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Radiographic Evaluation of the Adaptation of Prosthetic Components on Different Dental Implant Prosthetic Interfaces: Cone Morse, Internal Hexagon and External Hexagon

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Abstract **Introduction:** Currently, the reliability of the dental implant system is not only reflected in its osseointegration success rate. The adaptation of prosthetic components is essential to accomplish the prosthetic rehabilitation. In the long run, a maladapted prosthetic component can lead to failure of the dental implant-prosthesis structure, as an example the creation of an ideal condition for the development of perimplantitis. The objective of this work was to demonstrate, by means of radiographic images, a comparison between the images of the interface between the dental implant and the prosthetic component, with one adapted and the other maladapted. **Materials and Methods**: For this purpose, interproximal incidence radiographs of the screwed prosthetic components on the dental implants were performed with simulation of maladaptation by interposing a 50 µm polyester matrix and without maladaptation. Three types of dental implant prosthetic interfaces were used: cone morse, internal hexagon and external hexagon. The prosthetic components used were three mini abutments, three CoCr UCLAS and three solid abutments. The dental implants with the screwed prosthetic components were positioned and stabilized with utility wax on the dummy and later radiographed with a phosphor plate system. Eighteen radiographs were taken, nine representing adapted joints and nine maladapted. **Results:** Results showed that in the radiographs of the cone morse dental implants there were no differences between the images, whereas in the internal hexagon and external hexagon dental implants, in the maladapted images there were identified a radiolucent line between the dental implant and the prosthetic component. **Conclusion:** In conclusion, It was possible to demonstrate the differences between the images of the adapted and maladapted prosthetic components to the external hexagon and internal hexagon dental implants.

Keywords: *prosthetic component, radiography, dental implants, prosthesis*

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1. Introduction

Nowadays, various brands and models of dental implants and prosthetic components are present on the market. The first dental implant prosthetic interface design was the external hexagon (EH), recommended by Professor Branemark, which is still used today. With the evolution of dental implantology, internal hexagon (IH) design emerged [1]. The other interface type is the cone morse (CM) that is precisely machined, provides strong stability, eliminates the microgap and prevents the rotation of the prosthetic component on the dental implant [2,3].

The prosthetic components, due to the large variety, were divided into two big groups: machined and adaptable [4]. The machined ones are already standardized and placed directly over the dental implant prosthetic interface and only one impression is needed to manufacture the prosthetic restoration. The adaptable ones need to be customized in the laboratory, so a previous impression of the dental implant prosthetic interface is needed [5].

The perfect adaptation of the prosthetic component on the dental implant cannot be neglected by the professional when placing the prosthetic restoration as they can cause several problems that lead to treatment failure. According to [6], the maladaptation between the dental implant and the prosthetic component and the lack of passive adaptation between them can lead to fractures of the fixing screw, as well as the prosthetic component or the dental implant itself. In addition, also leads to inadequate distribution of forces to the supporting bone and the accumulation of bacteria, even causing loss of osseointegration [7].

Considering that due to the subgingival location of the connection of the dental implant prosthetic interface and the prosthetic component, it is difficult to identify the maladaptation between them in the clinical evaluation [8]. Therefore, radiographies are essential for the identification of problems in this region [9].

The intraoral technique used for the accurate diagnosis of the adaptation between the prosthetic component and the dental implant prosthetic interface is the use of a parallelism positioner to direct the x-ray beam perpendicularly to the dental implant and the prosthetic component. In the absence of a positioner, the best technique would be to try to align the tube head perpendicular to the dental implant [7,10].

In the periapical technique of parallelism the use of specific radiographic positioners distances the image receiver (radiographic film, sensor or the phosphor plate) from the object, aiming at the position of both in relation to parallelism [11]. This technique has the advantage of reducing distortions produced by geometric differences in the angle between the image receiver and the object to be radiographed [12].

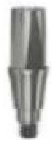
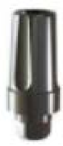
To perform the image examination with the bisector technique with positioner, the digital system with phosphor plates can be used instead of radiographic films [13]. The advantage of using this system is the speed in the visualization of the image. As soon after the image is captured in the phosphor plates, it passes through a reader and is reproduced in a few seconds on the computer monitor, eliminating chemical processing. There is also the advantage of using filters and changing brightness and contrasts in the captured image, improving its quality. Another advantage when using this system is the low radiation dose required to perform the radiographic exam [14].

Regarding the importance of having a perfect adaptation between dental implants and prosthetic component, dental professionals must carefully evaluate intraoral radiographs and know how to diagnose any mismatch.

2. Materials and Methods

Regarding the prosthetic interface, three different types of dental implants manufactured by Systhex® (Curitiba, Brazil) were selected and, along with them, prosthetic components also manufactured by Systhex® (Curitiba, Brazil).

Table 1. Dental implants and prosthetic components models and design

PROSTHETIC INTERFACE	DENTAL IMPLANT	PROSTHETIC COMPONENTS		
CONE MORSE	 Attract	Mini Conical Abutment 	CoCr base UCLA 	Solid Abutment 
INTERNAL HEXAGON	 Classic IN CR	Mini Conical Abutment 	CoCr base UCLA 	Solid Abutment 
EXTERNAL HEXAGON	 Classic CI	Mini Conical Abutment 	CoCr base UCLA 	Solid Abutment 

Source: Systhex® catalog.

Table 2. Dental implants and prosthetic components specification

CONE MORSE	INTERNAL HEXAGON	EXTERNAL HEXAGON
Attract model 3.5 x 10 mm Switching platform 3.5 mm	Classic IN CR model 3.75 x 10 mm Platform 4.3	Classic CI model 3.75 x 10 mm Platform 4.1
Mini Conical Abutment Height 2.5 mm	Mini Conical Abutment Height 2 mm	Mini Conical Abutment Height 2 mm
CoCr base UCLA Anti-rotational 3.5 mm platform	CoCr base UCLA Anti-rotational 4.1 mm platform	CoCr base UCLA Anti-rotational 4.1 mm platform
Solid Abutment 3.5 mm platform Height 2.5 mm	Solid Abutment 4.1 mm platform Height 2 mm	Solid Abutment 4.1 mm platform Height 2 mm

Source: Systhex® catalog.

The materials used in the study (dental implants and prosthetic components) were supplied by manufacturer without any conflict of interest.

Maladaptation were simulated interposing a 50 µm thick and a 4 mm diameter hole polyester matrix strips brand TDV® (Pomerode, Brazil) between the dentals implants and the prosthetic components.

The dental implants already with their prosthetic components were positioned with their recommended torques (HE and HI 32 Ncm and CM 20 Ncm) and stabilized on a dummy brand MOM® (Marilia, Brazil) with utility wax brand Lysanda® (São Paulo, Brazil).

Figure 1. Dummy with positioned

The radiographic images were taken using phosphor plates from Dürr Dental® (Bietigheim-Bissingen, Germany). The plates were inserted into positioners from Indusbello® (Londrina, Brazil) and inserted in position for simulation of radiographic examination on the dummy and scanned with the Vistascan equipment from Dürr Dental® (Bietigheim-Bissingen, Germany). The X-ray equipment used was a periapical Spectro brand Dabi Atlante® (Ribeirão Preto, Brazil), the power of 70 kV, 7 mA, 0.4 seconds exposure.

After the realization of the images they were analyzed to establish the radiographic characteristics of mismatches between implant and prosthetic component in a qualitative way.

3. Results

There were obtained eighteen radiographic images, comparing the three types of dental implant prosthetic interface and their three different prosthetic components, in an adapted and maladapted way.

In the images obtained between the Internal and External Hexagon prosthetic interface, it was possible to observe a radiolucent line in the region of the prosthetic component/dental implant prosthetic interface in cases of maladaptation simulation.

The adaptation of the Cone Morse showed no differences in the radiographic images in the adapted or maladapted way even with an interposed polyester matrix strip.

Table 3. Cone Morse set of radiographs

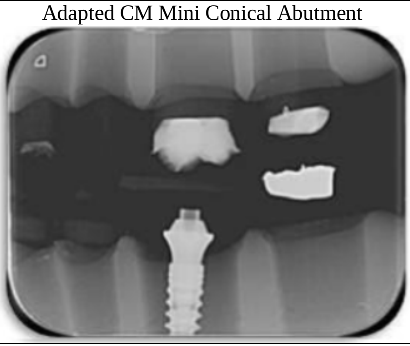
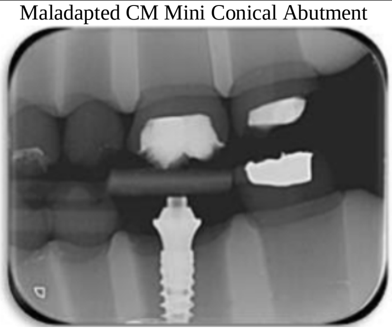
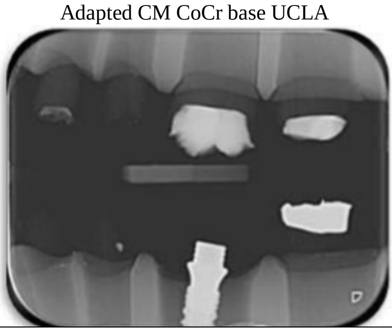
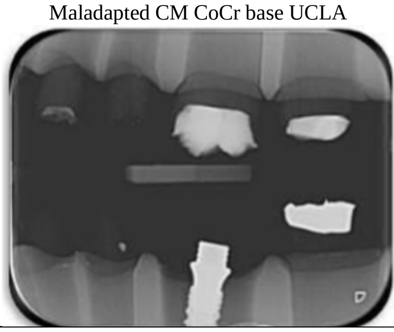
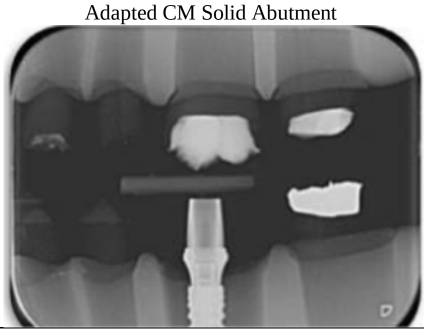
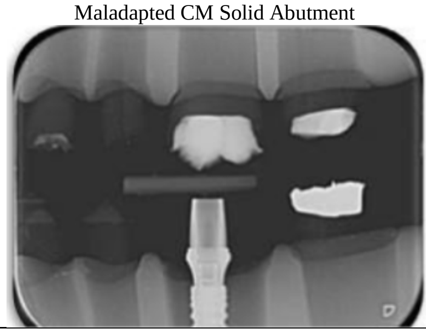
Adapted CM Mini Conical Abutment 	Maladapted CM Mini Conical Abutment 
Adapted CM CoCr base UCLA 	Maladapted CM CoCr base UCLA 
Adapted CM Solid Abutment 	Maladapted CM Solid Abutment 

Table 4. Internal Hexagon set of radiographs

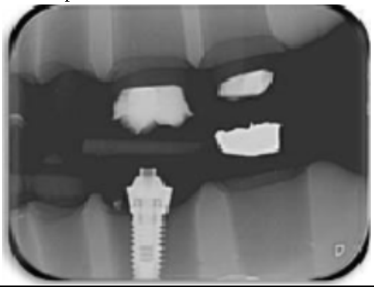
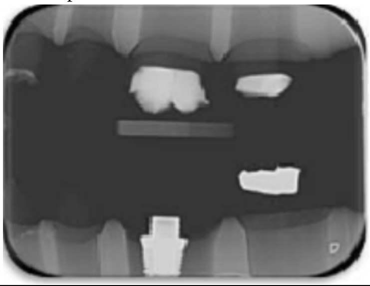
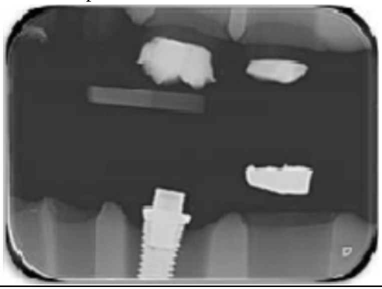
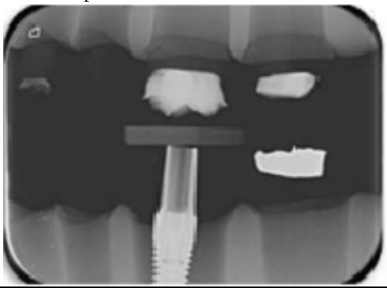
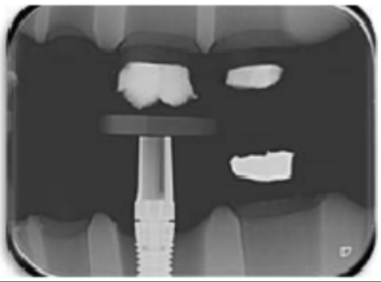
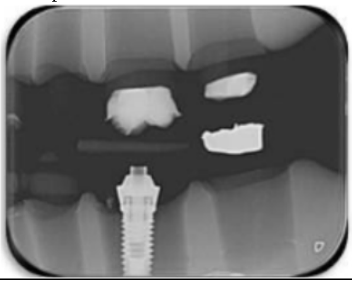
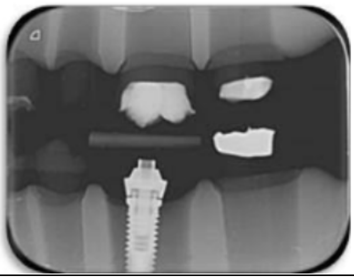
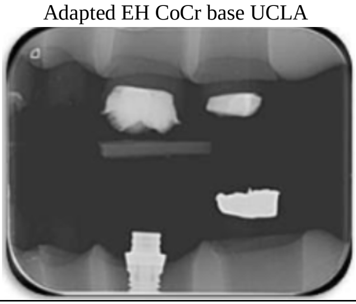
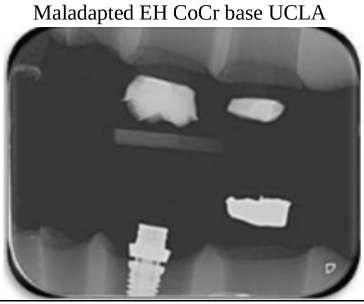
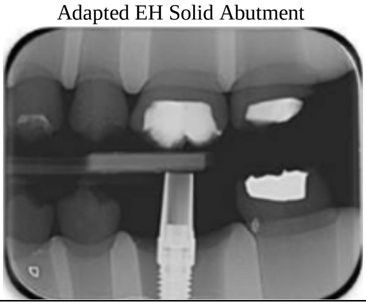
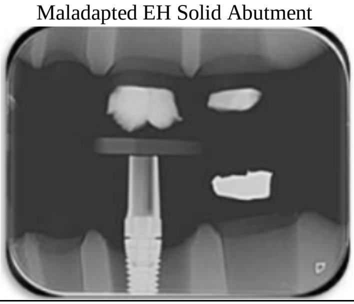
Adapted IH Mini Conical Abutment 	Maladapted IH Mini Conical Abutment 
Adapted IH Mini CoCr base UCLA 	Maladapted IH Mini CoCr base UCLA 
Adapted IH Mini Solid Abutment 	Maladapted IH Mini Solid Abutment 

Table 5. External Hexagon set of radiographs

Adapted EH Mini Conical Abutment 	Maladapted EH Mini Conical Abutment 
Adapted EH CoCr base UCLA 	Maladapted EH CoCr base UCLA 
Adapted EH Solid Abutment 	Maladapted EH Solid Abutment 

4. Discussion

Researchers [15] simulated 0, 50 and 100 µm micro gaps at the junction of the dental implant prosthetic interface with a temporary crown on a typodont dummy. Radiographs were used to assess the effectiveness of the parallelism device in helping to diagnose prosthetic maladaptations.

Another group of researchers [16] evaluated the conventional and digital radiographic diagnostic capacity to evaluate the marginal adaptation of prosthetic abutments, with different openings between the abutment and the dental implant. In addition, the diagnosis of maladjustments performed by radiographs is considered the best alternative, together with the clinical examination, which is paramount in this type of research, as shown in the study by [17], which corroborates the parameters of the study presented [6,18,19].

There is no micro gap (maladaptation) between two components in the cone morse system, because during the placement of the abutment (component) next to the dental implant there is an intimate adaptation between the surfaces on posts, generating a mechanical resistance similar to a single piece [20]. This characteristic of the cone morse is very well described in a study that reported that this perfect adaptation not only reflects on a more stable prosthesis result, but is also closely related to the gingival behavior, allowing an ideal biological sealing [21].

Maladaptations between dental implants and prosthetic components can cause several problems that lead to treatment failure [22]. These failures are very well described in a literature review that considers six etiological factors for the failure of prosthetic restorations on dental implants, including surgical trauma, occlusal overload, peri-implantitis, micro gap, biological width and module of the crest of the implant [23].

In other studies, it was described that the lack of prosthetic adaptation in prostheses on dental implants can cause several problems such as: fracture screw or prosthetic abutment, loosening of the screw, accumulation of bacteria around the dental implant causing early bone loss and even loss of bone integration of the implant [6,23,24]. The maladaptation of the prosthetic abutments can lead to major fractures of the definitive prostheses [25] in an in vitro study comparing the EH, IH and CM connections, it can be confirmed that the internal connection is the most resistant to loads applied to adapted or maladapted prosthetic components [26,27,28].

A relationship between the size of micro gaps and the ability of examiners to detect them can be established. Although tactile examination alone is not accurate enough, radiographic analysis associated with a degree of clinical experience has characteristics for an adequate clinical management of restoration defects, [29] in other in vitro studies were able to prove this fact, in which they artificially created maladaptations between the dental implant and the prosthetic components and performed periapical radiographs under orthogonal conditions. The authors noted that the maladaptations were significantly more detected by radiographic examination than by clinical examination, corroborating to the this present study and other authors [30,31,32].

5. Conclusion

Regarding the information obtained in this study, it is possible to conclude that:

- Interproximal radiography is an excellent mean of diagnosis regarding the verification of adaptation of the prosthetic component.
- The Systhex® brand prosthetic components, CM, HI and HE did not present a maladaptation radiographic line when they were perfectly adapted with their respective ideal insertion torques, indicating an excellent adaptation.
- As expected in the literature, there were no image differences between the adapted and maladapted prosthetic components on the cone morse dental implant. Therefore clinical analysis is complementary for an accurate confirmation of the adaptation.

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