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The influence of splinting procedures on the periodontal and peri-implant tissue damping characteristics

A longitudinal study with the Periotest® device

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Abstract. The aim of the present study was to evaluate the capability of the Periotest® device in detecting and monitoring functional changes in the periodontal as well as in the peri-implant damping characteristics. In the first part of this study, 107 teeth were splinted by means of 40 full acrylic fixed prostheses (AFP) and another 37 teeth were splinted by means of 14 ceramometallic fixed prostheses (C-MFP). The Periotest® measurements of individual teeth were done the day the fixed prostheses were cemented temporary (PTV 1), and again after a mean observation period of 27.4 days (PTV 2). In the 2nd part, 78 osseointegrated two-stage implants were splinted by means of 23 full acrylic fixed prosthesis (AFP) and other 18 implants were left without it. Using the same abutment length, Periotest® measurements were performed, at abutment connections and before installation of the final prosthesis. In a 3rd part, using both implants and teeth as abutments, 29 osseointegrated implants were connected with 25 abutment teeth by means of 7 AFP. The measurements were performed at the beginning of the prosthetic treatment and 2, 4 and 6 weeks later. After splinting teeth by means of AFP for the observation period, no statistically significant reduction in PTVs was found. When on the other hand, a C-MFP was used, PTV 2 showed a significant reduction. The PTVs at abutment connection went down after a period of time, during which some implants were interconnected by means of an AFP and others were not. Although this difference was not significant, it was more notable in the implants that received a AFP. In this study, the establishment of a connection between teeth and implants, did not induce any significant change in the damping characteristics of the periodontal tissues detectable by the Periotest®, even after a period of 6 weeks.

Key words: Periotest®; damping characteristics; tooth mobility; osseointegration; osseointegrated prosthesis; connected teeth; splinting

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Oral rehabilitation becomes a key factor in periodontal treatment planning when teeth need to be replaced in order to reestablish adequate occlusal stability and aesthetics. In these circumstances, splinting procedures are frequently used to interconnect teeth (American Academy of Periodontology 1989), implants (Naert 1993) or teeth with implants (Naert 1993). Assessment and monitoring the stability of teeth and implants when adapting changes in their mechanical environment is clearly of considerable clinical and scientific value. This has been done by tapping the teeth or implants in between two instrument handles to evaluate subjectively eventual mobility or the distance between the two extreme positions. Although this approach seems very reproducible (Laster et al. 1975), the need for an objective assessment is evident. Some methods, as the periodontometer of Mühlemann, are extremely complex and time consuming for daily practice (Mühlemann 1967). Recently, the periotest® method (Siemens AG, Bensheim,

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Germany) has been reported to measure functional changes of the periodontal tissue damping characteristics (Schulte & Lukas 1992). The aim of the present study was to evaluate the capability of this device in detecting and monitoring functional changes that occur in the periodontal as well as in the peri-implant damping characteristics when splinting procedures are applied.

Material and Methods

The Periotest® device consists of a handpiece connected by a cable to a unit which controls functions and analyses measurements. Inside the handpiece, a metal rod is accelerated until it reaches its nominal speed, and contacts the tooth. Upon impact, the tooth is slightly deflected and the rod is decelerated. This deceleration is measured by an accelerometer. The faster the deceleration the higher the stability and greater the damping of the periodontal tissues. The contact time between tooth and tapping head, is the signal used for analysis by the Periotest® system. Using the measured contact times (ms), the Periotest® values (PTVs) are calculated and based on a numerical scale from −8 to +50.

The aim of the first part of the present study was to examine by means of the Periotest® method, the eventual change in periodontal tissue damping characteristic, when splinting teeth by means of fixed prostheses made of two different material (acrylic resin and ceramo-metal).

The total sample material comprises 36 partially edentulous patients (20 females) who were referred for rehabilitation by means of conventional fixed prosthesis. The patient's age ranged from 20 to 62 years (mean=45.8; S.D.= 13.75).

107 abutment teeth were splinted by means of 40 full acrylic fixed prostheses (AFP) (Unifast®, G.C.-Japan) and another 37 abutment teeth were splinted by means of 14 ceramometallic fixed prostheses (C-MFP) (Herador-NH®, Heraeus, Germany/Vita®, H. Rauter GmbH & Co. KG. Bad Säckingen, Germany. Both types of fixed prostheses were temporarily cemented (Temp-Bond®, Kerr-USA), in order to be able to remove them afterwards. The observation period ranged from 16 to 54 days (mean=27.4 days; S.D.=10.88), because of the retrospective character of the study. The distributions of AFP and C-MFP according to their number of abutment teeth, number of pontics and jaws, are shown in Table 1 and 2, respectively. The proportions abutment teeth/pontics in the AFP and C-MFP were 1.3/1 and 1.5/1, respectively.

Table 1. Distribution of acrylic fixed prostheses (AFP) according to the number of abutment teeth, pontics and jaw

No. abutment teeth	No. pontics	Total AFP	
		upper	lower
2	1	16	2
2	2	1	4
2	3	–	2
3	1	5	2
3	2	2	–
3	3	1	–
4	5	1	–
4	8	1	–
4	9	1	–
5	3	–	1
6	6	1	–

Table 2. Distribution of ceramometallic fixed prostheses (C-MFP) according to the number of abutment teeth, pontics and jaw

No. abutment teeth	No. pontics	Total C-MFP	
		upper	lower
2	1	4	1
2	2	–	2
2	3	–	1
3	1	4	–
3	3	1	–
5	4	1	–

The Periotest® measurements were performed the day the fixed prostheses were cemented temporary (PTV 1), and again after the observation period mentioned above (PTV 2). Measurements were performed 2× on every examined tooth, by the same investigator, with the methodology described earlier (Schulte 1990). An average of both PTVs obtained was calculated and half scores could be used.

For the statistical analysis, a paired *t*-test was carried out for the conditions vital and non-vital and the following null hypothesis was tested: $\mu_{PTV\,1-PTV\,2}=0$.

The aim of the 2nd part was to evaluate the effect of interconnecting implants by means of fixed prostheses on the implant's stability also measured by the Periotest® method. The series consisted of 21 partially and 10 totally edentulous patients (17 females), with an age ranging from 24 to 72 years (mean=51.1, SD=14.05). In these patients, a total of 96 screw-shaped pure titanium implants (Brånemark System, Nobelpharma AB, Gothenburg, Sweden) were installed. The mean healing period of the fixtures before abutments were installed, was 5.1 months for the mandible (range=3.3 to 7.0 m.), and 7.9 months for the maxilla (range=6.0 to 12.0 m.). At abutment connection, Periotest® measurements were performed 2× for each implant, with the methodology described earlier (Schulte 1990), and the mean PTV was calculated.

78 implants were splinted by means of 23 AFP (Unifast®, GC-Japan) screwed directly onto the titanium abutments (test group). The other 18 implants were left without an AFP until the final prosthesis was made (control group). In these patients a tissue conditioner (Coe Soft®, Coe, Laboratories Inc, Chicago), was used to reline the removable prosthesis over the implants.

The mean period of time between the abutment connection and the installation of the AFP was 1 month (range= 0 to 3.1). The mean period of time that the abutments were splinted by means of AFP was 5.6 months (range=1.1 to 13.0). The mean period of time for the group of implants that did not receive AFP, was 3.5 months (range=2.0 to 6.2).

At the end of the above-mentioned observation period, Periotest® measurements of the implants were performed using the same abutment lengths as at the 2nd stage surgery. No implant was lost during this period.

The PTVs at abutment connection (PTV 1) and those of the end of the observation periods (PTV 2), were analyzed with a paired *t*-test. A comparison was made between the patient group receiving an AFP and the group of patients that did not.

Finally, the aim of the 3rd part was to investigate the damping characteristics of the periodontium, when connecting teeth with implants by means of fixed prostheses. The sample material consisted of 7 partially edentulous patients (4 females), who were treated by means of oral implants. The age ranged from 19 to 83 years (mean=48.5; SD= 14.25).

Using both implants and teeth as abutments, 29 screw-shaped pure titanium implants (Brånemark System, Nobelpharma AB, Gothenburg, Sweden) were connected with 25 abutment teeth by means of 7 AFP (Unifast®, GC-Japan), screwed directly onto the ti-

tanium abutments, and temporary cemented (Temp-Bond®, Kerr-USA) on the natural teeth. All of them were located in the upper jaw, and their distribution according to the number of abutment teeth, implants, pontics and the sequence of these elements in the arch of the patients is shown in Table 3.

Periotest® measurements were performed 2× on every examined tooth, with the methodology described earlier (Schulte et al. 1990). An average of both PTVs was calculated and half scores could be used. The measurements were carried out with the AFP removed; at the beginning of the prosthetic treatment (PTV 1), 2 (PTV 2), 2 (PTV 3) and 6 weeks (PTV 4) later.

A paired *t*-test was used to analyse the change of PTVs in time, for the conditions vital and non-vital, and the following hypotheses were tested: $\mu_{PTV\ 1\text{-}PTV\ 2}=0$; $\mu_{PTV\ 2\text{-}PTV\ 3}=0$; $\mu_{PTV\ 3\text{-}PTV\ 4}=0$.

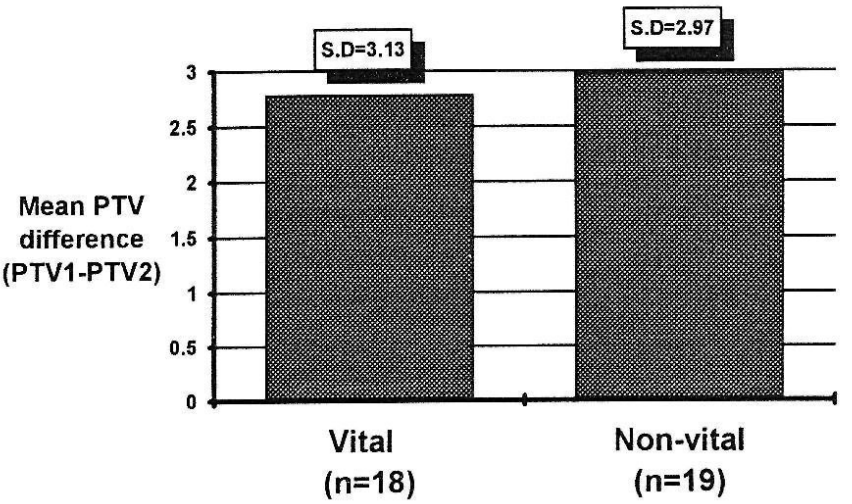

Fig. 1. This graph displays the mean PTV differences (PTVs at the prostheses installation (PTV 1), minus the PTVs after the mean observation period of 27.4 days (PTV 2)), for vital and non-vital abutment teeth splinted by means of C-MFP. PTV 2 showed a statistically significant reduction, as well for vital as non-vital teeth (p=0.0001 and 0.0003 respectively, α=0.05).

Results

No statistically significant changes in PTVs were found after splinting teeth for the observation period, by means of AFP. However, when a C-MFP was used, the PTV 2 showed a statiscially significant reduction, as well for vital as non-vital teeth (p=0.0001 and 0.0003 respectively, α=0.05) (Fig. 1).

The mean difference between PTV 1 and PTV 2 for the 78 implants which were splinted by means of AFP was 0.63 (SD=2.6), with lower values at PTV 2, which means that after using the AFP, the PTVs of the implants were 0.63 units lower. This difference was not statistically significant (p=0.1). The mean difference between PTV 1 and PTV 2, for the 18 implants that were left without AFP, was 0.17 (SD=1.34), with lower values at PTV 2. This was also not statistically significant (p=0.6) (Table 4).

When jaws are considered separately, in the upper jaw, 67 implants were interconnected by means of AFP. These implants showed a mean difference between PTV 1 and PTV 2 of 0.8 units (SD=2.7) with lower values at PTV 2, which was statistically significant (p=0.02). For the same jaw, 9 implants were left without AFP, and showed a mean difference between PTV 1 and PTV 2 of 0.2 (SD=1.1), with lower values at PTV 2, which was not statistically significant (p=0.5) (Fig. 2).

In the lower jaw, 11 implants were splinted by means of AFP and presented a mean difference between PTV 1 and PTV 2 of 0.4 units (SD=0.94). Here, after the observation period, the PTVs of the implants were higher. This difference was not significantly significant (p=0.2). Furthermore, in the lower jaw, 9 implants which were left without AFP, showed a mean difference between PTV 1 and PTV 2 of 0.06 units (SD=1.55). This time towards lower values at PTV 2, and again was not statistically significant (p=0.9).

Only those implants that were splinted by means of an AFP were considered per location within the jaw. In the upper jaw, 28 implants were located in the anterior region and showed a mean difference between PTV 1 and PTV 2 of 0.5 units (SD=3.9), whereas in the same jaw, 39 implants located in the posterior region showed a mean difference between PTV 1 and PTV 2 of 1 unit (SD=2.5). Both changes were towards lower values at PTV 2. Changes in the anterior region were not statistically significant (p=0.4), whereas those in the posterior region were statistically significant (p=0.02).

For the lower jaw, there were no interconnected implants in the anterior region. On the other hand, the 11 implants in the posterior region showed an increase between PTV 1 and PTV 2 of

Table 3. Distribution of patients wearing acrylic fixed prostheses (AFP) according to the number of abutment teeth (T), implants (I) and pontics (P); the sequence of these elements in the arch for each patients is also given

Patient no.	No. abutment teeth (T)	No. implants (I)	No. pontics (P)	Sequence of elements in the arch
1	1	2	0	ITII
2	2	5	1	ITIIPITI
3	2	7	3	IPTITIPIPIII
4	4	3	4	TTTIPPIPTPI
5	5	6	0	IIITTTTTIII
6	5	6	0	IIITTTTTIII
7	6	4	2	IPITTTTTTIPI

Table 4. This table shows the mean PTV at abutment connection (PTV 1) and before the installation of the final prosthesis (PTV 2), of implants that were splinted by means of AFP and those that were not; PTVs at abutment connection (TPV 1) went down after a period of time (TPV 2); although this difference was not statistically significant, it was more notable in the implants that received AFP

	PVT 1	PTV 2
splinted	−2.4	−3.0
non-splinted	−2.3	−2.4

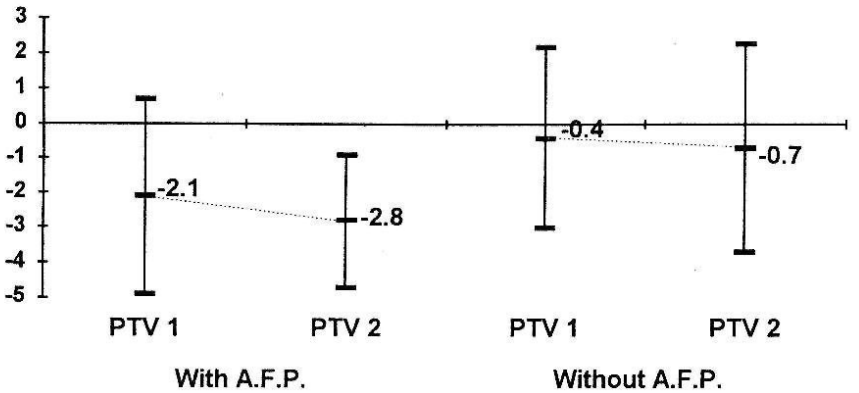

Fig. 2. This graph displays the mean PTV at abutment connection (PVT 1) and before the installation of the final prosthesis (PTV 2), of implants located in the upper jaw, which were splinted by means of an AFP and the ones that were not. PTVs at abutment connection (PTV 1) went down after a period of time (PTV 2). This difference showed to be statistically significant in the implants that received APF ($p=0.02$, paired t-test).

0.4 units (SD=0.94). This difference was found not to be statistically significant ($p=0.2$).

When controlling the effect of connecting of teeth with implants by means of AFP for a period of 6 weeks, no statistically significant reduction in the PTVs was found.

Discussion

When splinting teeth by means of a ceramometallic fixed prosthesis, for a limited period of time (mean=27.4 days), the PTV of individual teeth showed a significant reduction. This reaction is observed for both vital and non-vital teeth. When on the other hand, an acrylic provisional prosthesis is used to splint teeth or connect teeth with osseointegrated implants even for a period of 45 days, neither clinically meaningful nor statistically significant changes in PTVs of individual teeth took place. Indeed acrylic resin does not offer sufficient rigidity. It has been documented that alterations in the biophysical state of periodontal structures, can be artificially produced by compressing the periodontal ligament (Mühlemann et al. 1957, Mühlemann & Rateitschak 1965, Mühlemann 1967) or by applying abnormal forces (Picton & Wills 1981). It is not an overstatement to say that routine procedures of prosthetic treatment (for instance: impression procedures, the trying-in of the metal structures or the procedure used to remove the temporary prostheses at every session) may produce such trauma. It seems clear that in the period of preparation sessions within the prosthetic treatment (1 of 2 months), the involved teeth undergo a certain alteration on the damping capacity of the periodontium. Moreover, after a period of relative "rest" in which teeth are rigidly splinted and no therapeutic traumas are applied any more, a relative improvement could be expected on the supporting tissues condition and therefore a decrease in PTV. This is supported by several studies in man and dogs which indicate that a better tissue reorganization is reached, if the teeth are splinted during the post operative healing phase (Lindhe & Ericsson 1976, Fletszar et al. 1980).

The results obtained in the second part of this study, showed that the PTVs at abutment connection (PTV 1) went down after a period of time (PTV 2), during which some implants were splinted by means of a temporary fixed prosthesis and others were not. Although this difference was not statistically significant, it was more notable in the implants that received an AFP. It should be noted that the mean period between abutment connection and installation of the AFP plus the period of load, was 6.6 months. On the other hand, the mean period of observation after abutment connection was 3.5 months for the group that did not receive AFP.

The PTVs of splinted implants did not show any statistically significant difference after the observation period, probably because an interconnection period of less than 4 mounths was too short. Hoshaw et al. (1986) reported that after 12 months of loading, the fluorochrome label given 8 weeks after loading the implants, could be detected, suggesting that the bone deposited early in the modeling phase was being remodeled by secondary osteons. It has also been published (Lindquist & Carlsson 1985, Carr & Laney 1987, Carlsson & Haraldson 1985) that there is a gradual increase in maximum occluding force when conventional dentures are replaced by implant supported prosthesis. The application of increased functional bite forces (in relation to the local bone properties), may lead to bone microfractures which may heal with non-mineralized connective tissue (Adell 1985, Listgarten et al. 1991, Davis et al. 1988). This is likely to occur if the increased load is of a repetitive nature as occlusal forces are (Adell 1985). On the other hand, and as it may occur in the interconnected implants loaded by means of a temporary fixed prosthesis, controlled intermittent forces applied over several weeks produce an increase in bone deposition on both the endosteal and periosteal surfaces of the cortex (Sandy et al. 1993). Therefore, based on our results and according to the scientific background given in the literature, som of the reasons because the use of an AFP might be suggested are: (1) there would be a bone remodeling without peak force transmission during function, and (2) a control of the "quality" of osseointegration at abutment connection, when loaded (functional loading) would be allowed. Nevertheless and in spite of the obtained results, it is quite clear that the clinical meaning remains doubtful.

The oral environment in partial edentulism clearly differs from that in full edentulism (Naert 1991). As is known, the tissues surrounding osseointegrated implants and natural teeth are histologically and biomechanically different. It has been ascertained (Ericsson et al. 1986, Sullivan 1986, Naert 1991, Åstrand et al. 1991) that from a theoretical point of view, when fixtures and teeth are combined to serve as abutments for a fixed prostheses, differences in their bone anchorage may create a potential risk of biomechanical complications. In this study the connection of teeth and implants, showed not to induce any significant change in the periodontal tissues detectable by means of the Periotest method, within an observation period of 45 days. Again, the reason for these results might be found in the fact that an acrylic resin prosthesis does not offer enough stiffness.

Because of technological and practical reasons encountered in the follow up of patients wearing osseointegrated fixed prostheses connected with teeth, this study had to be performed with patients wearing temporary fixed prostheses made of acrylic. Nevertheless, our results agree with several published studies (Van Steenberghe et al. 1989, Naert 1991, Åstrand 1991, Naert 1993) indicating that teeth with physiological mobility can be rigidly connected to Brånemark implants. This can be done without increasing periodontal problems compared to the unconnected situation, at least for the observation periods considered. Moreover, when rigidly splinting teeth together, the mobility characteristics of individual teeth change because they start to operate as a block. For that reason it would be advantageous to study the displacement characteristics of the teeth block, in order to determine on which circumstances the mobility characteristics of implants and the teeth block are alike and the combination of both implants and teeth, to serve as abutment for a fixed prostheses, does not represent a risk of biomechanical complications any more.

Zusammenfassung

Der Einfluß der Verblockung auf die Dämpfungseigenschaften parodontaler und periimplantärer Gewebe. Eine Langzeitstudie mit dem Periotest® Gerät

Mit vorliegender Studie wurde beabsichtigt, das Potential des Periotest® Gerätes bei Entdeckung und Überwachung funktioneller Veränderungen parodontaler, wie auch periimplantärer Dämpfungseigenschaften zu bewerten. Im ersten Abschnitt dieser Studie wurden 107 Zähne mit 40 Akrylatbrücken (acrylic fixed prostheses; AFP) und weitere 37 Zähne mit 14 Metallkeramikbrücken (ceramometallic fixed prostheses; C-MFP) verblockt. Die Periotest® Messungen der einzelnen Zähne wurden am Tage vor der vorläufigen Zementierung (Periotest values 1; PTV 1) vorgenommen und nach einer mittleren Beobachtungszeit von 27.4 Tagen (periotest values 2; PTV 2) wiederholt. Im zweiten Abschnitt wurden 78 osseointegrierte zwei Phasen-Implantate mit 23 Kunststoffbrücken (AFP) verblockt. Weitere 18 Implantate wurden unverblockt belassen. Die Periotest® Messungen wurden anläßlich der Fixation der Pfeilerpfosten und vor der Inkorporation der endgültigen Brücke, an Pfeilerpfosten gleicher Länge vorgenommen. Im dritten Abschnitt wurden sowohl Implantate als auch Zähne als Pfeiler angewandt. 29 osseointegrierte Implantate wurden mit 25 Pfeilerzähnen durch 7 AFP verblockt. Die Messungen wurden zu Beginn der prothetischen Behandlung und 2, 4 und 6 Wochen danach vorgenommen. Nach AFP-Verblockung der Zähne während der Beobachtungsperiode, wurde keine wesentliche Reduktion der PTVs konstatiert. Handelte es sich dagegen um ein C-MFP, waren die PTV 2-Werte signifikant reduziert. Die anläßlich der Fixation der Pfeilerpfosten gemessenen PTV-Werte verringerten sich nach einiger Zeit. Während dieses Zeitabschnitts waren einige Implantate durch AFP verblockt und andere nicht. Obwohl zwischen den PTV-Werten der beiden Versorgungsvarianten kein erheblicher Unterschied vorlag, war er bei den mit AFP verblockten Implantaten deutlicher. Auch nach einer Zeitspanne von 6 Wochen hatte eine Verblokkung von Zähnen und Implantaten in dieser Studie zu keiner deutlichen, mit dem Periotest® meßbaren, Veränderung der Dämpfungseigenschaften der parodontalen Gewebe geführt.

Résumé

Influence des attelles sur les caractéristiques d'amortissement des tissus parodontaux et péri-implantaires. Une étude longitudinale avec le Periotest®

Le but de la présente étude a été d'évaluer la capacité du Periotest® à détecter et enregistrer les variations fonctionelles d'amortissement au niveau du parodonte et du tissu péri-implantaire. Dans la première partie de cette étude, 107 dents on été fixées avec 40 prothèses fixes en acrylique (AFP) et 37 autres ont été reliées avec 14 prothèses fixes céramométalliques (C-MFP). Les mesures du Periotest® des dents individuelles ont été faites le jour où les prothèses fixes ont été cimentées de manière provisoire (PTV 1) et à nouveau après une période d'observation moyenne de 27.4 jours (PTV 2). Dans la deuxième partie de cette étude 78 implants ostéointégrés en 2 phases ont été reliés à l'aide de 23 prothèses fixes en acrylique (AFP) et 18 autres laissés sans rien. En utilisant la même longueur de pilier, les mesures du Periotest® ont été effectuées au moment de la connection des piliers et avant l'installation de la prothèse finale. Dans une troisième partie, en utilisant tant les implants que les dents comme piliers, 29 implants ostéointégrés ont été reliés avec 25 dents piliers à l'aide de 7 AFP. Ces mesures ont été faites au début du traitement prothétique et 2, 4 et 6 semaines après. Après avoir relié les dents a l'aide de l'AFP pour la période d'observation, aucune réduction significative n'a été trouvée dans les PTV. Par contre quand un C-MFP avait été utilisé, PTV 2 accusait une réduction significative. Les PTV au moment de la connection des piliers ont diminué pendant un certain laps de temps durant lequel quelques implants étaient interconnectés à l'aide d'un AFP tandis que d'autres ne l'étaient pas. Bien que cette différence n'était pas significative, elle était plus décelable au niveau des implants ayant recus un AFP. Dans cette étude, l'établissement d'une connection entre les dents et les implants n'a entrainé aucune variation significative des caractéristiques d'amortissement des tissus parodontaux détectables par le Periotest®, même après une période de 6 semaines.

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