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Research Article

PROSPECTIVE CRITICAL ANALYSIS OF IMPLANT OSSEOINTEGRATION BY DIFFERENT METHODS OF IRRIGATION - AN IN-VIVO AND IN-VITRO STUDY

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A B S T R A C T

Purpose: To analyse the difference in heat generation by different methods of irrigation while osteotomy preparation of dental implants and its clinical implications on osseointegration.

Material and Methods: Goat's mandibles were used to evaluate heat generated during bone preparation for placing dental implants. Osteotomy was prepared using two different methods of irrigation (group I internal and external irrigation system, and group II external irrigation system). Temperature was measured using a thermocouple attached to the bone at different length from the alveolar ridge. Based on observations of in vitro study, an in vivo study was carried out. 30 patients with partial edentulism were clinically & radiologically assessed for implant osseointegration when osteotomy was prepared using same clinical settings as that of in-vitro study.

Results: No significant difference ($p>0.05$) was observed on comparing the efficacy of different cooling systems on implant osseointegration.

Conclusion: Internal & external cooling system cumbersome to sterilize and expensive. External irrigation system on the other hand has same efficacy as the other system and is comparatively user friendly, therefore external irrigation system is a better modality to control bone temperature during osteotomy preparation for dental implants.

INTRODUCTION

The use of dental implants to provide support for replacement of the missing teeth has become an important component of modern dentistry. The success of osseointegrated dental implants has revolutionized dentistry.[1] Bone is very susceptible to heat. Heat is generated by the drill during implant osteotomy.[2] A major method to reduce the bone temperature during drilling is the use of cooled irrigation. The time during which bone is prepared is also a factor related to bone trauma. Additional factors such as drill speed and internal versus externally cooled drill are also important.[3] Regardless of implant design or manufacturer, several surgical concepts are crucial for initial rigid fixation. Lavelle has shown, heat generated from a drill can be transmitted more than 3mm away from the site and reach temperature over 50°C under copious irrigation.[4] Eriksson has demonstrated that at temperature of 40°C for 7 minutes or 47°C for 1 min bone death occurs.[5,6] Overheating can be dealt with External and or internal cooling agents, cool saline irrigation, intermittent pressure on the drill, pause after every 3-5 seconds while drilling, using new drills and incremental drilling sequence.[7]

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Purpose of the study

1. To compare the effect of internal – external cooling system and external cooling on healing and osseointegration of an implant.
2. To estimate and compare the amount of pocket formation around implants placed with two different methods of irrigation.
3. To compare and evaluate the marginal bone loss while placing the implants by external and internal-external cooling system.
4. To study the stability of the implant placed after osteotomy done under two different methods of irrigation.

Working hypothesis: Internal and external cooling system when used concomitantly should have better ability to control the temperature while osteotomy preparation for dental implants.

MATERIALS AND METHODS

The implant systems have two mechanisms for attaining the optimum cooling during the osteotomy, one with only external irrigation and the other with internal & external irrigation. The present study was carried out to evaluate the measurable outcomes of both the systems pertaining to the osseointegration and implant stability. As the measurement of temperature difference in a live human bone while preparing

an osteotomy is difficult, it was decided to conduct an in vitro study to measure the temperature changes while making osteotomy using both internal & external irrigation and external irrigation. For the purpose of temperature measurement, a thermocouple was designed with sharp tip, to penetrate monocortical bur holes (**figure 1).** The thermocouple had an inbuilt digital analyzer, which could read temperature from 36 to 100°C. Based on the readings of thermocouple statistical analysis was done using p- test to ascertain as to which system is more effective in terms of controlling the bone temperature below critical levels during osteotomy preparation, in goat's mandible.

Five freshly sacrificed goat's mandibles were prepared for the in-vitro study. Osteotomy preparation on right side of all the mandibles was carried out under internal and external irrigation system and was attributed to group I, whereas in group II all the osteotomies were done with external irrigation system on left side of goat's mandible.

The outer diameter of the osteotomy was marked on the bone at the lower border and 3 mm lateral to the site, longitudinally oriented monocortical serial holes were drilled under copious normal saline irrigation at 3mm, 5mm and 11mm distance from the crest of ridge (Fig 1). Osteotomy for implant placement was done with a bur speed of 1200 revolutions per minute, at controlled room temperature of 23°C by sequential drilling in which bone to drill contact was not more than 30 seconds. Average time required for the complete osteotomy was 3 min and 45sec. Initial temperature of the mandible and the temperature variations during osteotomy preparation were measured by a thermocouple introduced in the monocortical hole at 3mm, 5mm and 11mm, made earlier.

Based on observations of the above mentioned in-vitro study, in vivo study was conducted as an open, prospective study in our department from July 2015-2016 after obtaining the approval from the Institutional ethics committee. Selection criteria were outlined as follows: all the patients requiring replacement of single missing tooth in upper or lower jaw were considered for this study irrespective of their sex, caste & religion, written informed consent was obtained from all participating adult subjects or from parents or legal guardians for minors or incapacitated adults.

The sample size comprised of 26 patients with 30 single missing teeth divided in two groups. Group I, Osteotomy was done using internal and external irrigation system. Group II Osteotomy was done using external irrigation system.
Diagnostic cast & x-ray were obtained preoperatively for all the patients.

1. Preliminary Orthopentomograph & Intra Oral Periapical radiographs were done for all patients to assess the bone density at the edentulous site for implant, any bone loss if present, any periapical pathology, and involvement of furcation of surrounding tooth.
2. Impressions were done to make study models to assess dimension of edentulous ridge both buccolingual width of ridge and mesiodistal width of the ridge, Shape of ridge, Mesial/distal tilt of adjacent teeth if any, Supra-eruption of opposing tooth if present.
3. Study models were mounted & evaluated for factors such as available gap for restoration, occlusion classification, based on which we had decided the implant type and position.

Adin implant system (Adin Dental Implant Systems Ltd., Israel) was used having self tapping, tapered design with Aluminum oxide blasted surface. **(Figure 2.a-2.c)**

The patients were prescribed preoperative antibiotics and anti-inflammatory drugs on the day of surgery, two days prior chlorhexidine 0.2% mouth rinse was prescribed to all patients. Two months after implant placement, second stage surgery for the connection of titanium prosthetic abutment was performed in all the patients. The distance from a fixed reference point which was at highest point on the implant, to the first bone-to-implant contact point was measured using a grid method on 3rd, 6th and 12th month on a standard Intra oral periapical radiograph taken using long cone technique. Clinical examination assessing bone loss, periodontal pocket and clinical stability of the implant in both the groups was ascertained. Implant mobility, erythematous gingiva surrounding the implant, presence of tenderness on percussion, and radiological observation regarding status of peri-implant periodontia were noted at subsequent follow up (figure 2.d-2.f) and were then compared between the two groups using P test to evaluate the significance of the observations. To eliminate bias, and obtain more consistent results, all the observations were made by same clinician.

RESULTS

In the in-vitro study model, we concluded that, while preparing osteotomy there is considerable amount of heat generation. Similar temperature rise in the bone was observed on comparing the efficacy of both the irrigation systems $p>0.05$**.(Table 1)**

Clinical settings in either of the studies were kept constant. Method of irrigation in the study groups were variable but were similar in both the study models. This was done, so that, efficacy of irrigation methods, being the only variable can be evaluated**.(Table 2)**

Following Results were Observed after Comparing the Efficacy of both the Irrigation Methods in the in-vivo study Model

1. All the implants placed in either of the groups were stable at the end 1year.
2. The increase in crestal/marginal bone loss after one year post operatively was 2.06 ± 0.49mm in group I and in group II, it was 2.37 ±1.27mm. These observations are in accordance with the previous studies and there was non-significant difference ($p> .05$) in both the groups. (Table 3)
3. There was no statistically significant difference observed in increase of periodontal pocket depth after one year of follow up period in both the groups i.e. $p> 0.05$. (Table 4)

DISCUSSION

To reduce the thermal bone injury, many techniques have been advocated, such as controlling speed of the burs [8], copious irrigation with different irrigants and different irrigation systems like internal and external irrigation system. [9]

Maximum temperature recorded in the present in-vitro study was 44.5°C with a mean of 43.80±0.57°C in group I and 43°C with a mean of 42.60±0.42°C in group II. We observed that the temperature difference in both the groups was not statically

significant. This is in contrast to the observations recorded by Abdulhameed N Al–Dabag *et al*[10]. they compared temperature difference in bovine femur cortical bone by using cooled and room temperature irrigant at a depth of 15mm. Mohamed Sharawy[8] conducted a similar study to evaluate external and internal irrigation system and effect of drilling speed using different drilling systems on a porcine jaw, he concluded that at 8mm depth mean maximum temperature rise in internal and external irrigation group was significantly less than group in which osteotomy was done using only external irrigation at a speed of 1650 rpm. As the frictional heat generated is directly proportional to the amount of cortical bone negotiated, hence results observed by Mohamed Sharawy[8] differ from that observed by us. Ian C. Benington, Paul *et al*[9]conducted a similar study on a sheep mandible and found that there is no significant advantage of internal cooling when concomitantly used with external irrigation while preparing osteotomy for dental implants. Michael Nogler,*et al*[11]concluded in their study on human hip bone that there is no significant difference in temperature rise when external irrigation system was compared with internal irrigation system, which is in accordance to our study.

Thermal injury to bone leading to fibro-osseointegration compromises the stability of the implant.[5] Such an interface between bone and implant causing undesired mobility increases the sulcular depth around the implants harboring bacterial colonies. Presence of bacterial colonies farther deepens the sulcus causing a periodontal pocket around the implant.[12] Though inadvertent handling of periosteum, during stage I procedure is a common reason for crestal bone loss after implant insertion, progressive deepening of periodontal pock*et al*so favors gradual crestal bone loss.[13] If all these factors are left unchecked, the results can be disastrous as far as success of implant is concerned.

In present study, periodontal pocket depth was measured on all four aspects of implant by William's graduated probe at 3rd, 6th and 12th month post operatively. A mean value was computed for each implant. It was observed that there is no significant difference in pocket depth when implants are placed by different methods of irrigations. Kees Heydenrijk *et al* [14]observed similar results on comparing outcome of implants placed in a single stage with two stage procedures.[14] Critical periodontal pocket depth at the end of 1 year is ≤ 3mm as stated by Rafael Juan Blane *et al*.[15] However, the pocket depth of less than 3mm was observed in both the studies and on long term evaluation, there is progressive deepening of periodontal pocket around implants, which is a common observation in all the studies including the present study.

Overloading, microgap at implant abutment interface, polished implant necks, infection, inflammation, trauma during surgical procedure remain the most common cause of crestal bone loss in implant therapy as mentioned by Montaser N Al Qutub.[16] Jacob Horwitz [17] conducted a study on non loaded implants, he observed similar amount of bone loss as that of the present study after one year follow up. Overall bone loss, after one year of implant placement in the present study was found to be within normal range and non statistically significant difference p>0.05 was observed on comparing the efficacy of either of the systems after 12 months of follow up.

Linish Vidyasagar *et al*[3], observed that implant stability is directly proportional to the bone loss, initial stability of the implant and density of the bone in which implant is placed, similar results were observed in the present study. Corinaldesi *et al*[18], also observed similar implant stability, when implants were placed after bone augmentation procedure.

Dennis Flanagan[19] suggested that no irrigation is required for cooling the osteotomy site while bone preparation. It is long been advised to use irrigation while bone cutting by various authors, moreover irrigation during osteotomy preparation is not going to harm the clinical and surgical site proper and patient as whole, hence to be on the safer side, we suggest that irrigation should be practiced while osteotomy preparation.

Table 1 Temperature difference observed by in vitro study

	Serial Number	Baseline temperature in °C	Temp in °C at 3mm	Temp in °C at 5mm	Temp in °C at 11mm	Mean Temp in °C
Left side. Osteotomy prepared using external irrigation. Group I	1	23	38.5	42.5	44	41.6
	2	23	39	42.5	43	41.5
	3	23	38.5	41	43.5	41
	4	23	38	42	44	41.3
	5	23	38.5	42.5	44.5	41.5
			38.50 ±0.35	42.10 ±0.65	43.80 ±0.57	41.38 ±0.24
Right side. Osteotomy prepared using internal & external irrigation. Groups II	Serial Number					
	1	23	38.5	40.5	42.5	40.5
	2	23	38.5	41	43	40.8
	3	23	38.5	40	42	40.2
	4	23	38	39	43	40
	5	23	39	40.5	42.5	40.6
			38.50 ±0.35 t=0.0; P>0.05	40.20 ±0.76 t=7.36; p<0.0001	42.60 ±0.42 t=6.57; p<0.0001	40.42 ±0.32

Table 2 Distribution according to region and type of irrigation

Region	Group I (n=15)	Group II (n=15)	Total (n=30)
Maxillary anterior	320.0%	426.6%	723.3%
Maxillary posterior	533.3%	426.6%	930.0%
Mandibular anterior	213.3%	106.6%	310%
Mandibular posterior	533.3%	640.0%	1136.6%

Table 3 Comparison of bone loss on consecutive follow-ups in studied type of irrigation

Bone Loss	Group I (n=15)	Group II (n=15)	Significance
At 3rd month	0.81±0.512	1.13±0.535	t=1.174;p>0.05
At 6th month	1.69±0.359	1.92±0.783	t=1.096;p>0.05
At 12th month	2.069±0.4936	2.375±1.2760	t=0.905;p>0.05
Significance	t=7.00;	t=7.31;	
3/6	P<0.0001	P<0.0001	
3/12	t=9.30; P<0.0001	t=5.55; P<0.0001	

Table 4 Comparison of Probing Depth on consecutive follow-ups in studied type of irrigation

Probing Depth	Group I (n=15)	Group II (n=15)	Significance
At 3rd month	2.4856±0.34827	2.7125±0.58644	t=1.365;p>0.05
At 6th month	2.55±0.518	3.01±1.015	t=1.667;p>0.05
At 12th month	2.86±0.758	3.29±0.904	t=1.514;p>0.05
Significance			
3/6	t=0.469; P>0.05	t=2.12; P<0.05	
3/12	t=191; P>0.05	t=4.19; P<0.001	

FIG 1 B Pre Op Frontal View

fig 1 C implant in situ

Fig 1 D Closure

Fig 1.E 3 month post operative radiograph

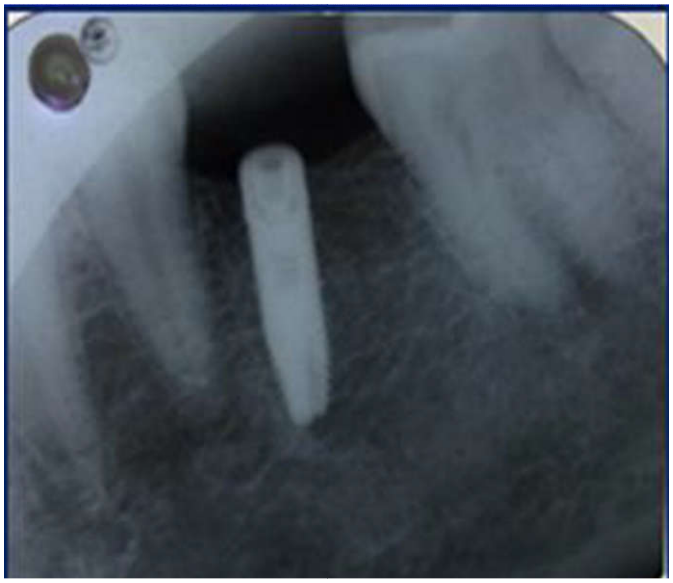

Fig 1.f 6 month postoperative radiograph

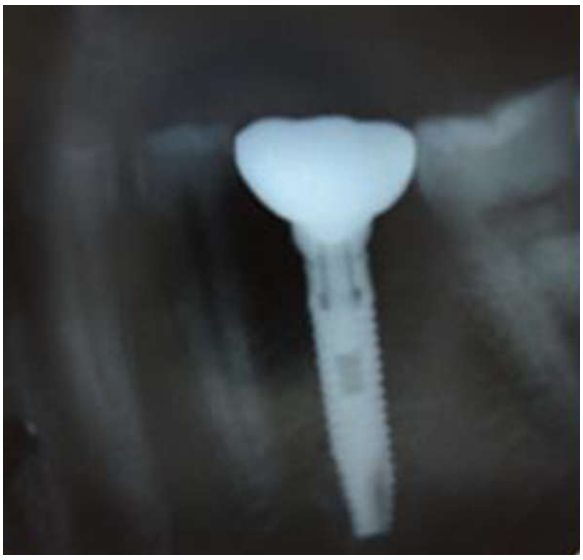

Fig 1.G 12 month post operative radiograph

CONCLUSION

Drills of internal irrigation system are more costly than drills of external irrigation system. External irrigation system has a provision of a jet outlet attached to the hand piece, whereas the burs of internal irrigation system have hollow core and lateral holes between the flutes, in the bur body. During osteotomy preparation, lateral holes usually clog by the bone dust. These drill are difficult to clean owing to their small diameter, hence they add to mechanical difficulty in maintaining drill hygiene, thus jeopardizing its sterilization. For the above mentioned reasons and in lieu of conclusion drawn from the present study, external irrigation system appears to be a better modality for osteotomy preparation. Since external irrigation system provides similar range of heat generation as that of internal and external irrigation system, it is reasonable to use only external irrigation while preparing the osteotomy site for dental implants.

We suggest that, study should be continued farther with a larger sample size and longer follow up period on a multicentric basis to enhance the scope of understanding on heat generation during osteotomy, which is one of the most

important factors related to implant failures in modern day practice.

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