Original Article

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Comparison Between Primary and Secondary Implant Stability of Hybrid Versus Resorbable Blast Media (RBM) Surfaces Using Resonance Frequency Analysis: Randomized Controlled Trial

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Author`s Contribution

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ABSTRACT

Objective: To compared the primary and secondary stability of implant surfaces made of Resorbable Blast Media (RBM) and Hybrid, sandblasted & acid etched (SBA).

Methodology: This randomized controlled trial (registration number NCT06620315) was conducted in the Department of Prosthodontics at the Institute of Dentistry, CMH Lahore Medical College from June to December 2023. A total of 60 patients were randomly assigned to two groups using the lottery method: Group 1 received Hybrid-SBA implants, and Group 2 received RBM implants. Primary implant stability was measured using resonance frequency analysis (Osstell Mentor) at the time of implant placement, and secondary stability was assessed 12 weeks postoperatively. All implants were placed using a non-submerged technique. A chi-square test was applied to compare RFA scores for primary and secondary implant stability between the two implant types.

Results: Results indicated that Hybrid-SBA implants had higher primary (74.33 ± 3.51) and secondary (75.03 ± 3.00) stability compared to RBM implants (primary: 69.20 ± 4.44, secondary: 71.07 ± 3.98). The mean age of patients in the SBA group was 30.7 years (SD = 6.75), while in the RBM group, the mean age was 31.2 years (SD = 6.23). Although statistically significant differences were not found overall, secondary stability was significantly higher in females with Hybrid-SBA implants.

Conclusion: The findings suggest that Hybrid-SBA implants may offer superior stability, likely due to their rougher surface enhancing osseointegration. This study provided insights into the potential long-term success of different implant surfaces, emphasizing the importance of surface treatment in dental Implantology.

Keywords: Dental implants, Implant stability, Resonance frequency analysis, Osseointegration.

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Introduction

Dental implants have completely revolutionized the dental profession because they offer a dependable way to replace missing teeth. The results for patients with missing teeth have greatly improved as a result of their effective integration into the dental office. The durability of dental implants, a crucial component of the surgical procedure, is largely responsible for their success. The amount and biomechanical characteristics of the bone tissue surrounding the implant determine its stability.[1] The stability of the implant during the osseointegration process and at the moment of insertion are two critical factors affecting implant life.[2]

Osseointegration is described as a direct structural and functional connection between living bone and the surface of a load-bearing implant, a concept originally introduced by Brånemark et al.[3] In order to find clinical proof of successful osseointegration and implant survival, Albrektsson and colleagues developed generally recognized standards for evaluating implant success. There are two phases of osseointegration: primary and secondary.[3] When the implant is positioned within the bone tissue, primary stability is achieved. Primary stability is influenced by various factors, including drilling method, implant type, length and width of implant, and bone density. Achieving strong primary stability improves the dependability of immediate and early loading and is essential for the long-term success of implants.[4]

Subsequently, secondary stability is impacted by the implant surface and wound healing time and is dependent on bone development and remodelling at the implant-bone contact.[5] By means of bone remodelling and regeneration, secondary stability offers biological stability. Crucially, the degree of initial stability attained influences secondary stability. Determining the state of osseointegration requires constant, quantitative monitoring of implant stability. The accuracy and dependability of conventional techniques like the Periotest and the Dental Fine Tester have been questioned.[3] Radiographs, the sensation of the surgeon, insertion torque (cutting torque analysis), seating torque, reverse torque testing (RTT), percussion testing, impact hammer method, implant mobility checker, pulsed oscillation waveform (POWF), resonance frequency analysis (RFA), and ultrasound technique are some of the more recent techniques.[6] As a non-invasive diagnostic method for assessing implant stability, RFA has grown in ~~favor~~ among these. For this, the Osstell® resonance frequency analysis system—in particular, the Osstell Mentor®—has emerged as the go-to tool. This device converts kHz data into Implant stability Quotient values, acting as an electronic tuning fork.[4] When Lazzara et al. evaluated the primary stability of acid-etched and smooth titanium implants, they discovered that the former had a primary stability of 73% while the latter had a primary stability of 34%. For smooth titanium implants, the secondary stability was 54%, but for acid-etched implants, it was 93%.[6]

There are few clinical research and inconsistent findings from the studies that are currently available on the primary and secondary implant stability. Thus, against this background, the goal of the current clinical investigation was to use the Osstell Mentor device to examine the primary and secondary stability of Hybrid, Sand blasted and acid-etched (SBA) implants and Resorbable Blast Media (RBM) implant surfaces, both at early loading and three months later. In order to better understand long-term implant performance, the study sought to determine which implant surface yields the best results.

Methodology

This randomized controlled trial was conducted in the Department of Prosthodontics at the Institute of Dentistry, CMH Lahore Medical College from June to December 2023, following the acquisition of ethical approval from the Ethical Committee of CMH Lahore Medical/ Dental College (reference number: 23/1207/61D). A sample size of 60 implant sites (30 in each group) was calculated based on a 95% level of significance and 80% power, assuming an expected primary stability rate of 73% in Group 1 and 34% in Group 2. Implants were primarily placed in the posterior maxilla using the osteotome sinus floor elevation technique. However, additional implant sites across the maxilla and mandible were included to evaluate anatomical variation in implant stability. A simple random sampling technique was used. The randomized controlled trial was registered with National Institute of Health clinical trial registry (Registration number: NCT06620315)

The inclusion criteria included patients of both genders aged between 20 and 50 years, who were suitable for implant supported restorations based on CBCT diagnosis. Suitability was determined by bone height of at least 12mm, bone width of at least 5mm, and adequate proximity to vital structures (nerves, blood vessels). The exclusion criteria included patients with diabetes, Parkinson's disease, myasthenia gravis, or bulbar palsy, conditions linked to emotional stress or impairing mental health (e.g., depression, anxiety, sleep disorders), poor oral hygiene, severe parafunctional habits (e.g., clenching, bruxism), heavy smoking, those who had undergone radiotherapy or chemotherapy, osteoarthritis, osteoporosis, or those taking bisphosphonates.

The patients presenting to the Institute of Dentistry were examined in the general OPD. Those meeting the inclusion and exclusion criteria were referred to the Prosthodontics department. After obtaining a detailed history, complete oral examination, and informed consent, patients were randomly assigned to two groups using the lottery method. Group 1 received Hybrid SBA implants, while Group 2 received RBM implants.

Implant primary stability was measured using a resonance frequency analyzer (Osstell Mentor) at the time of implant placement and after 12 weeks postoperatively to assess secondary stability. Each implant was fitted with a standardized abutment (Smartpeg) of fixed length. The transducer probe was aimed at the small magnet on top of the Smartpeg at a distance of 2-3 mm in both buccal and lingual directions, and the mean ISQ value was calculated. ISQ1 was evaluated immediately during initial implant loading (primary stability), and ISQ2 was evaluated after 12 weeks of implant placement (secondary stability). The implant fixtures used were DIO UF II for the Hybrid implants and the Osstem TSII plus system for the RBM implants. Data were stratified for age, gender, and implant site to address the effect modifiers.

All implants were placed using a non-submerged technique. Under local anaesthesia, a full-thickness mucoperiosteal flap was raised to expose the underlying alveolar bone. The surgical template was positioned, and the implant position was marked in the crestal bone using a round bur attached to a straight hand piece. Osteotomy was carried out using osteotomy drills, and the implant was then driven into the prepared implant bed.

Data were analyzed using SPSS 23. A chi-square test was used to compare the primary and secondary implant stability between Hybrid and Resorbable Blast Media implants. A p-value of <0.05 was considered significant for hypothesis testing. Data were stratified by age, gender, and implant site. Mean values were calculated for age, and frequencies and percentages were calculated for gender and implant site.

Results

The study included a total of 60 patients, with 30 patients in each group who reported to the department for implant placement. The mean age of patients in the SBA group was 30.7 years (SD = 6.75), while in the RBM group, the mean age was 31.2 years (SD = 6.23). In both groups, the majority of the participants were female, comprising 70% of the SBA group and 76.7% of the RBM group. The mean primary stability score for the SBA group was 74.33 ± 3.51, compared to 69.20 ± 4.44 for the RBM group. The mean secondary stability score in the SBA group was 75.03 ± 3.00, while in the RBM group, it was 71.07 ± 3.98. Table I

Table I: Descriptive statistics of study.

	SBA	**RBM**
Age, Mean (SD)	30.7 (6.75)	31.20 (6.23)
Gender	Number (%)	
Male	9 (30%)	7 (23.3%)
Female	21 (70%)	23 (76.7%)
Stability		
Primary stability (ISQ1)	74.3 (3.51)	69.2 (4.44)
Secondary Stability (ISQ2)	75.0 (3.00)	71.0 (3.98)

In the study, primary implant stability was observed in 96.7% (29 out of 30) of cases in the SLA group and 90% (27 out of 30) in the RBM group. The difference between these groups was not statistically significant (p-value > 0.05). Regarding secondary implant stability, 100% (30 out of 30) of cases in the SLA group and 90% (27 out of 30) in the RBM group achieved stability, with no statistically significant difference between the groups (p-value > 0.05). Table II

Table II: Comparison of primary and secondary Implant stability in Type of Implant surface with respect to age group (years).

Age group (Years)	**Primary implant stability**	**Type of implant**		**p-value**
		SLA	**RBM**	
20-34	Yes	21 (95.5%)	16 (88.9%)	0.433
	No	1 (4.5%)	2 (11.1%)	
35-50	Yes	8 (100%)	11 (91.7%)	0.402
	No	0	1(8.3%)	
	Secondary implant stability			
20-34	Yes	22 (100%)	17 (94.4%)	0.263
	No	0	1(5.6%)	
35-50 years	Yes	8 (100%)	10 (83.3%)	0.224
	No	0	2(16.7%)	

When analyzed by age groups, among participants aged 20-34 years, 95.5% (21 out of 22) in the SLA group and 88.9% (16 out of 18) in the RBM group achieved primary implant stability. In the 35-50 years' age group, 100% (8 out of 8) in the SLA group and 91.7% (11 out of 12) in the RBM group achieved primary implant stability. There was no statistically significant difference in primary implant stability between the SLA and RBM groups in both age ranges (p-value > 0.05). Table II

Among male participants, primary implant stability was achieved in 88.9% (8 out of 9) of cases in the SLA group and 91.3% (21 out of 23) in the RBM group. Among female participants, 100% (21 out of 21) in the SLA group and 85.7% (6 out of 7) in the RBM group achieved primary implant stability. There was no statistically significant difference in primary implant stability between the SLA and RBM groups for both genders (p-value > 0.05). Table III

Table III: Comparison of Primary Implant stability in Type of Implant surface with respect to gender.

Gender	Primary implant stability	Type of implant SLA	Type of implant RBM	p-value
Male	Yes	8 (88.9%)	21(91.3%)	0.833
	No	1 (11.1%)	2 (8.7%)	
Female	Yes	21(100%)	6 (85.7%)	0.078
	No	0	1 (14.3%)	
Secondary implant stability				
Male	Yes	9 (100%)	22 (95.7%)	0.525
	No	0	1(4.3%)	
Female	Yes	21 (100%)	5 0(71.4%)	**0.011***
	No	0	2 (28.6%)	

Among male participants, secondary implant stability was achieved in 100% (9 out of 9) of cases in the SLA group and 95.7% (22 out of 23) in the RBM group. There was no statistically significant difference between the groups for male participants (p-value > 0.05). Among female participants, 100% (21 out of 21) in the SLA group and 71.4% (5 out of 7) in the RBM group achieved secondary implant stability. The frequency of secondary implant stability was statistically higher in the SLA group compared to the RBM group among female participants (p-value < 0.05). Table III

Table IV presents the comparison of primary and secondary implant stability between different implant surface types and implant sites. In the SLA group, primary implant stability was achieved in 66.7% of cases in the anterior mandible site and 100% of cases in the anterior maxilla, posterior maxilla, and posterior mandible sites. In the RBM group, primary implant stability was achieved in 100% of cases at all sites except the posterior maxilla, which had an 83.3% success rate. Regarding secondary implant stability, the SLA group achieved 100% stability across all sites. In the RBM group, 100% secondary implant stability was observed in the anterior mandible and anterior maxilla sites, while the posterior maxilla and posterior mandible sites achieved 91.7% stability.

Table IV: Comparison of Primary and Secondary Implant stability in Type of Implant surface with respect to Implant site.

Implant site	Primary implant stability	Type of implant SLA	Type of implant RBM	p-value
Anterior mandible	Yes	2 (66.7%)	0 (0%)	0.248
	No	1(33.3%)	1(100%)	
Anterior maxilla	Yes	9 (100%)	5 (100%)	-
	No	0	0	
Posterior maxilla	Yes	9 (100%)	10 (83.3%)	0.198
	No	0 (%)	2 (16.7%)	
Posterior mandible	Yes	9(100%)	12(100%)	-
	No	0	0	
secondary implant stability				
Anterior mandible	Yes	3(100%)	0	-
	No	-	-	
Anterior maxilla	Yes	0	1(100%)	0.046
	No	9 (100%)	5 (100%)	
Posterior maxilla	Yes	9 (100%)	11 (91.7%)	0.375
	No	0	1 (8.3%)	
Posterior mandible	Yes	9(100%)	11(91.7%)	0.375
	No	0	1(8.3%)	

Discussion

Since its inception, the implant placement technique has been the subject of extensive research. Research indicates that it is an effective surgery that can offer patients substantial advantages. The success of implant therapy can be influenced by a variety of elements, but the two most crucial ones to take into account are probably those linked to the patient and the implant.[7] One of the many desired results for physicians in implant surgery is primary stability, which is said to primarily depend on implant macro geometry and bone density.[8] However, to guarantee implant success and attain the best possible aesthetic results, meticulous planning and case selection are essential.[9] The immediate loading of dental implants causes a noticeable biological reaction in both soft and hard tissues. After implantation, threaded implants are thought to provide the best mechanical stability. Implant-to-bone contact, stability, and osseointegration are believed to be improved by the use of tapered implants and increasing lateral bone compression during drilling.[10-12]

It has been mentioned that RFA offers a quantitative and qualitative way to assess the stability of different implant kinds and look at how they behave in various loads and bone scenarios.[13-15] RFA does have certain drawbacks, though, namely its insensitivity to the condition of the surrounding bone.[16-18] The surface treatment of the implant might also affect its primary and secondary stability. SBA and RBM surfaces are two popular treatments. While RBM, an alternative to bioincompatible alumina blasting, uses Hydroxyapatite (HA) blasting and soft etching of the implant surface, SBA uses micro-grit sandblasting to produce a rough surface.

In the present study, data stratified by age showed no statistically significant difference in implant stability between the SBA and RBM groups. Among participants aged 20-34 years, 95.5% in the SBA group and 88.9% in the RBM group achieved primary implant stability, while 100% in the SBA group and 94.4% in the RBM group achieved secondary implant stability. For the 35-50 years' age group, primary implant stability was achieved by 100% in the SBA group and 91.7% in the RBM group. Secondary implant stability was observed in 100% of cases in the SBA group and 83.3% in the RBM group.

Gender-based analysis revealed no statistically significant difference in primary stability between the SBA and RBM implant surfaces. This finding is consistent with previous studies that reported no significant gender-based differences in primary stability between SBA and RBM surfaces.[17,18] Ostman also found no difference in primary implant stability with respect to gender. However, the present study noted greater secondary implant stability in females compared to males, aligning with findings from Valencia University, Spain.[21] This contrasts with other studies that reported higher implant stability in males than females, attributing the lower stability in females to postmenopausal bone density reduction.[22] Balshi et al. reported higher implant stability in males at placement, with no significant difference observed at a 90-day follow-up. Long-term studies have generally reported no significant relationship between gender and implant stability[22] Long-term studies have reported that there is no significant relation between gender and implant stability.

When data were stratified by implant site, no statistically significant differences in primary and secondary implant stability were found between the surface-treated groups. This contrasts with a study by Barewal et al., which reported higher implant stability in the mandible compared to the maxilla, likely due to differences in bone quality.[23] Consistently, the literature suggests that the maxilla typically has lower quality bone, affecting implant stability.[24]

Finally, the study found that SBA-treated implants had better primary and secondary stability compared to RBM-treated implants. This finding is consistent with other studies that have shown SBA surfaces offer stronger osseointegration due to their moderately rough surface. For instance, Abrahamsson et al.[25] reported that SBA surfaces provide better implant stability than RBM surfaces.[25] Elkhaweldi et al.[18] noted that the rougher SBA surface compensates for poor bone quality, potentially increasing survival rates during the initial months of osseointegration. Jeong et al.[26] attributed the superior stability of SBA-treated implants to their uniform roughness and increased surface porosity, which reduces the time required for bone integration

Limitation of the Study: The small sample size, and sample recruitment from a single urban-based hospital using a nonrandomized technique limited the generalization of findings to the whole population.

Strength of the Study: These findings are important in predicting the possible impact of CD treatment in terms of patient well-being and can apply to other under-developed populations with similar socioeconomic and demographic characteristics like the Pakistani population.

Conclusion

According to the study's limitations, the primary and secondary implant stability of SBA-treated surfaces is superior to that of RBM-treated surfaces. The consistent roughness and increased surface porosity of the SBA-treated implant surface appear to be superior because they shorten the time it takes for bone to integrate. In comparison to the less rough RBM surface, the rougher SBA treated surface had a compensatory impact in locations with poor bone quality through enhanced bone-implant contact, which may increase the survival rate.

Future Recommendations: The principal predictor variables influencing primary and secondary stability should be the subject of clinical trials in the future, perhaps multicentric, in order to make more definitive claims using larger samples, a greater range of implant dimensions (diameter and length), and a longer follow-up time.

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