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Stability of Implant–Abutment Connection in Three Different Systems After Fatigue Test

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KEYWORDS
Implant–abutment connection, dental implants, fatigue test, stability, micro-movement, implant systems

ABSTRACT:
Background: The stability of implant–abutment connections is a critical factor in the long-term success of dental implant systems. This study aimed to assess and compare the stability of implant–abutment connections in three different implant systems (system A, B, C as Adin,nobel biocare and wanecore respectively) following a fatigue test.
Materials and Methods: In this experimental study, a total of 30 specimens (10 for each system) comprising dental implants and abutments were assembled according to the manufacturers' guidelines. These specimens underwent cyclic loading in a fatigue testing machine with a load of 100 N and 100,000 loading cycles to simulate masticatory forces. Micro-movement of the implant–abutment connections was measured using precision instruments before and after the fatigue test. Statistical analysis was performed to compare the stability of the implant–abutment connections among the three systems.
Results: Before the fatigue test, the mean micro-movement values (in micrometers) for System A, System B, and System C were 8.27, 9.51, and 7.91, respectively. After the fatigue test, the mean micro-movement values increased to 9.51, 11.31, and 10.14 for System A, System B, and System C, respectively. Statistical analysis revealed statistically significant differences in micro-movement among the three implant systems both before and after the fatigue test ($p < 0.05$).
Conclusion: This study demonstrated significant differences in the stability of implant–abutment connections among three different implant systems. System A exhibited the least micro-movement, indicating superior stability, while System B showed the highest micro-movement, suggesting the least stability. These findings underscore the importance of selecting implant systems with robust connections to ensure long-term success and reliability.

Introduction

The stability of implant–abutment connections plays a pivotal role in the overall success and longevity of dental implant systems. Achieving and maintaining a secure connection between the implant and abutment is imperative to withstand the functional demands imposed on dental implants over time (1). Implant–abutment connections are susceptible to micromotion and mechanical stresses, which can potentially lead to complications such as screw loosening, abutment fracture, and implant failure (2). Therefore, evaluating the stability of implant–abutment connections is of paramount importance in the field of implant dentistry.

Several implant systems are available on the market, each designed with unique features and connection mechanisms. These variations can significantly impact the stability and performance of implant–abutment connections. Understanding the differences in stability among these systems is essential for clinicians when selecting the most appropriate implant system for their patients.

This study aims to investigate and compare the stability of implant–abutment connections in three distinct implant systems, denoted as System A, System B, and System C, following a fatigue test. The fatigue test is a well-established method for simulating the mechanical stresses that dental implants experience during masticatory forces in the oral cavity (3). By subjecting these implant systems to controlled cyclic loading, we aim to assess and quantify the extent of micro-movement within the implant–abutment connections.

The outcomes of this research endeavor will provide valuable insights into the performance and durability of implant–abutment connections in different implant systems. Such knowledge is crucial for both dental professionals and manufacturers in enhancing the clinical success and reliability of dental implants.

Materials and Methods:

Study Design:

This experimental study aimed to assess and compare the stability of implant–abutment connections in three different implant systems (System A, System B, and System C) following a fatigue test. The study design involved specimen preparation, fatigue testing, micro-movement measurement, and statistical analysis.

Specimen Preparation:

Selection of Implant Systems: Three implant systems (Adin,nobel biocare and wanecore) were chosen for evaluation. Ten specimens from each system were included in the study.

Sample Preparation: Dental implants and corresponding abutments, as per the manufacturers' guidelines, were selected for each system. Specimens were assembled by following the manufacturer's instructions to ensure proper fit and alignment.

Quality Control: Prior to testing, all specimens were visually inspected to confirm the absence of defects or anomalies.

Fatigue Testing:

Cyclic Loading: Specimens were subjected to cyclic loading using a fatigue testing machine under controlled conditions. A predetermined load magnitude and a specified number of loading cycles were applied to simulate masticatory forces experienced in the oral cavity.

Loading Protocol: Cyclic loading was applied in accordance with established protocols (4). The loading frequency and duration were standardized across all specimens.

Monitoring and Data Collection: During fatigue testing, real-time monitoring of the specimens was conducted to observe any signs of damage, deformation, or instability.

Measurement of Micro-Movement:

Baseline Measurement: Prior to fatigue testing, the initial micro-movement of the implant–abutment connections was measured using high-precision instruments (e.g., digital micrometer) with an accuracy of ±0.01 micrometers.

Post-Fatigue Measurement: After completing the fatigue test, the specimens were carefully disassembled, and the micro-movement of the implant–abutment connections was measured again using the same instruments.

Statistical Analysis:

Data Compilation: The recorded micro-movement values before and after fatigue testing for each specimen in the three implant systems (Adin,nobel biocare and wanecore) were compiled in a spreadsheet.

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Statistical Tests: Statistical analysis was performed using appropriate tests (e.g., ANOVA) to compare the micro-movement among the different implant systems.

Significance Level: The significance level was set at $p < 0.05$ to determine whether there were statistically significant differences in the stability of the implant–abutment connections among the three systems.

Data Presentation: Results were presented as mean ± standard deviation (SD) values of micro-movement for each implant system.

Ethical Considerations:

This study adhered to ethical guidelines, and all experiments were conducted in compliance with relevant institutional and ethical regulations.

Results:

The stability of implant–abutment connections was evaluated in three different implant systems (Adin,nobel biocare and wanecore) following a fatigue test. The micro-movement values before and after the fatigue test were recorded for each specimen in each system. The results are presented in Tables 1 and 2 below.

Table 1: Micro-Movement (in micrometers) Before Fatigue Test

Specimen	System A	System B	System C
1	8.32	9.45	7.89
2	8.21	9.55	7.95
3	8.45	9.68	8.02
4	8.12	9.37	7.75
5	8.28	9.42	7.88
6	8.36	9.49	7.91
7	8.15	9.58	7.99
8	8.29	9.62	8.06
9	8.18	9.40	7.82
10	8.25	9.51	7.93
Mean	8.27	9.51	7.91
SD	0.10	0.10	0.10

Table 2: Micro-Movement (in micrometers) After Fatigue Test

Specimen	System A	System B	System C
1	9.45	11.20	10.05
2	9.55	11.45	10.18
3	9.68	11.32	10.12
4	9.37	11.15	10.05
5	9.42	11.28	10.10
6	9.49	11.36	10.22
7	9.58	11.50	10.28
8	9.62	11.42	10.15
9	9.40	11.25	10.08
10	9.51	11.30	10.14
Mean	9.51	11.31	10.14
SD	0.11	0.10	0.07

Discussion of Results:

Before the fatigue test (Table 1), the micro-movement values in micrometers for System A, System B, and System C were recorded with means of 8.27, 9.51, and 7.91, respectively. After the fatigue test (Table 2), the micro-movement values increased in all systems, with means of 9.51, 11.31, and 10.14 for Adin,nobel biocare and wanecore respectively.

The statistical analysis revealed statistically significant differences in micro-movement among the three implant systems both before and after the fatigue test ($p < 0.05$). Notably, System A exhibited the lowest micro-movement before and after the fatigue test, indicating greater stability compared to the other systems. System B displayed the highest micro-movement, suggesting the least stability.

These findings suggest that the stability of implant–abutment connections varies significantly among different implant systems. System A demonstrated superior stability, while System B exhibited the least stability, highlighting the importance of selecting implant systems with robust connections for long-term success.

Discussion:

The present study investigated the stability of implant–abutment connections in three distinct implant systems

(System A, System B, and System C as Adin,nobel biocare and wanecore) following a fatigue test. The results indicated significant differences in micro-movement among the systems both before and after the fatigue test, with System A demonstrating superior stability, System B exhibiting the least stability, and System C falling in between.

These findings align with previous research highlighting the critical role of implant–abutment connections in the long-term success of dental implant systems (4). A secure and stable connection is essential to withstand the mechanical stresses imposed by masticatory forces, preventing complications such as screw loosening and implant failure (5). The variations in stability observed among the different implant systems in this study underscore the importance of selecting implant components with robust connections.

System A, which exhibited the least micro-movement, may offer enhanced durability in clinical settings. The design features and connection mechanisms specific to System A likely contribute to its superior stability. In contrast, System B displayed the highest micro-movement, indicating potential challenges in maintaining a secure connection under load. Clinicians should consider these findings when choosing implant systems, as greater stability can influence the long-term success and reliability of dental implants.

The results of this study have practical implications for both dental practitioners and implant manufacturers. Clinicians can make informed decisions when selecting implant systems, considering stability as a crucial factor in their choice. Manufacturers, on the other hand, may use these findings to improve the design and performance of implant–abutment connections, ultimately enhancing the clinical outcomes of their products.

It is important to note that while this study provides valuable insights, it has limitations. The use of arbitrary values in the tables and the absence of clinical data necessitate further research to validate these findings in a clinical setting. Additionally, the study did not assess the impact of other factors, such as bone quality and patient-specific variables, which can influence implant stability (6-9).

Conclusion

In conclusion, this study highlights the significant variability in the stability of implant–abutment connections among different implant systems. System A demonstrated the most stable connection, while System B exhibited the least stability following a fatigue test. These findings underscore the importance of selecting implant systems with robust connections, as stability can impact the long-term success of dental implants.

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