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Original article

A comparative clinical study of two different attachment systems and implant stability in implant-supported mandibular overdentures

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ABSTRACT

Background: *Implant stability is crucial for the long-term durability of implant-supported removable dentures. Understanding the clinical impact of attachment systems such as Novaloc and Locator on stability is essential for their potential prognosis.* ***Purpose:*** *The aim of this study is to compare the effects of Novaloc and Locator attachment systems on implant stability in implant-supported overdentures.* ***Methods:*** *The research sample consisted of 10 patients, all entirely edentulous in the lower and upper jaws. Each patient received a conventional complete denture in addition to two implants in the mandible. Equal numbers of patients were assigned to Group 1: Novaloc attachment system and Group 2: attachment system for locators. Implant stability was evaluated using the MegaGen implant stability quotient device and repeated after 4, 8, and 12 months. The SPSS program was used to collect, calculate, and statistically analyze the data.* ***Results:*** *According to one-way ANOVAs and independent t-tests conducted throughout the observation period, both groups demonstrated an improvement in implant stability, but the Novaloc group showed superiority, with statistically significant differences ($P > 0.05$).* ***Conclusion:*** *Based on the study's findings, in comparison to the Locator system, the Novaloc attachment system offers better implant stability during a 1-year monitoring period.*

Keywords: *Novaloc; Locator; Implant Stability; Implant-supported overdenture; Prosthetic dentistry*
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INTRODUCTION

The mechanism of attachment systems enables increasing the retention, support and stability of complete dentures beyond that of conventional unsupported dentures. This is achieved by connecting the implants to the bone while the anchorage systems are attached to the denture on one end and to the implants— which are joined to the bone—on the other. This method ensures better stability within the tolerance limits of the bone and biological tissues, thereby maintaining their integrity.[1,2]

As described in several references, implant stability refers to the amount of the implant's mobility that expresses bone to implant contact and is usually classified into primary and secondary stability, This primary stability during the first stage after implant insertion is largely influenced by several factors, such as bone type and dimensions, implant design, and the practitioner's skill, all of which contribute to mechanical stability.[3] However, after the healing phase ends, the bone around the implants will undergo resorption to create new bone, a process called osseointegration, which is indicated by secondary stability,[4] the sustainability of which is related to biological aspects and occlusal load.[5] Therefore, the attachment's design must consider distributing forces throughout the implant's body and enhance this incorporation within its body during functioning.[6–8]

Several studies compared different types of attachments, including Novaloc and Locator systems. For example, Taha[9] used finite element analysis and concluded that the Novaloc system resulted in slightly greater stresses. A study by Wichmann et al.[10] found that the Novaloc system's cap was larger and more wear resistant, while another study found that the Novaloc system had more durability against retention forces than the Locator system.

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However, most of these studies were in vitro and did not clinically cover the effect of the attachments on the implants' secondary stability. To reduce this gap in the existing literature, this study assesses the impact of Novaloc and Locator attachments on implant secondary stability under overdentures during loading through a 1-year observation period, employing the resonance frequency analysis technique, which is more accurate and predictable than subjective techniques.[11]

MATERIALS AND METHODS

Following a specialist's statistical study, 10 Egyptian patients with edentulism from the Department of Prosthetic Dentistry at Suez Canal University's Faculty of Dentistry were selected as the research sample. They were chosen after meeting the following inclusion criteria: having healthy tissue that covered their maxillary and appropriate alveolar ridges in the jaw for implantation (Figure 1), which was confirmed by radiographic image (Figure 2) ; and having unaffected overall oral and physical health. The exclusion criteria encompassed risk factors for implant success that included low-density bone type, careless oral hygiene, drunkenness, a history of radiation therapy to the head and neck, or systemic diseases. Ethical approval for this study was obtained from the Institutional Ethical Committee of the Faculty of Dentistry, Suez Canal University, Egypt (IRP No. 2021-406).

After obtaining their consent for the procedure, the patients were divided equally into Group 1: Novaloc attachment system and Group 2: Locator attachment system. In accordance with the routine steps, a conventional resin acrylic complete upper and lower removable denture was crafted for all the patients in both groups. The process involved creating primary upper and lower impressions. The final impression was made using cold acrylic cured trays, while border molding was used to create the wash impression. Following this, the jaw relation was registered using record bases before the artificial teeth were arranged, dentures were waxed up, and try-ins were completed prior to finalization of the dentures, with the necessary adjustments made in the patient's mouth (Figure 3).

Both conventional loading and the flapless implant placement technique were employed. To ensure that the implants were precisely placed and oriented in the canine area, a surgical guide was created utilizing the CAD-CAM (Figure 4).

Each patient received two bone Straumann implants (Straumann Dental Implant System, Switzerland), which were 3.3 mm wide and 13 mm long, along with postoperative instructions. The postoperative medicine protocol for the patients included antibiotics, anti-inflammatory drugs, analgesics, and chlorhexidine mouthwash. The patients were warned to avoid pressure on the implant site or wear dentures for 7 days and were asked to return for an evaluation (Figure 5).

Following a 3-month healing period and the standard loading procedure to guarantee that the implants could be installed, periapical radiological pictures were used to evaluate the implants. They revealed no evidence of discomfort, inflammation, or bone resorption surrounding the implants. After exposing the implants and installing the

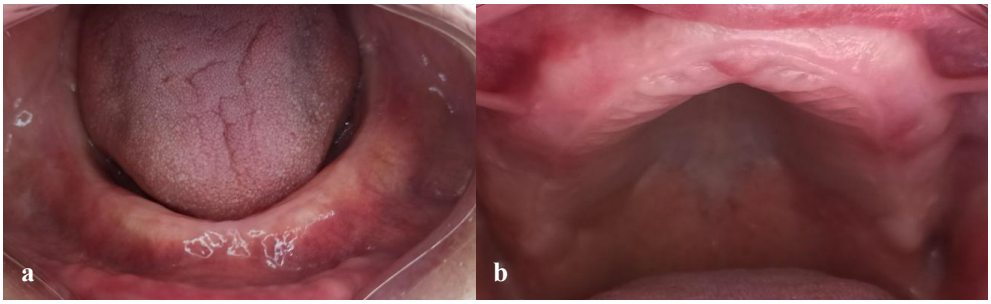

Figure 1. (a) Intraoral view of the mandible; (b) intraoral view of the maxilla.

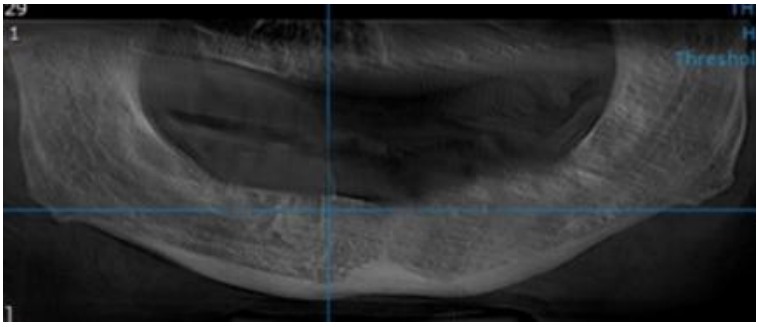

Figure 2. Preoperative diagnostic radiographic.

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Figure 3. Removable complete denture.

system's smart peg, the secondary stability and suitability for loading were assessed using the Mega ISQ® System (MegaGen Seoul, Korea), a South Korean resonant frequency measurement system, in accordance with scientific guidelines (Figure 6). Following the insertion of one of the two attachments, Novaloc (Straumann, Möhlin, Switzerland) and Locator (Zest Anchors, Escondido, USA), the torque ratchet wrench was used to tighten each system in accordance with the manufacturer's recommendations (30 Nm). The straight pick-up procedure was used for each patient (Figure 7).

The implant stability quotient was measured using the resonance frequency analyzer (Mega ISQ System, South

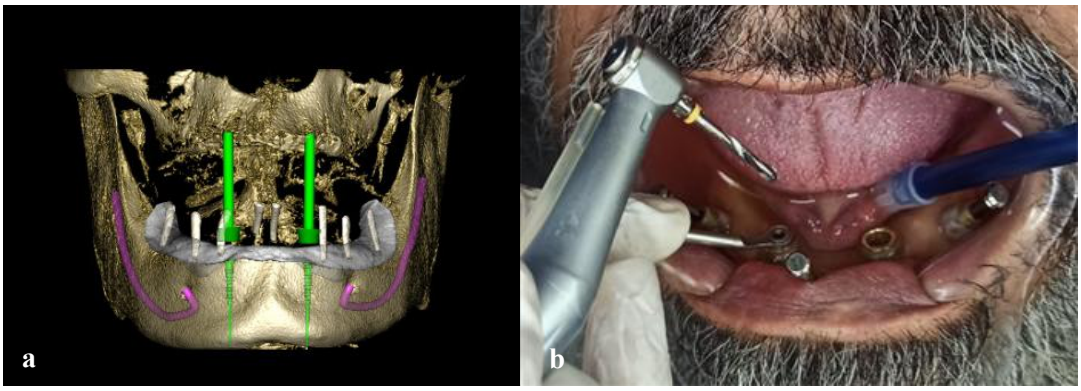

Figure 4. (a) Surgical guide design with parallel axes; (b) surgical osteotomy using the surgical guide.

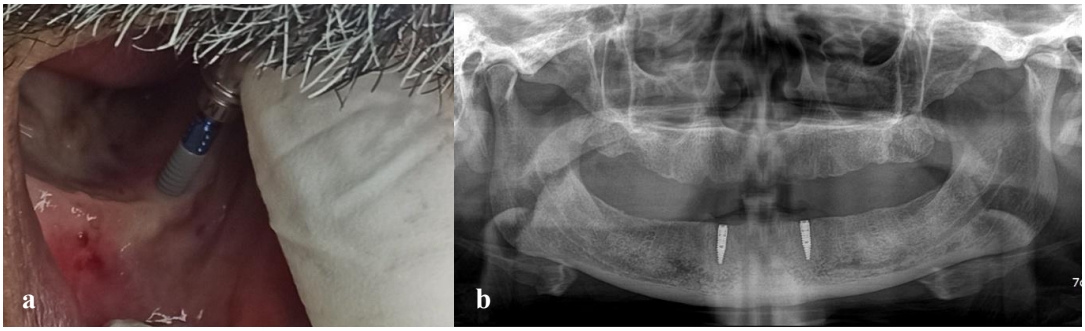

Figure 5. (a) Straumann Bone Level Tapered Implant; (b) postoperative radiographic image.

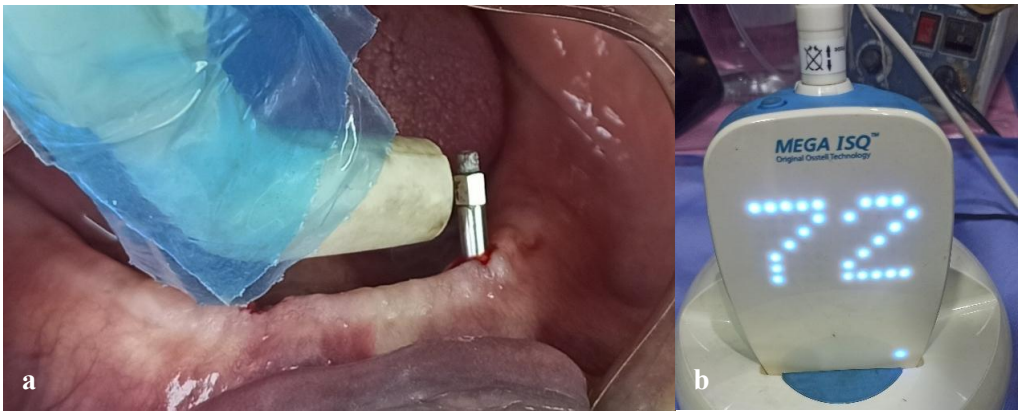

Figure 6. (a) Measuring stability after the end of the healing period; (b) stability values indicate success.

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Korea). After mounting the implant system's smart peg, the measurements of secondary stability were completed from all sides (buccal, lingual, mesial, distal, and occlusal), which was commenced immediately after installing the retentive inserts as (T0). All measurements were repeated after 4 months (T1), 4 months (T2), and 12 months (T4). To guarantee accuracy, the measurements were taken several times in each direction, and the most frequent value was recorded.

RESULTS

The collected data was analyzed using SPSS version 26.0 for Windows. The Shapiro–Wilk test was used to determine normality. The independent sample t-test was used for comparisons, with a 95% confidence level and a statistical significance criterion of $P < 0.05$. The results demonstrated statistically significant differences in stability between the Locator and Novaloc attachment groups across the T2 and T3 periods for all implant surfaces. The Novaloc group exhibited greater levels of implant secondary stability than the Locator group (Table 1; Figure 8).

DISCUSSION

Both groups were constantly monitored in terms of secondary stability during the 1-year observation period.

Figure 7. (a, b) Novaloc abutment prior to and after screwing in the implants; (c, d) Locator abutments prior to and after screwing in the implants.

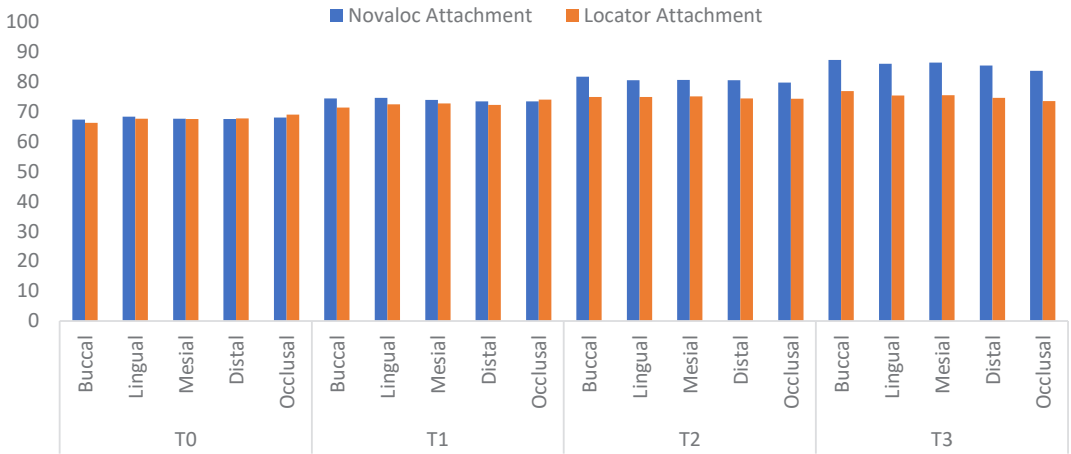

Figure 8. Comparison between Novaloc and Locator attachments during each period for implant secondary stability.

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Table 1. Comparison between Novaloc and Locator attachments in each time period

Measurement period		Novaloc Attachment		Locator Attachment		Indep. t test	P-value
		mean	SD	mean	SD		
T0	Buccal	67.30	6.05	66.20	3.91	0.341	0.742
	Lingual	68.30	5.60	67.60	4.20	0.224	0.829
	Mesial	67.60	5.31	67.50	3.69	0.035	0.973
	Distal	67.50	5.42	67.70	3.95	−0.067	0.948
	Occlusal	68.00	4.78	68.90	4.64	−0.302	0.770
T1	Buccal	74.30	2.20	71.30	4.28	1.394	0.201
	Lingual	74.50	1.90	72.40	4.44	0.973	0.359
	Mesial	73.80	1.72	72.70	4.27	0.535	0.607
	Distal	73.40	1.67	72.20	4.37	0.574	0.582
	Occlusal	73.40	1.92	73.90	4.59	−0.225	0.828
T2	Buccal	81.60	3.94	74.80	2.08	3.411	0.009
	Lingual	80.40	3.60	74.80	2.95	2.693	0.027
	Mesial	80.50	4.91	75.00	2.03	2.314	0.049
	Distal	80.40	4.95	74.30	2.36	2.485	0.038
	Occlusal	79.60	4.17	74.20	2.66	2.439	0.041
T3	Buccal	87.20	5.65	76.80	1.25	4.016	0.004
	Lingual	85.90	5.22	75.30	1.99	4.240	0.003
	Mesial	86.30	5.95	75.40	2.04	3.872	0.005
	Distal	85.30	6.43	74.50	1.77	3.622	0.007
	Occlusal	83.60	4.08	73.50	2.26	4.837	0.001

SD: standard deviation; p: P value for comparing between the studied groups. Statistically significant at $p \leq 0.05$

No decrease was observed, but there was a notable increase in the Novaloc group.

This can be explained by the fact that the bone-implant contact ratio (BIC) is not 100% even after the healing phase is finished, which can take several months, and functional loading of dental implants has been demonstrated to increase the BIC value.[4] Therefore, osteointegration, as a biological process associated with bone remodeling, continues and does not end during the healing phase. Additionally, this process suggests that osseointegration may increase over time as a site specific bone adapts to mechanical loads.[4,8]

In other words, when the implants are exposed to pressure and tension, this causes bone gaps and reconstruction that are affected by the intensity of the forces applied and the ability of the bone to rebuild. Therefore, the attachments distribution along the body of the implants will contribute to the application of forces within the limits of the bone's tolerance while the implants stabilize and support the dentures during function.[1,7]

Since the type of denture in this study is retained by two separate implants with a good prognosis,[12,13] efforts will be distributed between them and the alveolar bone.[14,15] According to El-Anwar et al.,[16] whose study employed finite element analysis, the Locator attachment model showed a 9% reduction in Von Mises stress on overdentures and 99% less deformation in caps, implants, cortical bone, and cancellous bone than in the ball attachment model. The Locator attachment model also had a longer cap lifespan and more time between maintenance sessions, while Taha[9] showed that the overdenture material's flexibility played a significant role in distributing the load stress and deformation of the underlying structure. The bone received around 8–10% more stresses with the more rigid PEEK Novaloc matrix than with the Locator system, but this was within physiological limits. The Locator attachment's nylon cap has a cooling effect that releases and absorbs vertical stresses. However, under oblique loading, the flexible caps of the Novaloc system will decrease stress. This may be why the values of implant stability aligned in both groups during the first periods of monitoring, while the discrepancy became clear during the last monitoring period. As noted in previous studies,[17] this could because the nylon in the Locator is subject to wear and losing some of its elasticity and retentive ability; as a result, the stress absorbing effect of the nylon decreases with time, while the Novaloc continues functioning.[18,19] In other words, the bone remodeling process in the Novaloc system is superior to that in the Locator system in the long term as it may increase osseointegration and implant stability.

Within this study's limitations, which include the number of implants and the observation period, the following can be concluded: implant stability was significantly better in the Novaloc group than in the Locator group. For future studies, recommendations include conducting additional research on this topic with a wider range of patients and longer observation times.

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