SP-30

Efficiency Of Customized Connectors In Evaluatingmini Implant Stability Using Resonance Frequency Analysis – An In Vitro Study

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Abstract: Mini-implant stability depends on primary stability followed by a consolidating period of secondary stabilization and to determine primary stability a non-invasive,clinically efficient modality is required. Torque measurements are effective only during insertion and removal of implants hence it is not efficient in measuring implant stability during treatment.Resonance frequency analysis (RFA) effectively and non-invasively measures the stability of mini-implants as and when desired .The only disadvantage is RFA device cannot be used effectively as a chair side procedure as it warrants the use of connector to establish a stable coupling between the device and implant head. The objective of the study was to design customized connector that aids in using RFA as a chair side routine procedure to evaluate prognosis of mini-implants.16 mini-implants (1.5 * 8 mm - Bioray) were inserted in fresh goat mandible . The Osstell™ Mentor device for RFA was used which demands stable coupling between SmartPeg transducer and the mini implant .Hence a stainless steel connector was manufactured that snugly fits to the miniimplant head on one side and screw type attachment for SmartPeg on the other . RFA and Periotest were performed parallel and perpendicular to bone fibers.The mean ISQ value for RFA 63.25+/-10.25 , and Periotest was 1.53+/-2.39 . Differences between the two directions of measurement were statistically significant ($P < 0.001$) and high correlation ($r = -0.939$) was established for RFA and Periotest.Results concluded that customized connector was efficient in measuring the resonance frequency and can be used as routine chair side aid to assess miniimplant stability.

Keywords: Implants, Resonance frequency, Connectors, Periotest.

INTRODUCTION

Orthodontic mini implants play anintegral role in augmenting anchorage for orthodontic tooth movement. The success of mini implants depends on primary stability followed by a consolidating period of secondary stabilization. Hence, primary stability is regarded as the key indicator of success and varies according to bone quality, implant material, cutting edge design, and clinical factors[1,2]. In order to ensure the success of mini implants and its primary stability, a non-invasive,reliable and clinically efficient modality is required . There are different methods to measure the stability of mini implants. The most widely reported approach is measurement of maximum insertion and removal torque for which precise torque sensors are required .While these torque sensors are effective only during insertion and removal of the implants,Resonance frequency analysis (RFA) stands out by being effective in measuring the stability of mini implants as and when desired . During RFA a small bending force is applied to an implant through a transducer (SmartPeg)[3].The only disadvantage is thatwhen a detection device (Osstell ™ Mentor instrument) is used for resonance frequency analysis (RFA), stable coupling between the SmartPeg transducer and implant is required. A transducer suitable for the size and structure of a particular mini implant may be difficult to obtain. Hence this niche has been filled by a customized connector that has been designed for both orthodontic mini screw and smartpeg making it possible to measure the resonance frequency chair side at frequent intervals. In this study, the customized connector is made for a commercially available mini-implant. The main advantage of RFA over traditional methods such as torque assessment is the ability to perform measurements without changing or disrupting the mechanical characteristics of the bone-implant interface.[4]

AIM

To design a customized connector that aids in using RFA as a chair side routine procedure to evaluate the prognosis of mini implant

MATERIALS AND METHODS

A total of 16 (N= 16) orthodontic titanium micro-implants of size 1.5 mm diameter and 8 mm length from Bio ray(Fig 1)were tested .

FIG I
(IMPLANT)

Fresh goat mandibles were used for testing as an experimental model as there is a similarity of micro anatomical dimensions between the goat and human mandibles, making it more suitable for many implant experiments concerning biomechanical testing5.Eight fresh goat mandibles without any overt osseous pathology were used for this study. The collected mandibles were kept refrigerated until use. The miniscrews were placed 5mmbelow the cement enamel junction in the posterior region(Fig 2).

FIG 2
(Fresh goat mandible)

The miniscrews were inserted manually until full engagement of thread. Feeling the final resistance of bone during insertion was considered as the indicator for primary stability .The Osstell TM Mentor instrument (Fig 3) a commercially available device for resonance frequency analysis was used.

FIG 3
(Osstell Mentor instrument)

None of these systems had aconnector for performing resonance frequency analysis with the OsstellTM Mentor Resonance Frequency Analysis device. Hence, a stainless steel connector has been manufactured and customized for commercially available miniimplant –BIORAY. It snugly fits to the mini implant head on one side and a screw type attachment for the SmartPeg transducer on the other (Fig 4).

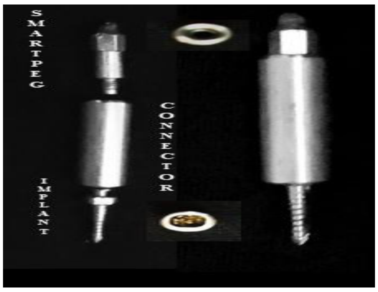
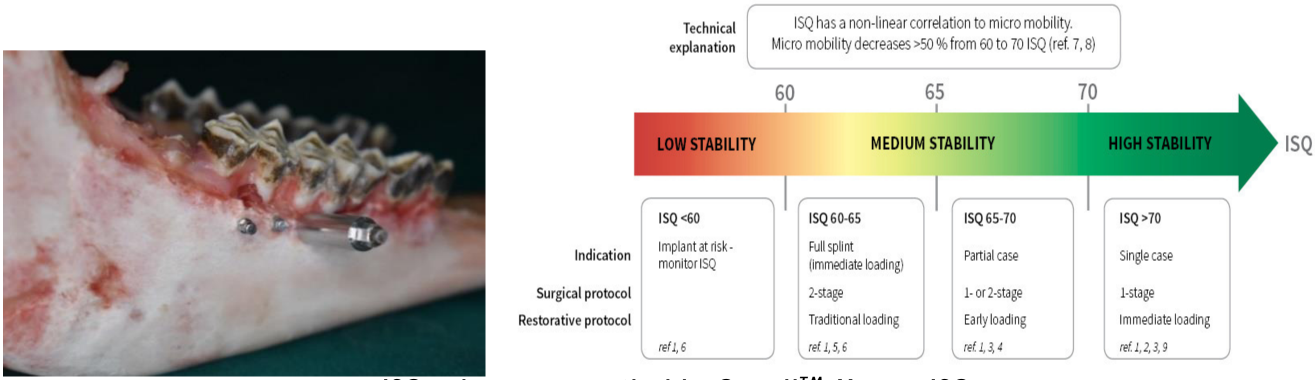


Fig4
(stainless steel connector)

The mini-implants were inserted into fresh goat mandible without osseous pathology and RFA was carried out using the custom made connector to check its efficiency. The smart peg was finger tightened on the connector (Fig 5) and oriented perpendicular to the bone.Periotest values were recorded as there is high correlation established between RFA and periotest[4].Periotest, was performed and compared with RFA to ensure that the connector does not interfere with the RFA results.[6]



ISQ values as prescribed by Osstell™ Mentor ISQ (Integration Diagnostics AB, Goteborg, Sweden)

FIG 5
(smart peg connector)

The resonance frequency is the peak of the amplitude-frequency plot received from the transducer, and it can be conveniently read on the display of the device. The Osstell TM Mentor transforms resonance frequencies into implant stability quotients from 0 to 100 , with higher values indicating higher stabilities(Fig 5). RFA was performed (Fig 6) parallel and perpendicular to the surface of superficial bone . ISQ values (Fig 7)were measured three times parallel to the superficial cortical fibers of the goat bone and afterward three times perpendicular to it.Similarly,Periotest was also performed in the same directions.For analysis, the arithmetic mean of RFA and periotestvalues of each direction and the overall mean values for micro-implant were calculated.

FIG 6
(RFA performed in goat mandible)

FIG 7
(periotest)

STATISTICAL ANALYSIS

The statistical analysis was done using the SPSS software (Version 22)." Data were tabulated in an excel sheet and descriptive statistics (mean,standard deviation) are summarized in table 1. Pearson correlation test between Periotest and RFA showed correlation coefficients of r = - 0.939 (Table 2).

TABLE 1

	V2-RFA HORIZONTAL	V3-RFA VERTICAL	V4-RFA MEAN	V5-PERIOTEST HORIZONTAL	V6-PERIOTEST VERTICAL	V7 – PERIOTEST MEAN
N valid	16	16	16	16	16	16
Missing	3	3	3	3	3	3
Mean	63.25	63.25	63.25	1.50	1.56	1.53
Std.Deviation	10.555	9.983	10.258	2.633	2.190	2.398
Skewness	-1.988	-1.915	-1.960	1.052	0.992	1.050
Std.Errorof skewness	0.564	0.564	0.564	0.564	0.564	0.564
Minimum	35	37	36	-2	-1	-2
Maximum	74	74	74	8	7	8

TABLE 2

		V2-RFA HORIZONTAL	V5-PERIOTEST HORIZONTAL
V2	Pearson correlation	1	-.955**
	Sig.(2-tailed)		.000
	N	16	16
V5	Pearson correlation	-.955**	1
	Sig.(2-tailed)	.000	
	N	16	16

*****correlation is significant at the 0.01level(2-tailed)***

		V3- RFA VERTICAL	V6- PERIOSTAT VERTICAL
V3	Pearson Correlation	1	-.900**
	Sig.(2-tailed)		.000
	N	16	16
V6	Pearson correlation	-.900**	1
	Sig(2-tailed)	.000	
	N	16	16

*****correlation is significant at the 0.01level(2-tailed)***

		V4- RFA MEAN	V7- PERIOTEST MEAN
V3	Pearson Correlation	1	-.939**
	Sig.(2-tailed)		.000
	N	16	16
V6	Pearson correlation	-.939**	1
	Sig(2-tailed)	.000	
	N	16	16

*****correlation is significant at the 0.01level(2-tailed)***

RESULTS

Both RFA using the connector and the periotest device showed uniform results which indicated that the connector did not interfere with the RFA results. The mean ISQ value was 63.25 with a standard error of 10.25. Periotest measurements showed mean values of 1.53 with a standard deviation of 2.39. The differences between the two directions of measurement were statistically significant ($P < 0.001$) for RFA and the Periotest.

DISCUSSION

Treatment success using implants depends mainly on its primary stability. To ensure primary stability of the mini-implants, implant design and insertion protocol are the factors to be considered .Insertion and removal torque are few widely used methods to assess the implant stability. The disadvantage in measuring the insertion and removal torques are that during the healing phase or loading, the stability of the mini-implant is subject to change because of the remodelling processes.[7]Hence,assessing the primary stability in every phase of treatment is important to ensure the longevity and durability of the mini-implants. Resonance frequency analysis is a standard method to assess the implant stability as and when required during the treatment phase hence can be considered superior over the above-mentioned methods. The initial pilot studies regarding RFA for mini-implants used adhesive fixation of a magnet to the mini-implant's head.[8] Uysal T in 2010 [9]modified the mini-implant with an external screw head. The method was reliable for stability measurements yet it had limited clinical efficiency as the design failed to engage attachments for orthodontic tooth movement. Veltri et al[10] in 2009 evaluated the primary stability of three different mini-screws using resonance frequency analysis.The author soldered an abutment on the mini-implant head and a L-shaped transducer screw was finger tightened on the abutment and oriented with its cantilever beam perpendicular to the bone.The author customized the abutment and the L-shaped transducer. Resonance frequency is the peak of amplitude frequency plot received from the transducer.Seperate modifications of the miniscrew head and customization of the transducer screw were done for measuring the resonance frequency. Effective application of this technique in a clinical scenario is questionable as it is time consuming,technique sensitive and involves complex laboratory procedures. Niekumper et al[6]in 2013 evaluated mini-implant stability using resonance frequency analysis. He used specially designed mini-implants with the head possessing an inner screw thread. The design aided in establishing a stable connection between implant and the tranducer head.Different kinds of connector can be screwed onto the head. Hosein et al in 2019[11]developed an adopter for attachment of Osstell's SmartPeg onto a variety oforthodontic mini-implants. The Mini-implant smart peg adaptor(MISPA)can be secured onto various implant designs by clamping onto the implant head and a smartpeg was attached on top of the MISPA via a screw mechanism. The connecting screw had smart peg threaded on one side inserted through the MISPA device and the other end of the screw contacted the mini-implant head and it was tightened. The study was performed in a synthetic bone block and results were obtained. The measurements obtained from novel mini-implant adaptor agreed with those obtained using a conventional SmartPeg attachment. The main disadvantage with MISPA is that the screw component contacts the implant head which in itself might alter the primary stability. In addition, placing the MISPA device in a patient is technique sensitive and the associated soft tissue factors involved in a patient has a negative influence on the fit and stability of MISPA. Hence, considering the above factors this technique cannot be validated in a day-to-day clinical practice. The main rationale of this study was to interlink the implant head to the smart peg using a connector which by itself should not interfere with the mini-implant stability and to overcome the other disadvantages of previously available connector designs. The study aimed at achieving effective, chair side clinical assessment of primary stability using RFA. The connector was designed for commercially available mini-implants such as Bioray and Dentos and it was custom-made to the diameter of implant for secure coupling to the mini-implant head.The design accepted smart peg threads on one side and snugly fit on the mini-implant head on the other.1.5*8mmBioray and Dentos implants were placed in fresh goat mandible .RFA measurements were made using the Ostell Mentor ™ device with the help of the customized connector. Periotest is efficient in detecting early implant failure.[12,13]There is a high correlation that is established between RFA and Periotest for dental implants.[14,15]Especially in in-vitro, the results are accurate and reliable because of the perfect handpiece angulation.Hence, periotest was also carried out to check the efficieny of the customized connector device. Periotest and RFA measurements were made in both parallel and perpendicular directions and the mean was calculated.The mean ISQ value for RFA 63.25+/-10.25 , and Periotest was 1.53+/-2.39 . The differences between the two directions of measurement were statistically significant ($P < 0.001$) and high correlation($r = -0.939$) was established for RFA and Periotest. The findings of this study suggest the potential to use the novel connector with the Osstell device for clinical assessment of mini-implant stability. Osstell ISQ device can be considered for a routine use in clinical practice. Further studies are required to validate the results for clinical applications.

CONCLUSION

The connector was found to be efficient in measuring the resonance frequency which can be used as routine chair side procedure to assess primary stability. Hence a connector can be customized and manufactured for commercially available implants similar to an implant driver which can effectively aid in measuring the clinical stability. With the results that we achieved on cadaveric goat mandibles, application on human jaws has to be performed to evaluate its clinical benefits.

CONFLICT OF INTEREST

Conflict of interest declared none.

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