

Vestibular-evoked myogenic potentials before and after dental implant surgery

Dental implant cerrahisinden önce ve sonra vestibüler uyarılmış miyojenik potansiyeller

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ABSTRACT

Objectives: This study aims to examine the effects of dental implant surgery on vestibular-evoked myogenic potential (VEMP) responses.

Patients and Methods: Between October 2012 and October 2014, a total of 60 consecutive patients undergoing dental implant surgery at Başkent University Hospital, Department of Otorhinolaryngology were included in the study. The control group consisted of 40 healthy subjects undergoing routine clinical examination. The VEMP response was evaluated at baseline, second and seventh days. Positional tests and Dix-Hallpike testing for vertigo were performed at baseline, second and seventh days.

Results: Hundred-eight dental implants were placed in 60 patients. There was no significant difference in the p1 and n1 latencies in the control group at baseline, second day, and seventh day ($p>0.05$). However, there was a significant increase at the second day for p1 latencies in the study group, compared to the baseline and seventh day ($p=0.038$). There was a significant increase at the second day for n1 compared to the baseline ($p=0.016$) and seventh day in the study group ($p=0.005$). There was a significant increase at the seventh day for n1 compared to the baseline in the study group ($p=0.016$).

Conclusion: The present study revealed a significant difference in the cervical VEMP response on the second postoperative day for p1 and n1 latencies compared to the baseline and seventh postoperative day in dental implantation patients. Dental implant patients should be informed of such possible temporary problems as dizziness and vestibular problems.

Keywords: Dental implant surgery; dental prosthesis; vestibular-evoked myogenic potential.

ÖZ

Amaç: Bu çalışmada dental implant cerrahisinin vestibüler uyarılmış miyojenik potansiyel (VEMP) yanıtları üzerindeki etkileri değerlendirildi.

Hastalar ve Yöntemler: Ekim 2012 - Ekim 2014 tarihleri arasında, Başkent Üniversitesi Hastanesi, Kulak Burun Boğaz Anabilim Dalı'nda dental implant cerrahisi yapılan toplam ardışık 60 hasta çalışmaya alındı. Kontrol grubu, rutin klinik muayene yapılan 40 sağlıklı kişiden oluşuyordu. Vestibüler uyarılmış miyojenik potansiyel yanıtı başlangıçta, ikinci ve yedinci günlerde değerlendirildi. Pozisyonel testler ve Dix-Hallpike vertigo testi başlangıçta, ikinci ve yedinci günlerde yapıldı.

Bulgular: Altmış hastaya 108 dental implant uygulandı. Başlangıçta, ikinci günde ve yedinci günde kontrol grubunda p1 ve n1 latens açısından anlamlı bir fark gözlenmedi ($p>0.05$). Ancak, çalışma grubunda başlangıçta ve yedinci güne kıyasla, ikinci günde p1 latens açısından anlamlı bir artış izlendi ($p=0.038$). Başlangıçta ($p=0.016$) ve yedinci güne kıyasla ($p=0.005$), ikinci günde çalışma grubunda n1 açısından anlamlı bir artış gözlemlendi. Çalışma grubunda başlangıçta kıyasla yedinci günde n1 açısından anlamlı bir artış gözlemlendi ($p=0.016$).

Sonuç: Bu çalışma diş implantı yapılan hastaların servikal VEMP yanıtı olarak p1 ve n1 değerlerinin ameliyat sonrası ikinci günde başlangıçta ve yedinci güne oranla anlamlı yüksek olduğunu göstermektedir. Diş implantı yapılacak hastaların baş dönmesi ve vestibüler sorunlar gibi olası geçici sorunlardan haberdar edilmeleri önerilmektedir.

Anahtar Sözcükler: Dental implant cerrahisi; diş protezi; vestibüler uyarılmış miyojenik potansiyeller.

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Implantation of dental prosthesis in maxillary bones is an old technique that is currently well developed, which can present with difficulties such as lack of bone mass. To overcome this, different procedures for increasing the alveolar crest have been proposed, from maxillary sinus augmentation to guided bone regeneration.^[1,2] By using these additional techniques, the number of cases that could be treated increased. However, as the operation time became longer with evolving technology, the inner ear trauma induced by dental turbine noise while working on the maxillary bone came into prominence.

In recent years, there has been growing awareness of vestibular dysfunction testing.^[3-5] One such test to assess vestibular abnormalities is cervical vestibular evoked myogenic potential (cVEMP). It is an objective, non-invasive, time-saving, and well-tolerated test to evaluate the function of the saccule and inferior vestibular nerve. The cVEMP is recorded from the sternocleidomastoid muscle (SCM) and represents a stimulus-evoked attenuation of electromyographic (EMG) activity following activation of the saccule and inferior vestibular nerve. The cVEMP responses arise from modulation of background electromyographic activity and differ from neural potentials in that they require tonic contraction of the sternocleidomastoid muscles.^[6]

Prolonged time in the supine position with head and neck hyperextension and inner ear trauma induced by dental turbine noise during dental implant surgery can all induce vertigo. In this study, the cVEMP was preoperatively collected in dental implant surgery patients and was compared with the postoperative response. Both the pre- and postoperative responses were compared with healthy controls to examine the effects of dental implant surgery on cVEMP response.

PATIENTS AND METHODS

This study was approved by the Baskent University Institutional Review Board (project no: KA/1295). Written informed consent was obtained from all subjects. Sixty consecutive patients undergoing dental implant surgery were compared with 40 control subjects undergoing routine dental clinical examination. The study group included 60 patients (29 males, 31 females)

with a mean age of 38.6 (range 22 to 54) years. The control group included 40 subjects (19 males, 21 females) with a mean age of 38.3 (range 21 to 55) years. Both implant surgeries and clinical examinations were performed in the same head position. According to the American Society of Anesthesiology (ASA) health status classification, both study and control groups were ASA I or ASA II. A detailed medical history was obtained (none of the patients had vestibular problems or vertigo) and all patients underwent ear, nose, and throat examination, audiologic evaluation (pure tone audiometry, 250-8000 Hz air-bone conduction), tympanometry and electronystagmography (ENG, Micromedical Technologies, Chatham, Illinois, USA). All subjects had otoscopic examination and were investigated for hearing loss. Subjects in the study and control groups who had conductive and sensorineural hearing loss, vestibular problems or sternocleidomastoid muscle pathology (injuries, painful disturbances, weakness and alterations in tonus of muscle) were excluded from the study.

Surgical procedure

In the study group, after local anesthesia injection and midcrestal incision, buccal and palatal full thickness flaps were reflected. A periodontal probe was used to make a preliminary assessment of potential implant sites. With the initial drill, the center of the implant recipient sites was marked and the initial pilot holes were prepared. Afterwards, a series of progressively larger-diameter drills were used. After the desired depth and diameter of the recipient site was accomplished, implant insertion was performed and wounds were closed. All procedures were performed by the same surgeon using the same implant material. Antibiotics (Amoxicillin 500 mg), analgesics (paracetamol) and chlorhexidine mouth rinses three times daily for five days were prescribed for all patients in the study group.

Vestibular-evoked myogenic potentials

The hearing level of each patient was evaluated using standard audiologic frequencies between 0.5 and 4 kHz before the cVEMP test. All subjects were seated upright with their chin turned over the contralateral shoulder to tense the SCM.

Surface electromyographic activity was recorded with an evoked acoustic potential system (Interacoustics/VEMP System, Eclipse/preamplifier EPA 4V, Smart EP 15, Assens, Denmark).

Active non-inverting recording electrodes were placed in the middle third of the sternocleidomastoid muscle; reference electrodes were placed in the ipsilateral sternal manubrium near the SCM tendon and a ground electrode was placed in the center of the forehead. The cVEMP responses were obtained by binaural acoustic stimulation and recorded from bilateral sternocleidomastoid muscles. Tone bursts at 500 Hz were delivered through an insert earphone at a 5.1/sec rate for an average of 200 repetitions (500 Hz; 120 dB SPL hearing level intensity; stimulation rate, 5.1/sec). Electromyographic signals were amplified and band-pass filtered (range, 10 to 1500 Hz). Electromyographic signals were recorded for 50 milliseconds. Mean peak latencies (in ms) of the two early waves (p13 and n23) were measured on the ipsilateral side of the stimulation. Recordings were determined by averaging 200 stimuli and two traces from each test to estimate reproducibility. Skin resistance was lower than 5 kilo ohms.

Outcome parameters

The cVEMP response was evaluated for the presence of positive (p1) and negative (n1) peaks of the first biphasic wave complex and latency (p1 and n1 latency) at baseline, on the second, and seventh day. Positional tests and Dix-Hallpike testing for vertigo were performed at baseline, on the second, and seventh day. The diagnosis of BPPV was based on medical history and observations of characteristic nystagmus with visual four-channel video-ENG during Dix-Hallpike and roll tests.

Statistical analysis

Data were analyzed using IBM SPSS version 21.0 for Windows (IBM Corporation, Armonk, NY., USA). A normal distribution of the univariate data was checked using Kolmogorov-Smirnov test, Shapiro-Wilk test, and coefficient of variation. Parametric tests were applied to data of normal distribution and non-parametric tests were applied to data of questionably normal distribution. Mann-Whitney U test with Monte Carlo simulation technique was used to compare independent groups. Friedman's two-way test was used to compare dependent multiple group and non-parametric posthoc test (Miller-1966 test) was used for posthoc analysis. Data were expressed as mean \pm standard deviation (SD) or median (interquartile range), as appropriate. All differences associated with a chance probability of 0.05 or less were considered statistically significant.

RESULTS

A total of 108 dental implants were placed in 60 patients. Implant diameter ranged from 3.8 to 4.2 mm, while the implant length ranged from 10 to 13 mm in the study group. None of the patients had nystagmus, vertigo, and subjective hearing loss before the surgery. Fifteen of 60 patients (25%) exhibited mild dizziness on the second day. Based on medical history and observations of characteristic nystagmus with visual four-channel video-ENG during Dix-Hallpike and roll tests, no benign paroxysmal positional vertigo was detected after the surgery.

The p1 latencies at baseline, second, and seventh days are shown in Table 1. Table 1 depicts the comparison of values of p1 latencies in the study and control groups. No significant difference was observed for the p1 latencies

Table 1. P1 latencies control group/study group

P1 latencies	Control group		Study group		p†
	Mean \pm SD	Median	Mean \pm SD	Median	
Baseline	14.99 \pm 1.76	14.8	14.67 \pm 0.96	15	0.777
Second day	15 \pm 1.89	14.3	14.73 \pm 0.84	15	0.821
Seventh day	14.99 \pm 1.82	14.8	14.6 \pm 0.89	15	0.734
p‡	0.067		0.001**		
Baseline-second day	0.01 \pm 1.9	-0.3	0.07 \pm 0.13	0	0.038*
Baseline-seventh day	0 \pm 0.64	0	-0.07 \pm 0.14	0	0.019*

† Mann Whitney U test; ‡ Friedman test; * p<0.05; ** p<0.01.

Table 2. N1 latencies control group/study group

P1 latencies	Control group		Study group		p†
	Mean±SD	Median	Mean±SD	Median	
Baseline	23.44±2.67	23	25.34±1.95	26	0.001**
Second day	23.43±2.2	22.8	25.79±1.31	26	0.001**
Seventh day	23.46±2.73	23	25.59±1.57	26	0.001**
p‡	0.144		0.001**		
Baseline-second day	0±3.1	-0.3	0.45±0.8	0	0.071
Baseline-seventh day	0.02±0.65	0	0.25±0.41	0	0.127

† Mann Whitney U test; ‡ Friedman test; * p<0.05; ** p<0.01.

between groups at baseline, second, and seventh day ($p>0.05$). The n1 latencies at baseline, second, and seventh days are shown in Table 2. Table 2 depicts the comparison of values of n1 latencies in the study and control groups. No significant difference was observed for the n1 latencies between groups at baseline, on the second, and seventh day ($p>0.05$).

There was no significant difference for the p1 latencies in the control group at baseline and on the second and seventh days ($p>0.05$). However, there was a significant increase in p1 latencies in the study group on the second day compared to baseline and the seventh day ($p=0.038$).

There was no significant difference in n1 latencies in the control group at baseline, and on the second and seventh days ($p>0.05$). However, there was a significant increase in the study group on the second day compared to baseline ($p=0.016$) and the seventh day ($p=0.005$). Also, there was a significant increase in n1 latencies compared to baseline ($p=0.016$) and the seventh day.

DISCUSSION

Dental implant surgery can induce vertigo. In this study, we attempted to demonstrate whether there was a difference between pre- and postoperative cVEMP response in dental implant surgery patients. Our study showed that there was a significant difference in the study group p1 and n1 cVEMP response latencies on the second day compared to baseline and the seventh day.

Dental implantation using an osteotome, especially in the maxilla, could expose the patient to minor trauma to the osseous labyrinth. This trauma could result in dizziness or vertigo. Although most patients can withstand such

minor head trauma without sequelae, some patients could experience this outcome. Chronic posttraumatic vertigo may result if otoliths become detached and settle on the ampulla of the posterior semicircular canal and excessively deflect during head motion. This will present as an episodic positioning vertigo. Vertigo can also result from traumatic leakage of perilymph into the middle ear. Rarely, a perilymphatic fistula could occur after physical trauma and can result in vertigo and hearing loss.^[7,8] In the present study, we aimed to document the cVEMP response which reflects otolithic function in dental implant surgery patients.

In the pathophysiology of BPPV, the degenerative processes of various insults that affect the macula of the saccule result in abnormal cVEMP responses in BPPV. Eryaman et al.^[13] demonstrated that the prolongation of mean latency values for p13 of cVEMP in patients with BPPV might signify neuronal degeneration in the macula of the saccule.

Yang et al.^[14] reported that patients with recurrent attacks of vertigo showed signs of more extensive saccular damage, higher recurrence, and resistance to positioning maneuver. Akkuzu et al.^[10] reported delayed latencies in some of their BPPV patients. In the present study, we found a significant difference in the study group second day p1 and n1 latencies compared to baseline and the seventh day.

Trauma to the head could cause a concussion of the labyrinth and result in vertigo. Vertigo is an important symptom of inner ear vestibular disorder. It has been shown that dentoalveolar surgery with a rotating bur for removal of impacted teeth and cysts could lead to vertigo. It has been proposed that energy in the form of

vibrations propagates throughout bony structures eventually reaching the labyrinth, leading to detachment of otoliths into the endolymph. There are some reports of BPPV following osteotome sinus floor elevation (OSFE).^[15,18] The OSFE introduced by Summers is generally used in moderately resorbed posterior maxilla to graft the maxillary sinus in combination with immediate implant placement.^[19] This technique requires striking the bone with a surgical mallet until the desired depth is reached. During the installation of maxillary dental implants using the OSFE, the surgical trauma induced by percussion with the surgical mallet, along with hyperextension of the neck during the operation, can displace otoliths and result in the appearance of BPPV.^[20] Di Girolamo et al.^[21] showed that four out of 146 patients who underwent osteotome sinus floor elevation developed BPPV, one or two days after the surgical procedure, which promptly resolved with the Epley repositioning maneuver. Sammartino et al.^[22] compared mallet osteotomes with screwable osteotomes determining BPPV following the osteotome closed sinus floor elevation procedure and concluded that preparation of implant beds with an osteotome transmits percussive and vibratory forces capable of detaching the otoliths from their normal location. Moreover, the patient's surgical head position favors the displacement of otoliths into the posterior semicircular canal. Vernamonte et al.^[23] postulated that the percussive forces of the osteotome and mallet are capable of detaching otoliths. Furthermore, the patient's head position, hyperextended and tilted to one side, favors the entry of these free-floating particles into the semi-circular canal. Wanner et al.^[24] revealed that BPPV is a sporadically reported unusual complication of dental implant surgery and stated that practitioners should be aware of all the possible complications and recognize them early so that adequate therapy can immediately be ensured. In our study we did not diagnose BPPV, but the significant difference in cVEMP results in the study group (especially on the second day) showed us that the prolongation of mean latency values for p1 and n1 of cVEMP in patients might signify temporary neuronal degeneration in the macula of the saccule. This was a single-institution study and further studies are needed. Nevertheless, to the best of our knowledge, this is the first study that used cVEMP after dental implant surgery.

In conclusion, the present study revealed a significant difference in the cVEMP response on the second postoperative day for p1 and n1 latencies compared to the baseline and seventh postoperative day in dental implantation patients. Dental implant patients should be informed of such possible temporary problems as dizziness and vestibular problems. Further randomized, prospective, controlled trials on larger series are necessary before making more precise interpretations.

Declaration of conflicting interests

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