and the abutments are made of an alloy containing Al, V, which explains the increased microhardness of these materials (Fig. 8).

Strauman implants, original and non-original abutments are made of different materials, which may also explain the variation in microhardness values.

Discussion

The implants and abutments of Nobel Biocare and Strauman have large deviations in size in the gap at the conical connection, microhardness, which may be due to the fact that the implants and abutments of these manufacturers are made of alloys of different chemical composition.

Analysis of the alloy composition, microhardness of the implants, original and non-original abutments, as well as the quality of the abutment/implant connections, allows to make a conclusion that among the original abutments, the connection is almost without a gap shown by BioHorizons Tapered Internal implants. The best connection quality among non-original abutments was found in Strauman BL implants.

Conclusions

Thus, there are the following conclusions:

1. BioHorizons implants showed the lowest micro-gap values in terms of original and non-original abutments, which may be due to the use of a single alloy for the manufacture of implants and abutments, as well as similar microhardness indicators.
2. StraumanBL implants show the micro-gap of 0.78±0.17 microns on the original abutments. On the non-original ones - 1.7±0.1 microns, which may be due to the different chemical composition of the alloys from which the abutments are made.
3. Nobelbiocare implants show an adhesion of the original abutments throughout, only at an increase of x5000, a micro-gap of 1.26±0.18 microns was detected in one area. On non-original abutments, a micro-gap is observed on almost the entire connection with a size of 7.59±3.40 microns. This can also be caused by the different chemical composition and microhardness of the implant and abutment, as well as the precision of manufacturing.

Acknowledgments

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Declaration of Interest

The authors report no conflict of interest.

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