

# STABILITY OF IMPLANTS AND NATURAL TEETH AS DETERMINED BY THE PERIOTEST OVER 60 MONTHS OF FUNCTION

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## KEY WORDS

**Implant  
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Various methods for evaluating tooth mobility have been developed throughout the years, but their acceptance has been limited because of the subjectivity associated with their use. In recent years, the Periotest has been studied and used to evaluate the mobility of natural teeth and is claimed to be potentially reliable in assessing the stability of the implant-bone interface. Few clinical implant studies have used natural teeth as controls to monitor changes in mobility associated with dental implants. The Dental Implant Clinical Research Group initiated a long-term clinical study in 1991 to assess the influence of design, application, and site of placement on clinical success and crestal bone height. As part of the study, Periotest values (PTVs) were recorded for 2623 of the 2998 implants placed and uncovered. For the statistical analysis, 2623 implants were tested at second-stage surgery, with the number of implants tested varying at each follow-up visit. Data were collected from investigators at 32 study centers for periods ranging up to 60 months. A total of 975 natural teeth from 409 partially edentulous study subjects served as controls. PTVs on natural teeth and implants were combined, and the overall average Periotest values (OA-PTVs) were compared with values for individual subjects. The effect of implant and natural tooth locations on mobility were evaluated and compared with each other. The combined OA-PTV for all natural teeth was +1.8 and the OA-PTV for all implants was -3.4 PTVs. Compared with those in the maxillae, mandibular teeth and implants were found to be more stable. Implants were found to be significantly more stable as compared with natural teeth. The recorded variations in PTVs for natural teeth and implants over the entire evaluation period were not found to be significantly different. This study developed the following conclusions: (1) implants were found to be significantly less mobile as compared with natural teeth for individual subjects; (2) the PTVs for natural teeth and implants did not exhibit significant variation over the evaluation period; (3) the Periotest can provide reproducible assessment of stability in a long-term clinical study; and (4) changes in PTVs may be helpful in evaluating improvement or degradation of the implant-bone complex.

## INTRODUCTION

Different methods of assessing tooth mobility have been developed throughout the years with various degrees of acceptance by the dental profession because of the subjectivity associated with their use. Tooth mobility is an important diagnostic indicator of the functional status of the periodontium and is considered by many clinicians and researchers as a factor affecting the severity, progression, and therapeutic outcome of periodontal diseases.<sup>1</sup> With limited objective criteria available to develop an evidence-based treatment plan, clinicians must rely largely on subjective criteria—such as expertise, experience, technical ability, and intuition—to treat and restore mobile teeth.

The clinical evaluation of dental implants is becoming increasingly important as the number of implant systems available to the dental profession and implant usage increase. The success of endosseous dental implants is related to the extent of osseointegration. Osseointegration must be verified before abutments are attached, after the prosthesis is completed, and during the maintenance phase. At the time of second-stage surgery, the definitive histologic status of the implant-bone interface is unknown. In the absence of clinical pathology and lack of mobility, it can be assumed that osseointegration has occurred.

Patient care can benefit from an instrument that provides an objective, reproducible, and quantifiable clinical assessment of the mobility of teeth and implants. Such a device should be user-friendly, noninvasive, nontraumatic, exhibit extreme sensitivity, and provide consistently reproducible data. More accurate prognostic data would be the result.

The Periotest (Siemens AG, Bensheim, Germany) has been used to evaluate the mobility of natural teeth and is claimed to have the potential of

reliably assessing the stability of the bone-implant interface. Studies have supported the use of the Periotest in providing information about bone atrophy<sup>2</sup> and inflammatory periodontal conditions.<sup>3</sup> The instrument has also been used in a study comparing dental implant systems to aid in the evaluation of bone and connective tissue healing around study implants.<sup>4</sup> The reliability of the Periotest in the evaluation of osseointegrated implant stability has been reported.<sup>5,6</sup>

The Periotest has been described in detail by Schulte.<sup>7</sup> The Periotest instrument uses a percussion rod that is electronically guided by a microcomputer. The rod impacts a tooth or implant 4 times per second for 4 seconds (16 total percussions). The more stable the periodontium, the quicker the percussion rod decelerates and rebounds into the hand piece. The instrument measures the time that the percussion rod is in contact with the tooth or implant, with a shorter contact time indicating a more stable periodontium. The microcomputer converts the information obtained from the measurement cycle to the Periotest value on the scale used by the system, with both audio and visual readouts provided.

The scale of possible Periotest values (PTVs) ranges from  $-8$  to  $+50$ . Setting part of the range of values below 0 was intended to be indicative of teeth that have ankylosed or implants that have osseointegrated. PTVs are comparable with values of the Miller Mobility Index<sup>8</sup> as follows: (1) Periotest values ranging from  $-8$  to  $+9$  coincide with a clinical mobility value of 0 (no discernible movement); (2) Periotest values ranging from  $+10$  to  $+19$  coincide with a clinical mobility value of 1 (just discernible movement); (3) Periotest values ranging from  $+20$  to  $+29$  coincide with a clinical mobility value of 2 (obvious visible movement); and (4) Periotest values ranging from  $+30$  to  $+50$  coincide with a clinical mobility value of 3 (mobile on pressure).<sup>9</sup>

Teerlinck et al<sup>5</sup> evaluated the Periotest in a trial involving 30 patients

with osseointegrated Nobelpharma implants, finding a repeated reading within 1 PTV unit of the first reading for an implant 95% of the time. However, readings for this study were in a very narrow range ( $-4$  to  $+2$ ).

Olive and Aparicio<sup>6</sup> used the Periotest to evaluate 204 commercially pure titanium implants. The range of 6 repeated measurements was generally within 3 PTV units, with a maximum range of 5 units. Failed implants all had recorded PTV values greater than  $+9$ .

The Dental Implant Clinical Research Group (DICRG) initiated a long-term clinical study in cooperation with the Department of Veterans Affairs in 1991 to investigate the influence of implant design, application, and site of placement on clinical success and crestal bone height.<sup>10</sup> In addition to radiographs, periodontal probing, and clinical mobility determinations, the Periotest was also used to evaluate the condition of the supporting tissue around all study implants and natural teeth selected as controls.

The purpose of this study was to evaluate the mobility of all study implants and 975 natural teeth in 409 partially edentulous subjects enrolled in the implant study for over a 60-month time interval and to compare the mobility of control natural teeth with study implants.

## MATERIALS AND METHODS

The implants used were generally representative of the designs and materials that are available from most implant manufacturers. They include basket, screw, bullet, and ledge designs. The implant materials used were commercially pure titanium, titanium alloy, and hydroxyapatite-coated titanium alloy. For the purpose of data analysis, the implant cases were placed in 5 different anatomical regions or strata, with different implant designs and materials used in each of the strata. The implants assigned to each case in each of the 5 strata were determined by randomization.<sup>10</sup>

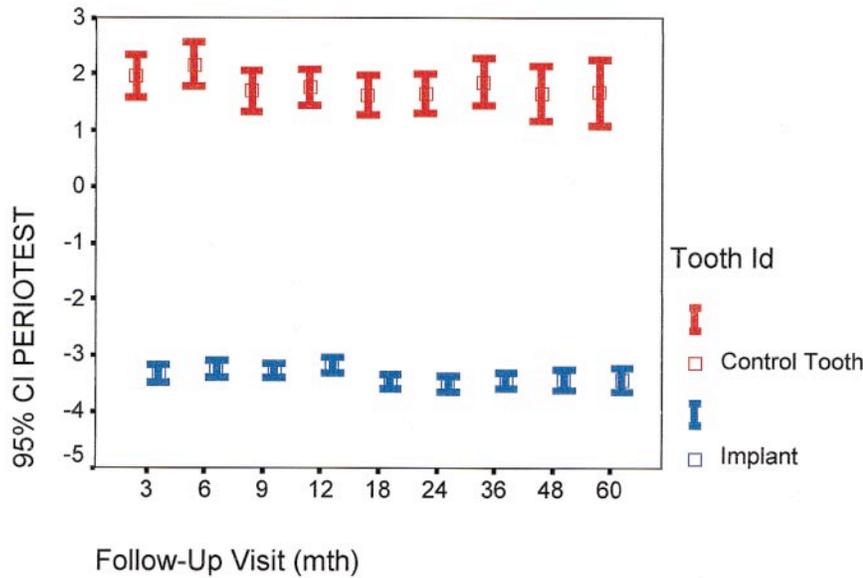


FIGURE 1. Mean stability Periostest values (PTVs) of all natural (study control) teeth and implants recorded over a period of 60 months. The mean PTVs (stability) of both natural teeth and implants do not vary significantly over the 60-month period. The stability of the implants was significantly greater ( $P < .05$ , 95% confidence interval) than the natural teeth.

PTVs were recorded for 2623 of the 2998 implants placed and uncovered. For the statistical analysis, 2623 implants were tested at second-stage surgery with the number of implants tested varying at each follow-up visit.

At the time of implant uncovering, healing collars were placed, the implants tested, and the PTVs recorded. Care was taken to place the tip of the Periostest at a location slightly above the soft tissues while holding the hand piece parallel to the floor before activating the instrument. Each implant was tested until 3 identical PTVs were obtained before recording the value on the investigation form. Before measurements were taken, the Periostest was calibrated by the examiner at each of the 32 study locations with the calibration sleeve provided by the manufacturer. Measurements were made at 3, 6, 9, 12, 18, 24, 36, 48, and 60 months after uncovering.

The assessment of the stability of natural teeth was conducted as part of the ongoing long-term investigation. Investigators recorded Periostest values of 975 natural teeth in 409 patients over time intervals up to 60 months. A minimum of 1 control tooth was selected for each implant. Since many study patients received more than 1 implant, PTVs for several control teeth were often recorded. An attempt was made to utilize natural teeth located contralateral to the implant sites. When an edentulous arch opposed natural dentition, control teeth were selected from the opposite arch. To obtain overall values for natural teeth and implants (OA-PTVs), the mean PTVs for each visit were combined and the mean calculated.

All data from the 32 study centers were forwarded to the DICRG Management Center in Ann Arbor, Mich, for tabulation and analysis.

**RESULTS**

*All teeth and implants*

Mean PTVs for natural teeth at each evaluation visit ranged from 1.6 to 2.2

TABLE 1A

60-month mean Periostest readings by follow-up visit: natural (control) teeth									
	3 mo	6 mo	9 mo	12 mo	18 mo	24 mo	36 mo	48 mo	60 mo
Mean	2.0	2.2	1.7	1.8	1.6	1.7	1.9	1.7	1.7
SD	4.8	5.3	4.8	4.7	4.7	4.8	5.1	5.1	4.9

TABLE 1B

60-month mean Periostest readings by follow-up visit: implants									
	3 mo	6 mo	9 mo	12 mo	18 mo	24 mo	36 mo	48 mo	60 mo
Mean	-3.3	-3.2	-3.3	-3.2	-3.5	-3.5	-3.5	-3.4	-3.4
SD	3.2	3.3	3.1	3.3	3.1	3.1	3.0	3.0	3.2

TABLE 2A

60-month mean Periostest readings by follow-up visit: maxillary arch/natural teeth									
	3 mo	6 mo	9 mo	12 mo	18 mo	24 mo	36 mo	48 mo	60 mo
Mean	2.6	2.6	2.1	2.5	2.6	2.4	2.5	2.7	3.1
SD	4.6	5.2	4.6	4.6	4.6	4.7	4.7	4.9	4.9

TABLE 2B

60-month mean Periostest readings by follow-up visit: maxillary arch implants									
	3 mo	6 mo	9 mo	12 mo	18 mo	24 mo	36 mo	48 mo	60 mo
Mean	-2.5	-2.0	-2.1	-1.8	-2.1	-2.1	-2.0	-1.8	-1.6
SD	3.2	3.7	3.3	3.7	3.4	3.4	3.3	3.4	3.5

(Table 1A), with the OA-PTV for all natural teeth being 1.8. The mean PTVs for implants at each visit ranged from  $-3.2$  to  $-3.5$  (Table 1B) and an OA-PTV of  $-3.4$  PTVs. There was no significant variation in the stability of natural teeth and implants over 60 months (Figure 1). The differences between the OA-PTV for natural teeth and implants was around 5 PTV units. The implants were significantly more stable as compared with the natural teeth ( $P < .05$ , 95% confidence interval [CI]).

### Maxillary arch

Teeth and implants in the maxillary arch exhibited less stability as compared with those in the mandible. The mean PTVs for each evaluation visit for the natural teeth ranged from 2.1 to 3.1 PTVs (Table 2A). The OA-PTV for the 60-month evaluation period for all maxillary natural teeth was 2.5 PTVs. The mean PTVs for implants ranged from  $-1.6$  to  $-2.5$  (Table 2B). The OA-PTV for all visits for all implants was  $-2.1$ . The overall average stability (the OA-PTVs) of natural teeth and implants in this jaw region differed by about 5 PTV units. The variations in PTVs for natural teeth and implants did not vary significantly over 60 months (Figure 2). The implants remained significantly more stable as compared with the natural teeth ( $P < .05$ , 95% CI).

### Mandibular arch

Mean PTVs for natural teeth ranged from 0.8 to 1.8, with most of the values for each visit recorded between 1.1 and 1.4 (Table 3A). The OA-PTV for all mandibular natural teeth was 1.2, approximately half of the value recorded for maxillary teeth (OA-PTV = 2.5), which reflects the differences in the bone qualities between the 2 arches. The mean PTVs for implants ranged from  $-4.0$  to  $-4.5$  (Table 3B). Although there was a gradual negative shift in values for both natural teeth and implants, the changes were not significant (Figure 3). The OA-PTV for all im-

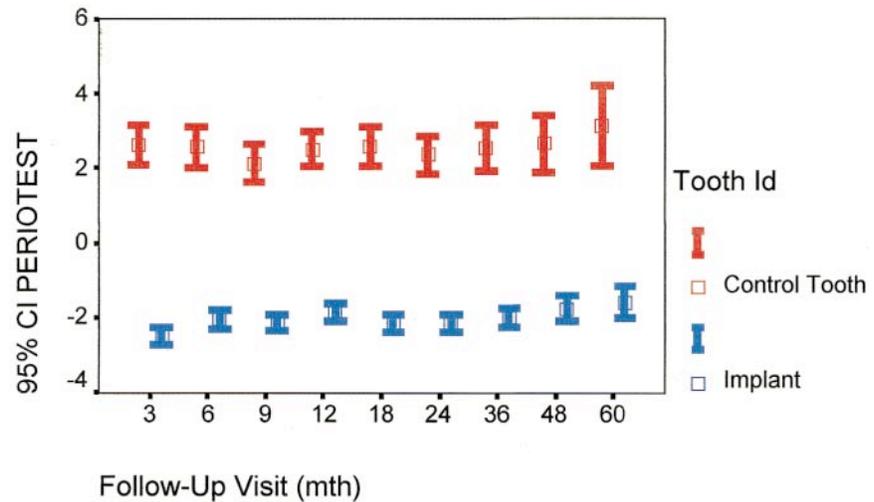


FIGURE 2. Mean stability Periotest values (PTVs) of maxillary natural (study control) teeth and implants recorded over a period of 60 months. The mean PTVs (stability) of both natural teeth and implants did not vary significantly over the 60-month period. The stability of the implants was significantly greater ( $P < .05$ , 95% confidence interval) than the natural teeth.

	3 mo	6 mo	9 mo	12 mo	18 mo	24 mo	36 mo	48 mo	60 mo
Mean	1.4	1.8	1.4	1.1	0.8	1.1	1.3	1.1	0.9
SD	5.0	5.4	4.9	4.6	4.5	4.9	5.2	5.1	4.5

	3 mo	6 mo	9 mo	12 mo	18 mo	24 mo	36 mo	48 mo	60 mo
Mean	-4.0	-4.2	-4.2	-4.2	-4.5	-4.5	-4.5	-4.3	-4.3
SD	3.1	2.6	2.6	2.4	2.3	2.3	2.2	2.4	2.5

plants for the entire 60-month period was  $-4.4$ , which represented a difference of about 4 to 5 PTV units when compared with the OA-PTV of the natural teeth. Implant stability remained significantly better ( $P < .05$ , 95% CI) than that of natural teeth during the 60-month evaluation period (Figure 3).

### DISCUSSION

Extensive testing by d'Hoedt et al<sup>9</sup> established a strong correlation between mobility levels of natural teeth with PTVs. The ability to recognize fine gradations of clinical mobility combined with a demonstrated capacity to generate highly reproducible results<sup>11,12</sup> make the Periotest a potentially useful

instrument for the clinical assessment of osseointegration.

Although a close correlation exists between PTVs and tooth mobility, the computed PTVs are not the result of direct measurement of tooth mobility. PTVs are, instead, considered to be a unique biophysical parameter.<sup>13</sup> The Periotest method of testing does not allow sufficient time for the interstitial or vascular-bound fluids to be pushed out of the peri-implant tissues.<sup>14</sup> The resultant PTV is, therefore, thought to reflect both the quantity and quality of the biological support.<sup>15</sup>

If bone quality can be correlated with PTVs, this information could be valuable in providing a method of as-

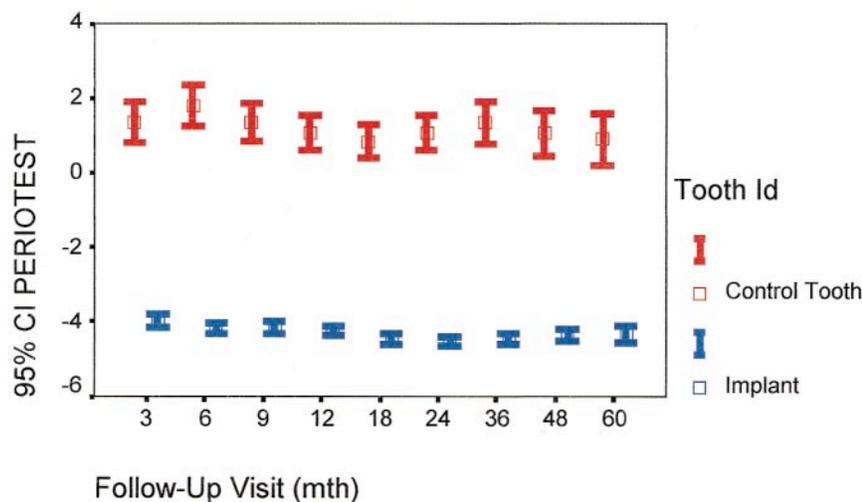


FIGURE 3. Mean stability Periotest values (PTVs) of mandibular natural (study control) teeth and implants recorded over the 60-month period. The mean PTVs (stability) of both natural teeth and implants did not vary significantly over the 60-month period. The stability of the implants was significantly better ( $P < .05$ , 95% confidence interval) than that of the natural teeth.

sessing the extent of osseointegration at uncovering for each area of the jaw. These data may possibly allow the clinician to monitor healing and establish time/integration curves for various types of implants, which, in turn, could indicate appropriate loading intervals.<sup>6,15</sup>

Ochi et al<sup>16</sup> reported that the Periotest is capable of detecting slight differences in the implant-bone complex. As such, it may be able to alert the clinician to an impending early change in the implant-bone complex. Comparison of PTVs of natural (control) teeth and implants from the same individual could then be evaluated for any possible correlations. Corrective treatment, if indicated, could be initiated in an effort to save ailing implants.<sup>17</sup>

The PTVs may also be helpful in determining the need for, or sequence of, progressive loading<sup>18</sup> and also provide the clinical researcher with a valuable tool with which to assess and compare changes in the implant-bone complex, possibly in conjunction with the natural teeth. Periotest baseline values may be useful in evaluating improvement or degradation of the implant-bone complex, which can alert the clinician to possible impending

failure if the implants are left untreated.

Implants were found to be significantly more stable as compared with natural teeth in study subjects. The variation in PTVs for natural teeth and implants in the same subjects during the evaluation period was not significant. The results suggest a correlation between implants and natural teeth in the same individual, which should be investigated further.

#### CONCLUSION

As part of the DICRG's long-term prospective investigation, PTVs for 2623 root-form implants were determined at second-stage surgery and during a 5-year follow-up period. A total of 975 natural teeth from 409 partially edentulous study subjects served as controls.

Implants were found to be significantly less mobile as compared with natural teeth. The PTVs for natural teeth and implants did not exhibit significant variations in mean PTVs for each evaluation period over the 60-month duration of the study. The results suggest that changes in PTVs can be helpful in evaluating improvement

or degradation of the implant-bone complex.

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