Radio frequency analysis of partially grafted immediate dental implant with and without use of static magnetic field: An *in vivo* study

ABSTRACT

Background: Replacement of missing teeth with dental implants represents one of the most successful treatment modalities in modern dentistry. Patients desire for a shorter treatment time has made clinicians to attempt loading implants early or immediately after placement. The primary stability is determined by density and mechanical properties of the bone, the implant design, edentulous site complications, and the surgical technique.Various researchers have tried to achieve faster osseointegration static magnetic field is one of them. So the aim of this study was to investigate whether Static magnetic field created by using safer magnets was useful to promote osseointegration.

Materials and Methods: Subjects were selected according to the predetermined inclusion and exclusion criteria in two groups (20 in each group). Conventional implant placement protocol was used and implant placement was performed and grafting was done. Magnetic healing cap was used in group I and conventional healing cap in group II. Implant stability assessment using radio frequency analyser was assessed at 2, 3 and 4 months on interval.

Result: Mann-Whitney U test revealed that there was significant difference was observed between the groups I and II at 2, 3 and 4 months of interval ($P < 0.001$). Static magnetic field improve osseointegration in group I as compared to group II.

Conclusion: The present double-blinded RCT showed significantly improved implant stability and osseointegration in implants which were stimulated by static magnetic field by using magnetic healing cap as compared to implants with conventional healing cap.

Keywords: Dental implants, immediate implants, osseointegration, static magnetic field

INTRODUCTION

Replacement of missing teeth with dental implants represents one of the most successful treatment modalities in modern dentistry. The majority of implant loss may be explained as biomechanically induced failures. Low primary implant stability, low bone density, short implants, and overload have been identified as risk factors for low primary stability. Hence, achievement and maintenance of firm implant stability are regarded as preconditions for a successful clinical outcome with dental implants.[1]

Patients' desire for a shorter treatment time has made clinicians to attempt loading implants early or immediately after placement. The application of immediate loading protocols is not possible in all situations because of several biological and mechanical factors. In such situations, if the healing period of 3–6 months could be reduced by

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Akanksha Yadav, Lakshya Kumar[1], Uma Shankar Pal[2], Mayank Singh[1], Madan Lal Brham Bhatt[3], Ranjitkumar Patil[4], Aditi Verma[5]

Departments of OMR and [1]Prosthodontics, Faculty of Dental Sciences, KG Medical University, Departments of [2]Oral and Maxillofacial Surgery, [3]Radiotherapy, [4]OMR and [5]Prosthodontics and Crown and Bridge, KG Medical University, Lucknow, Uttar Pradesh, India

Address for correspondence: Dr. Lakshya Kumar, FODS, K.G.M.U., Lucknow, Uttar Pradesh, India.
E-mail: lakshya79@yahoo.com

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improving implant stability faster, the patients would feel more comfortable and satisfied. Osseointegration is a treatment concept based on stability. The primary stability is determined by the density and mechanical properties of the bone, the implant design, edentulous site complications, and the surgical technique.[2] Secondary stability results after the formation of secondary bone is a biological phenomenon influenced by many factors such as primary implant stability, surgical technique, bone quality, implant configuration, wound healing, implant surface coating, implant length, quality and quantity of occlusal force, and prosthetic design.[3]

Radio frequency analysis (RFA) is a noninvasive intraoral method designed to reflect the bone/implant interface and hence may be useful in documenting clinical implant stability and outcome of implant treatments. This test has been proven reliable for detecting alterations in implant stability during early healing and is sensitive enough to identify differences in implant stability based on bone density at the implant recipient site.[4]

Many researchers have found various methods to fasten osseointegration, and the research is still going on this aspect. Few studies have shown that the static magnetic field fastens the regeneration of bone after the bone is wounded. The mechanisms involved in this faster and improved osseointegration are yet to be confirmed at the cellular level. The static magnetic field has the potency to promote differentiation of osteoblasts and bone maturation directly. The evidence available from biological safety testing suggest that the harmful effects with chronic exposure to magnets are negligible.[5] The aim of this study was to investigate whether static magnetic field created by using safer magnets is useful to promote osseointegration after the implant placement postgrafting. The objective of this study was to comparatively evaluate the stability of the implants which were exposed to the magnetic field and those not exposed to the magnetic field at baseline, 2 months, 3 months, and 4 months interval. All measurements were made by three different examiners.

MATERIALS AND METHODS

The present double-blinded randomized control trial was conducted in the Department of Oral and maxillofacial surgery and Department of Prosthodontics. Ethical approval was obtained from the institutional ethical committee (Registration No.: ECR/262/Inst/UP/2013/RR-16, dated on 28/04/2018). After informing about the details of the study, written informed consent was obtained from all the participants.

The study population consisted of individuals needing implant-supported fixed prostheses for single missing teeth in the mandibular posterior region and fulfilling the predetermined selection criteria. Inclusion criteria for the study were, implant site with the requirement of bone grafting, good oral hygiene with an oral hygiene index of 0.0–1.2, presence of adequate keratinized mucosa, and patient compliance for follow-up visits whereas exclusion criteria were any periodontal disease, any clinical or radiographic signs of infection at the implant site, history of systemic disease that precludes standard dental implant therapy, chemotherapy/radiotherapy, medications that interfere with the study, smoking, drug abuse, alcoholism, and parafunctional habits.

The sample size was statistically calculated using the formula:

$$N = 2X\,(Za/2 + Zb)^2\ X\ P\,(1\text{-}P)/(p1\text{-}p2)^2$$

where (n = sample size per group, P1: Prevalence in Group I, p2: Prevalence in Group II, P: pooled prevalence= (p1 + p2)/2, Za/2: Significance level, Zb = power of the study).

Assuming 80% power, 5% significance level and 95% confidence interval, the sample size per group is 36. Assuming 20% loss to follow-up, the final sample size was total 40 (20 i in each group). Subjects fulfilling the inclusion criteria were allocated in ration of 1:1 using random permuted blocks in Group I (partially grafted immediate dental implant with use of static magnetic field) and Group II (partially grafted immediate dental implant without use of static magnetic field). Sealed envelopes were used for allocation concealment.

After recording detailed history, the edentulous space to be restored was assessed for sufficient bone height and width on a preoperative cone-beam computed tomography scan (CS9300 Carestream, Atlanta, GA) and routine laboratory investigations were advised. Presurgical antibiotic coverage and oral hygiene maintenance aids were prescribed to the participant.

Dental implants were placed in both groups using standard drilling protocol. A crestal incision was made on the edentulous site to raise the full thickness flap using 15 c blade (Hu-friedy, Rockwell, St. Chicago). Osteotomy was started using 2 mm pilot drill and then sequential drills were used in increasing diameter to match the implant diameter. Implants were placed in both groups using hand drivers at the torque value of 25–30N/cm. Healing caps respective to each group (magnetic healing cap with a magnetic field strength of 186 milli tesla for Group I and conventional healing cap for Group II) were placed and the space between the implant surface and socket walls was filled with graft material (Bio-Oss, Geistlich Pharma AG Bahnhofstrasse 40CH-6110 Wolhusen). Flap was approximated using 3-0 silk suture (Ethicon, Johnson and Johnson Ltd., Chennai, India) [Figures 1 and 2].

The magnetic healing cap is made of Ti-6AI-4V (a standard titanium alloy used in implant dentistry) and is shaped like a simple healing abutment, with a 1.25 mm (0.05") hex socket. It is installed in accordance with the usual protocols for the use of healing abutments with the exception that the MED needs to be activated with an activator before being installed inside the implant. It consists of a battery, an electronic device, and a coil that fits most implant models in much the same way as current simple healing caps [Figure 3].

Baseline implant stability was measured as implant stability quotient (ISQ) with the help of a RFA (Ostell, a W and H company Brownstown, U. S. A.) on a scale from 1 to 100 at the baseline. Postoperative instructions regarding soft diet, oral hygiene maintenance, warm saline gargle after 24 h of surgery for 3-4 days, and medications were given to all participants [Figure 4a and b].

Figure 1: Intra-oral view of magnetic healing cap in Group I

Figure 3: Magnetic healing cap activation

All data hence collected after scheduled follow-up visits would be tabulated and statistically analyzed to draw a conclusion. ISQ values will be compared in both the groups using the Student's pair *t*-test and repeated analysis of variance.

RESULTS

This trial was performed according to CONSORT (consolidated standards of reporting trials) guidelines. No participant dropout and 100% implant survival were observed in both Group I (partially grafted immediate dental implant with use of static magnetic field) and Group II (partially grafted immediate dental implant without use of static magnetic field). Demographic and clinical characteristics (age, gender, and bone type) of both groups were recorded and compared [Figure 5a-c], and no statistically significant difference was found ($P > 0.05$).

The effect of static magnetic field on implant osseointegration was compared in two groups using implant stability assessment by radio frequency analyzer at baseline, 2 months, 3 months, and 4 months. Mann–Whitney U test revealed that there was a significant difference was observed between the groups at 2, 3, and 4 months of interval. At all the intervals mean of implant stability was higher in Group I as compared to Group II

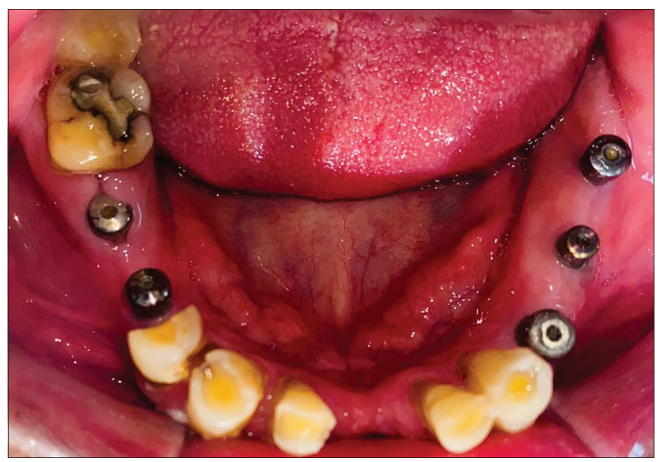

Figure 2: Intra-oral view of conventional healing cap in Group II

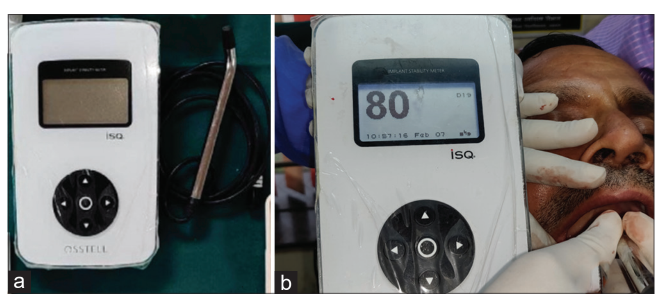

Figure 4: (a) Ostell RFA. (b) Assessment of implant stability using RFA. RFA: Radio frequency analyzer

Table 1: Intergroup comparison of implant stability in Group I and Group II using radio frequency analysis

	Groups, mean±SD			*Z*	*P*
	Group I (magnetic healing cap)	Group II (conventional healing cap)	Total		
At baseline	29.60±2.74	29.35±2.52	29.48±2.60	−0.274	0.784
At 2 months	71.00±4.09	55.70±6.70	63.35±9.49	−5.314	<0.001
At 3 months	75.15±7.90	69.35±4.27	72.25±6.92	−3.138	0.002
At 4 months	80.65±4.49	76.90±4.32	78.78±4.74	−3.159	0.002

Applied Mann-Whitney *U*-test for significance. SD: Standard deviation

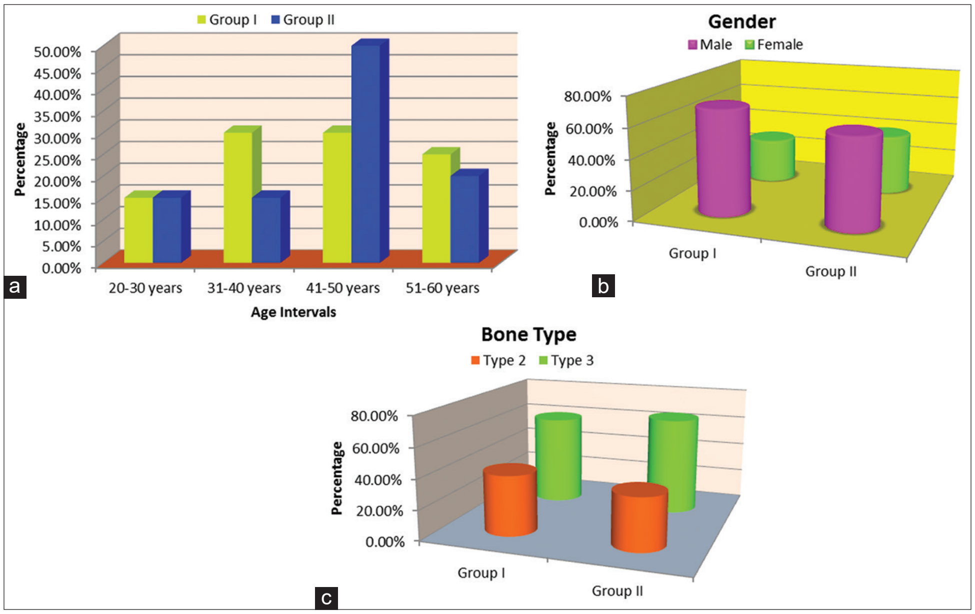

Figure 5: (a) Comparison of age in both the groups. (b) Comparison of gender in both the groups. (c) Comparison of type of bone in both the groups

which is showing improvement in stability after stimulation with the static magnetic field [Figure 6 and Table 1].

DISCUSSION

The present double-blinded randomized control trial showed significantly improved implant stability and osseointegration by static magnetic field stimulation by using magnetic healing cap as compared to at baseline, 2 months, 3 months, and 4 months of follow-up. There was improved healing time in Group I as compared to Group II.

This present study was homogenous regarding age, sex, education, and bone types at baseline, 2 months, 3 months, and 4 months of interval in both Group I and Group II.

In the present study, it was found that the osseointegration and implant stability were significantly higher in cases with magnetic healing cap placement than in groups with conventional healing cap.

The effect of magnetic fields on bone healing and bone formation is in research in some animal and clinical studies. In an animal study by Leesungbok *et al*.[6] compared the bone formation around commercial sandblasted, large-grit, acid-etched (SLA)-treated titanium implants with or without a neodymium magnet in a rabbit tibia through histomorphometric analysis. In rabbit tibia, the SLA-treated titanium implants with a neodymium magnet triggered faster peri-implant bone formation than those without a magnet. In another animal study by Bruce *et al.*,[7] in 1887, effect of a static magnetic force on a healing fracture, they implanted samarium cobalt magnets to radial fractures in adult rabbits. A magnetic field of 220–260 G was generated at the fracture site. Significantly greater forces ($P < 0.01$) were required to break those bone units exposed to magnetic fields.

Aydin and Bezer,[8] in there study, verified that an intramedullary implant with static magnetic field improves bone healing in the first 2 weeks radiologically and that the configuration difference in magnetic poles has an effect on bone quality and proposed that the combination of a strong SMF and a potent osteogenic agent such as BMP possibly may lead to effective treatment of bone fractures and defect.

Kim *et al*.[9] suggested that static magnetic field treatment enhanced osteoblastic and/or cementoblastic differentiation

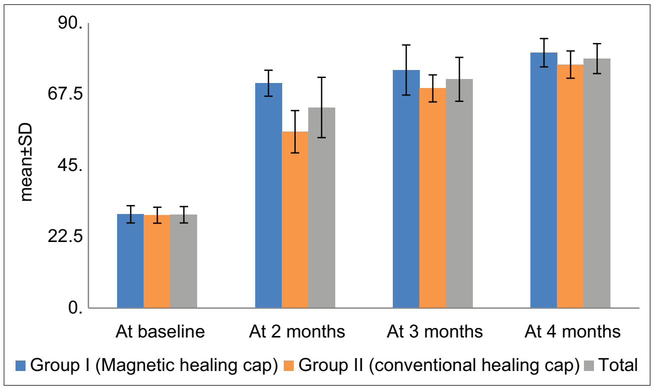

Figure 6: Comparative evaluation of implant stability in Group I and Group II

in osteoblasts, cementoblasts, and PDLCs. These findings provide a molecular basis for the beneficial osteogenic and/or cementogenic effect of SMFs, which could have the potential in stimulating bone or cementum formation during bone regeneration and in patients with periodontal disease.

Gujjalapudi *et al.*,[10] in 2016, suggested that the ISQ values obtained on the magnetic side were significantly greater than on the nonmagnetic side. A positive correlation exists between the magnetic field and osseointegration.

Barak *et al.*,[11] in 2015, indicated that the PEMF (pulsed electromagnetic field) device stimulated early bone formation around dental implants resulting in higher peri-implant BIC (bone to implant contact) and bone mass already after 2 weeks which suggests an acceleration of the osseointegration process by more than three times.[12]

Hence, the present study was supporting the use of the static magnetic field for improved implant osseointegration. Although the results were in favor of the magnetic healing cap, it has one limitation of the height of the healing cap. Because of its height, it cannot be used in cases with reduced space.

CONCLUSION

Within the limitation of the study, the following conclusions were made from the present study:

The present double-blinded RCT showed significantly improved implant stability and osseointegration in implants which were stimulated by static magnetic field by using magnetic healing cap as compared to implants with conventional healing cap.

It can be used in reducing healing time so ultimately treatment time can be reduced and can increase patient acceptance also.

Declaration of patient consent

The authors declare that they have obtained consent from patients. Patients have given their consent for their images and other clinical information to be reported in the journal. Patients understand that their names will not be published and due efforts will be made to conceal their identity but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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