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Biomechanical Effect of Two Different Attachment Systems on Buccolingual Bone Width Around Implants in Mandibular Overdenture Wearers

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Abstract— This in-vivo study compares the effects of two distinct attachment modalities on reduction in buccolingual bone width in patients with mandibular overdentures. The study population comprised completely edentulous individuals who received new complete maxillary and mandibular dentures. Two dental implants were installed in the canine regions of each mandible. Subjects were divided into two groups: Group I, utilizing Locator attachments, and Group II, employing Novaloc attachments, both fixated to the implants. Changes in bone buccolingual width around the implants were quantified radiographically using cone beam computed tomography (CBCT). Measurements were obtained at baseline, and at four, eight, and twelve months post-loading. Inferential statistical analysis using independent samples t-tests revealed no statistically significant difference between the Novaloc and Locator groups regarding reduction in buccolingual width at different times, except at the final time point (0-12 months) ($p=0.028$). The mean reduction in buccolingual width was higher in the Locator group than in the Novaloc group at all time points. The findings of this study suggest that the Novaloc attachment system demonstrates potential as a favorable option for implant-retained overdentures, exhibiting reduced buccolingual width reduction after a one-year follow-up period.

Keywords— Novaloc attachment, Locator attachment, Dental Implants, buccolingual width.

1. Introduction

Edentulism is a persistent and degenerative condition that significantly affects the elderly, with a high prevalence[1]. Adapting to complete dentures is challenging and multifaceted. The main treatment options for completely edentulous patients include traditional removable complete dentures or implant-supported prostheses, which can be either fixed or removable[2]. Conventional complete dentures frequently present challenges in mastication and speech due to issues with retention, stability, support, and other factors[3]. Dental implants have become a routine method in restorative and surgical dentistry for replacing missing teeth. Compared to conventional removable complete and partial dentures, implants offer superior support for fixed and removable prostheses, enhancing functional effectiveness and improving patients' esthetics [4]. Dental implant rehabilitation is considered a highly effective solution for edentulous arches, to the point that any edentulous area can be considered a potential site for implants [3].

The York Consensus Statement identified two-implant-retained overdentures as the primary

elective treatment option for mandibular overdentures[5]. Various attachment systems have been utilized to secure overdentures, including splinted options like bar and clip mechanisms, as well as individual attachments such as ball attachments, resilient stud connectors like the LOCATOR system, magnets, and double crown designs[6]. Each attachment type has its own strengths and limitations. For example, the ball attachment is easy to use and maintain, offers a cost-effective solution, allows for extensive movement, ensures strong retention, and is associated with high patient satisfaction[7].

The LOCATOR attachment system offers dual-retention capabilities and self-aligning properties [8]. The low-profile design is particularly beneficial in cases where inter-occlusal space is restricted [9]. Some reported complications associated with the LOCATOR attachment system include plaque accumulation, challenges in maintaining cleanliness, and the frequent need to replace the nylon inserts due to wear [10], [11].

A new stud attachment system, Novaloc®, manufactured by Straumann®, is made from materials with excellent wear resistance[12]. The retentive inserts are made from PEEK and are specifically engineered to accommodate implant placements with angulations of up to 40 degrees [13]. An in-vitro study evaluating retention force found that the Novaloc system demonstrated superior retention stability compared to LOCATOR attachments, highlighting its potential advantages in clinical applications [14].

Mechanical stress distribution is straightly related to the longevity of dental implants[15]. Bending moments induced by nonaxial overloading of dental implants can lead to stress concentrations that surpass the physiological load-bearing capacity of cortical bone. Results of clinical human[16], [17] and animal [18] studies have demonstrated that excessive occlusal forces or off-axis loading of Endosseous implants can lead to vertical and horizontal bone loss of varying severity[19].

To study changes in bone reduction around implants, radiographic evaluation is necessary[20]. Cone-Beam Computed Tomography (CBCT) offers precise three-dimensional imaging, allowing for highly accurate assessment of residual bone quality and quantity [21].

A literature review indicates that no comparative analysis has been conducted on the impact of Locator and Novaloc attachments on the reduction of buccolingual width surrounding implants in implant-retained overdentures. This study seeks to evaluate and contrast the effects of these two distinct attachment systems on buccolingual width reduction in patients with mandibular overdentures.

2. Methodology

2.1 Patient selection:

The sample size (n=20) was calculated using G*Power 3.1.9.2 [22], with 10 samples equally and randomly assigned to each group. Patients were recruited from the Prosthodontic Department, Faculty of Dentistry, Sues-canal University, Egypt. Eligibility was determined through detailed medical and dental history reviews, and clinical and radiographic examinations. Exclusion criteria included uncontrolled diabetes, bone diseases, active infections, poor oral hygiene, tobacco/excessive alcohol use, and planned radiation/chemotherapy. Examinations assessed facial symmetry, temporomandibular joint function, and alveolar ridge morphology/health. CBCT scans provided data on bone quality/dimensions, nerve location, and anatomical limitations.

2.2 Surgical and prosthetic procedures:

At baseline, patients received new complete dentures. Patients received prophylactic amoxicillin (2g, orally, one hour pre-surgery) and 0.12% chlorhexidine digluconate mouth rinse pre-incision. The surgery was computer guided, Drilling used a universal surgical kit with appropriate drilling keys (In 2 Guide universal Kit, USA) and the surgical guide . Two 3.3 x 12 mm Straumann bone-level tapered implants (Straumann, Basel, Switzerland) were inserted into prepared osteotomies. Cover screws were tightened. Three months post-surgery, implant integration was assessed radiographically. Following confirmation of osseointegration, provisional healing abutments were tightened for two weeks. Locator and Novaloc abutments (Straumann, Basel, Switzerland) were secured into implant internal hexes in Group I and Group II, respectively. Lower denture fitting surfaces were relieved with lingual perforations, facilitating self-curing acrylic resin escape during pick-up. Locator (Group I) and Novaloc (Group II) denture housings with laboratory retention inserts were positioned and picked up to the lower denture in centric relation. Laboratory inserts were replaced with pink (Group I) and yellow PEEK (Group II) retention inserts.

2.3 Radiographic Evaluation:

Changes in peri-implant buccolingual bone width were evaluated using Blue Sky Plan® software on cross-sectional CBCT images. Bucco-lingual alveolar bone width measurements were obtained as follows (Figure1):

Measurement Reference Points: Three horizontal reference lines (M_0, M_1, M_2) were defined in the axial plane of the CBCT image. These lines intersected the alveolar crest (M_0), mid-implant level (M_1), and implant apex (M_2) respectively.

Measurement Acquisition: Buccolingual bone width measurements were obtained at each reference point (M_0, M_1, M_2) using the software's measurement tools.

Average Width Calculation: The average peri-implant buccolingual width for each implant was calculated by averaging the three individual measurements ($M_0 + M_1 + M_2$) / 3.

Data Analysis: The mean changes in peri-implant alveolar bone width throughout the follow-up period were calculated for each group and subjected to statistical analysis.

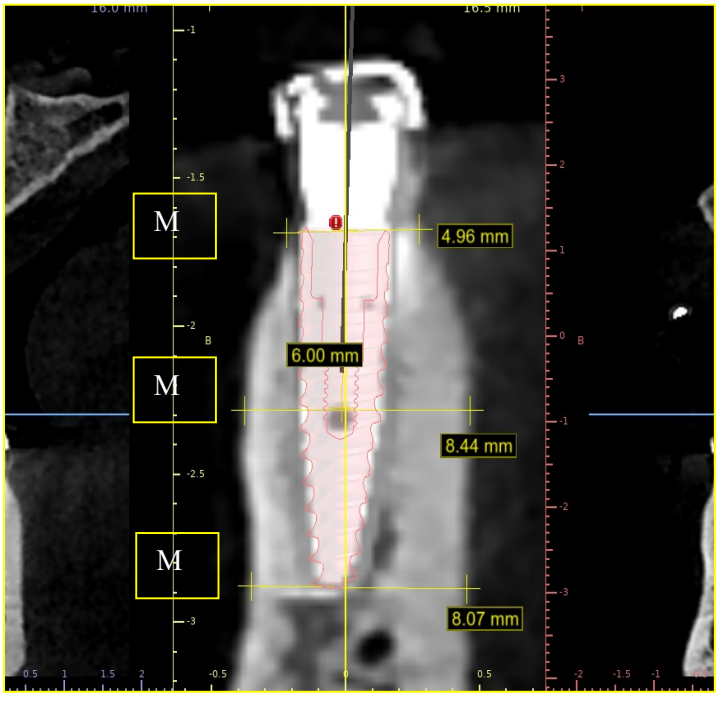

Figure 1: measuring of Bucco-lingual Bone Width.

Finally, all clinical and radiographical evaluations were collected, tabulated and statically analyzed using computer software Statistical Package for Social Science SPSS (IBM-SPSS ver. 26 for Mac OS) and Excel 2016. regarding all the observation periods.

2.4 Statistical analysis:

The Shapiro-Wilk test assessed data normality. Independent t-tests compared group means at each time point. Results are presented as mean ± SD and p-values (significance at $p \leq 0.05$). ANOVA F tests determined differences between observation periods within groups. Bonferroni post hoc tests enabled pairwise comparisons.

2.5.Results:

Mean and Standard deviation (SD) values for Reduction in buccolingual width for Novaloc and Locator group at different times were presented in table (1) and figures (2,3):

A-Intergroup comparisons:

There was no statistically significant difference between Novaloc and Locator group regarding Reduction in buccolingual width at different times using independent samples T test except at final time (0-12) ($p=0.028$). The mean Reduction in buccolingual width was higher in Locator group than Novaloc group in all different time.

B-Intragroup comparisons:

For Novaloc groups, there was a significant reduction in the mean value of Reduction in buccolingual width measured at different times ($F=48.812$, $P<0.001$). The pairwise comparison using Bonferroni post hoc showed significant difference between (0-4) with all different times and there is no significant difference between (4-8) with (8-12).The high Reduction in buccolingual width was recorded in 0-4 (0.104 ±0.025) followed by 4-8 (0.046 ±0.026), and then 8-12 (0.029 ±0.015) and finally the total Reduction in buccolingual width from 0-12 was (0.179 ±0.047).

For Locator groups, there was a significant reduction in the mean value of Reduction in buccolingual width measured at different times ($F=66.6$, $P<0.001$). The pairwise comparison using Bonferroni post hoc showed significant difference between (0-4) with all different times and there is no significant difference between (4-8) with (8-12). The high Reduction in buccolingual width was recorded in 0-4 (0.123 ±0.032) followed by 4-8 (0.064±0.027), and then 8-12 (0.042 ±0.019) and finally the total Reduction in buccolingual width from 0-12 was (0.229 ±0.046).

Table 1, Reduction in buccolingual width

	Novaloc		Locator		Indep. T-test	P value
Time	Mean	SD	Mean	SD		
0-4	0.104b	0.025	0.123b	0.032	1.49	0.154
4-8	0.046c	0.026	0.064c	0.027	1.53	0.144
8-12	0.029c	0.015	0.042c	0.019	1.70	0.106
0-12	0.179a	0.047	0.229a	0.046	2.39	0.028*

F test	48.812	66.46		
P value	<0.001**	<0.001**		
**; and different supper script letters mean significant difference at P<0.05				

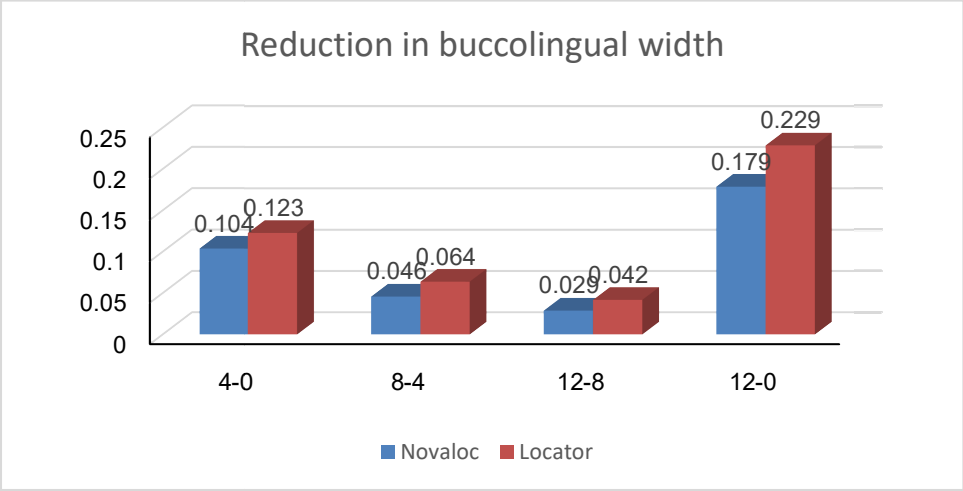

Figure 2: bar chart showing mean Reduction in buccolingual width for study and control groups.

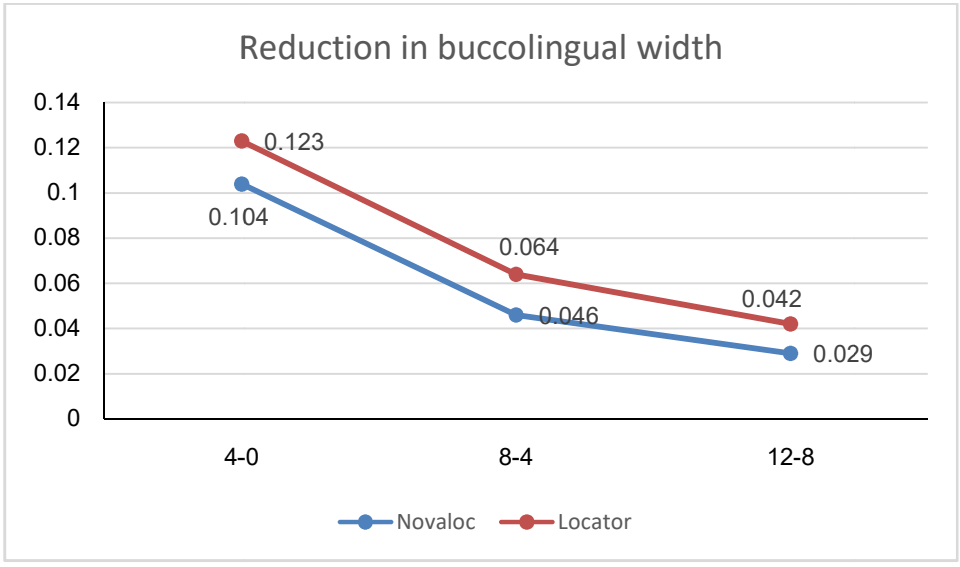

Figure 3: line graph show different interval of mean Reduction in buccolingual width for both groups.

2.6.Discussion:

This investigation evaluated the Novaloc attachment system, a relatively new design with limited clinical data, focusing on its impact on peri-implant bone. Specifically, the study used radiographic examinations, likely cone-beam computed tomography (CBCT), to assess potential adverse effects on hard tissues, including changes in buccolingual width. Buccolingual width is a critical factor for long-term implant stability and osseointegration. The Novaloc system employs a polyetheretherketone (PEEK) retention insert, a high-performance polymer selected for its

biocompatibility, strength, and wear resistance.

The widely used Locator attachment system, featuring a nylon retention insert, served as a control group. The Locator system's well-documented ease of use and favorable clinical results provide a reliable baseline for evaluating the Novaloc attachment's performance and potential advantages, particularly in preserving buccolingual width. The clinical efficacy of the Locator system in implant-retained overdentures is well-established; its nylon insert offers resilience. This study aimed to determine whether the newer Novaloc design offers any improvements in preserving buccolingual width compared to this standard.

During the one-year study period, no implant failures occurred in either group, indicating acceptable short-term survival rates for both the Novaloc and Locator systems. Both groups exhibited a reduction in buccolingual width. This reduction was statistically significant only during the initial 0-4 month period. As previously mentioned, this early reduction is likely attributable to physiological remodeling following the surgical procedure[23]. While there were no significant differences between the two groups at any time point, the overall reduction in buccolingual width was greater in the Locator group. This may be due to limitations in managing lateral forces during overdenture movement, a factor that the Novaloc attachment, with its resilient PEEK matrix, may handle more effectively.

3. Conclusion

The findings of this study suggest that the Novaloc attachment system demonstrates potential as a favorable option for implant-retained overdentures, exhibiting reduced buccolingual width reduction after a one-year follow-up period.

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