

A Qualitative Study on Patients' Perceptions of Two Types of Attachments for Implant Overdentures

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The aim of this qualitative study was to gain a deeper understanding of patient perceptions of wearing implant-retained overdentures with ball-shaped or cylindrical attachment systems. Twenty-two wearers of implant-supported overdentures participated in this qualitative study based on a randomized crossover clinical trial that aimed to compare a cylindrical attachment and a ball attachment. In phase I of the study, group A experienced ball attachments (n = 11) and group B Locator attachments (n = 11) for 1 year. Afterward, in phase II, the attachments were changed; group A received Locator attachments and group B received ball attachments. One week after the attachment's replacement, semistructured individual interviews were conducted. All interviews were audiotaped and transcribed. The analysis was guided by thematic content analysis. Most of the patients from both groups preferred the attachment they received in phase II, regardless the type. A major theme raised by the participants to justify their preference between the attachment types was prosthesis retention/stability, sometimes considered as a positive and other times as a negative factor. Other themes were also explored: oral function, pain, hygiene, previous experiences, confidence on the dentist's work, and esthetic. Aspects related to the retention/stability of the overdentures are the main concerns associated with the perceptions of most patients treated with implant overdentures regardless of the type of attachment. Adequate retention level should be identified and adjusted on an individual basis and maintained overtime as possible. Therefore, follow-up appointments should be planned for readjustment of the attachment's retention. Overretention should be avoided.

Key Words: *edentulous mandible, overdentures, dental implants, qualitative research, precision attachment*

INTRODUCTION

There is strong evidence from well-controlled clinical trials regarding the higher efficacy of implant-supported overdentures compared with conventional dentures in terms of patient satisfaction and quality-of-life outcomes.^{1,2} It is also noted that the attachment system plays a primary role as a mechanism of retention and stability for the implant overdenture. A wide variety of commercially available attachment systems to connect dental implants to the overdentures is presently available, for both individual and splinted implants.³ Between-implant parallelism, anatomic condition of the mandibular ridge, desired level of retention, hygiene, and cost are important considerations when choosing the appropriate attachment system.^{4,5}

Stud attachments are the most commonly used for connecting overdentures to implants.^{2,3} They are effective for retaining the overdentures; easy to install, clean, and replace;

and also relatively inexpensive.^{6,7} Recently, a self-aligning attachment system for implant overdentures with both vertical and hinge resiliencies, the Locator attachment, has been introduced to the market. Because of its small size, it is a suitable alternative for minor interarch spaces where traditional systems are difficult or even impossible to accommodate.⁸ Another advantage of this system is the availability of easily replaceable nylon components with a range of retentive capabilities to choose from.

Only a few clinical studies have been carried out to assess patient satisfaction with the retention/stability of implant overdentures and the maintenance needs associated with different attachment systems.⁹⁻¹¹ It is known that ball attachments tend to exhibit gradual but continuous degradation as well as loss of retention with repeated insertion-removal cycles.¹²⁻¹⁴ Concurrently, in a recent study, the Locator exhibited loss of retention in 75.5% of the male components after 1 year of function.¹¹ A number of quantitative studies can be found in the literature comparing different types of attachments and their impact on patients' quality of life.¹¹⁻¹⁵ However, clinical investigations of patients' perceptions of their implant-retained overdentures by different attachment systems are still scarce. A lack of data inhibits both patients and clinicians from making a well-informed decision with regard to the most appropriate attachment system for implant-overdenture therapies.

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DOI: 10.1563/aaid-joi-D-17-00166

The effort of researchers to develop instruments and methods for measuring the performance of prosthetic therapies, although legitimate, assumes normative parameters that may have little relevance to the patients themselves. It is possible that the perceived impact of the edentulism and the various treatment alternatives for this condition are only partially and superficially assessed with the use of these instruments and clinical parameters.¹⁶

To better understand patients' perceptions of the prosthetic treatment, clarify controversies, and ultimately contribute to the improvement of patients' quality of life, qualitative approaches should be considered.^{1,16,17}

Therefore, the aim of this qualitative research was to gain a rich and deeper understanding of patients' perceptions of ball and Locator attachments systems used to retain and support mandibular implant overdentures.

MATERIALS AND METHODS

The study adopted a qualitative approach. Qualitative methodologies focus on research issues rather than assumptions and aims at exploring and describing the observed phenomena instead of testing or disproving hypotheses. Qualitative research is exploratory in nature, and this is why we asked the participants of this study about their experiences with 2 different types of attachments used to retain their overdentures in place. This methodology allowed us to understand the associated events, deepening and amplifying our view of the research topic. Qualitative semistructured interviews were employed and contributed to enrich data and bring a level of understanding and interpretation that could not be achieved by means of quantitative analysis.¹⁶ We considered it most appropriate for in-depth understanding of patients' perspectives regarding implant-prosthesis therapy and related attachment systems. Data were collected through semistructured individual interviews. This study received ethical approval from the McGill Institutional Review Board, and written consent was obtained from all participants.

The data presented in this article came from a randomized crossover study conducted in Montréal, Canada, from 2008 to 2010 that aimed at comparing 2 different types of attachments. Twenty-four mandibular implant-overdenture wearers were recruited for this study. To be included in this study, the subjects were required to (1) be wearing a maxillary conventional denture and a mandibular 2-implant overdenture, (2) be willing to participate in the trial, (3) accept the protocol and sign an informed consent, and (4) be able to communicate verbally in the English or French language. Exclusion criteria were physical or physiological conditions that could impair the interviews.

In the first phase of the study (phase I), group A ($n = 12$) had ball attachments (Retentive Anchor, Straumann AG, Basel, Switzerland) and group B ($n = 12$) had Locator attachments (Zest Anchors, Inc, Escondido, Calif) connected to the implants. After 1 year (phase II), the attachments were replaced by new ones of a different type so that patients from group A received Locator attachments while patients from group B received ball attachments.

A researcher from outside the clinical team conducted the

semistructured individual interviews 1 week after the attachment's replacement (beginning of phase II), focusing on the patient's perceptions of the different types of attachment experienced in each phase of the study. The starting questions were kept open; participants were encouraged to talk about any issue regarding their perceptions of the current attachment and how it compared with the previous one they wore for 1 year. A topic guide was used to help ensure that areas of prior interest to the research team were explored in each interview. The interviews, which lasted from 15 to 25 minutes, were audio recorded for subsequent transcription.

The analysis was guided by thematic content analysis. This approach has been used successfully in qualitative health services research, generally and in the dental arena.^{18,19} Initial familiarization with the interview data reflected on the data collection, summarized findings, and identified emerging hypotheses and themes. Transcripts were systematically coded according to these themes. Thematic charts were then constructed with column headings for each theme and a row for each interview. Summaries of the relevant transcript sections were written into the charts. Potential reasons guiding the patients' preferences for specific attachment types were then identified and analyzed.

RESULTS

All 24 patients who had been treated and experienced the 2 types of attachments were invited for the interviews. Two people were excluded from the study; one from group A because of poor audiotape recording and the other from group B, who canceled the appointments due to a personal reason. The final sample was composed of 22 patients of various ages (68–81 years; mean 73.2, SD 3.1), different social backgrounds, and diverse experiences with implanted-supported overdentures. Eleven participants were female and 11 were male (ratio 1:1). Eight patients preferred ball-type attachment, 8 preferred the Locator attachment, and 6 had no preference.

Most of the patients stated that they preferred the attachment type that they were using in phase II, which for some patients was the Locator and for others the ball attachment. A major theme raised by the participants to justify their preference among the attachment from phase I, II, or none was the prosthesis's retention and stability. Other themes also developed by the participants that may have guided the patient's preference for a specific type of attachment were oral function, pain, hygiene, previous experience, confidence in the dentist's work, and esthetic. Quotations, referenced to the source interview, were used to illustrate the patient's phrases with their own language and concepts when discussing a specific subject.

The importance of retention and stability

Most of the patients preferred the attachment they were using in phase II regardless of its type, whether ball or Locator, and the main reason was the retention. For some patients, the retention represented a positive factor to guide their preference: "I prefer these ones [referring to the ball] because they are more retentive for me. . . . When I remove the prosthesis, I

don't have to force them a lot. It never lifts up or comes off, just when I force them" (vr0007).

Patients were asked to report their sense of retention on a scale ranging from 0 (*completely loose*) to 10 (*extremely tight*) during a quantitative evaluation of the attachments (data in publication process), and they were invited to comment on that evaluation: "Uh, from 0 to 10, the upper denture [conventional denture] is 8, because it's not that hard to remove. For the lower [implant-supported overdentures—Locator attachment], I would go with 10, 10 on 10. It's good, it's good, it's perfect" (vr0002).

Some patients preferred the attachment from phase II, regardless its type, because of the association that they made between retention and stability. Sometimes, these perceptions were also linked to safety (not biting their own buccal soft tissue): "They are firmer [referring to Locator]; a lot more stable. I'm not forced to pay attention because it's sure, I bit myself with the other ones that tipped over . . . it's really quite straight, you know, resting well" (vr0009).

Another important perception to guide patient preference to the current attachment was the denture fitting and comfort: "I think I would prefer to keep this one [referring to ball] at the moment. It feels like a . . . , it feels like a very expensive shoe that you just put on and, you know it's perfect, perfect. It fits better in the mouth. This one seems more comfortable in the mouth" (vr00002).

Patients reported often being able to remove their dentures using only their tongues. Reports of difficulties to remove the dentures were also frequent. Despite being very hard to remove their dentures, some of them still preferred the attachments from phase II:

With my tongue, uh, I find it's a little bit hard . . . with the old ones when I did that they rock and came out. With these ones [referring to Locator], I thought maybe that, if I would rock it, I could maybe take them off. But no, it doesn't. It holds on there. (vr0004.4)

However, other patients expressed being dissatisfied with the high retention of the attachments from phase II and had to rely on instruments to help removing their dentures, which sometimes represented an inconvenience in their social life. On the other hand, for some patients, the difficulty of removal was considered a question of practice and time to get used to the new type of attachment.

Some patients could not identify a large difference in retention between attachments, reporting that the ones from phase I might have been easier to remove but that it didn't represent a reason to guide their preference. However, for some patients, retention was a reason behind their choice for 1 of the 2 attachment types. For these patients, the attachment of phase II was too retentive, which represented a negative factor because of the difficulty of removing and reinserting their overdentures: "I prefer the other ones [referring to ball]. The other one was easy to take them out. I want these ones out, because it's too much tight" (vr00016).

Patients perceived the loss of retention over time after cycles of insertion/removal:

You know this thing here that receives that pin, it opens up with time. It's new but, uh, as you can, taking it off for

cleaning, and put it back and again it keeps on going out and out and out and out. And finally it opens up like a rose. And after the rose opened up, always fall down. (vr0006.6)

Most of the patients mentioned the "click," which is a little noise when the female is pressed against the male attachment components, to illustrate their perceptions regarding denture retention, stability, and fitting, where the click means for them that the prosthesis is in its right place: "This click is very much important for me because makes me feel confident that the dentures are in their place, correct place, adapted" (vr0007.7).

The importance of improving oral function

Most of the patients reported improvements in eating and talking with the new attachments from phase II. Another factor also reported by the patients was the presence of food underneath their prosthesis. They had fewer problems with food underneath their overdentures after changing to the new attachment, explained by the increase in retention and stability, which contributed to keep the overdentures in their place during masticatory and "talking" movements.

Naturally, while eating, then, uh, while talking, all that, they don't move [referring to ball]. I noticed it didn't move when I eat, and this is really important for me, because . . . I hate when I am eating and the dentures are like . . . dancing in my mouth. There was an improvement, because I was able to eat my vegetable soup, and to have something else after, like a meat or rice. Before I couldn't. (vr0010)

These ones [referring to Locator] have less food underneath and it appears more stable. There's almost no food there. Before there was some, and it really bothered me, every time I had to stop my meal to clean up the food underneath, so you can imagine that I couldn't go to a restaurant, it was impossible . . . now I feel more comfortable. (vr00012)

However, a few patients related that the food underneath their prosthesis was something natural that always happened in their lives, and they had to adapt to this:

This problems of food always happened with me, my dentures, even before, always retained some food. I think it is normal because there is a space between my real gums and the plastic gums. So this bothers me but I can't do anything . . . because the perfection I am never going to reach, because these are fake teeth anyways. (vr0004.4)

Presence of pain

The pain has also influenced patients' preference. Perceptions from this theme were divergent. Some patients preferred the attachments from phase I because they felt pain with the new ones on the inflamed mucosa surrounding the attachments, which was probably due to the short time after installation and during hygiene. Some patients did not have this problem and adapted themselves better with the new attachments, reporting that they did not feel pain with them.

"The only difference is when I install them, uh, maybe, I don't have the same confidence like I had before. But, uh, there's a certain pain on that side. You know sometimes there's little sores on the gums. (vr0005)

I am very satisfied, because I have no pain. It's like it's my natural teeth I would even say. (vr0004)

I like these ones better [referring to ball] because I find that my gums hurt less, around . . . around the implants. And it's less red right here. And when I brush my teeth, with my toothbrush . . . it hurts less. (vr00012)

Hygiene

Hygiene was related to the type of attachment. The ball attachment was considered easier to clean and to retain less debris than the Locator attachment by some patients who mentioned the presence of a platform in the Locator attachment that was harder to be cleaned.

The main difference between them is the cleaning. The other one [referring to ball] was easier to clean, because there was no plate. I don't know for the cleaning how good it's going to be because of the plate this one seem to have a platform [referring to Locator], which is not easy to clean up. (vr00014)

Before, with the little cylinder [referring to Locator], there was always food around the implants. I had to go with toothpicks. Toothpicks for olives, you know? It comes in a cocktail; it's ideal to go clean inside. (vr00013)

Previous experience with attachments

There was report of previous experiences with some sort of attachment that had influenced patients' preferences. In the following example, the patient was incredulous with the ball attachment because before this study, he/she had experienced this system, which failed:

Well I, the thing is that, uh, I was very happy with the previous one and this one I, what I have now, I had before some years ago which failed. In 2 weeks it goes like all over the place. . . . I feel fine with this one [referring to ball] now, no problems but in 2 weeks it'll fall out. It's just the thing, the thing that in 2 or 3 or 4 weeks I had problems with this ball. . . . The first one [referring to Locator] it's as solid, as a rock, retentive. I could eat anything I wanted with it. It never bothered me. But I don't have any complaint with this new ball yet. But I am expecting problems because I had the same system before. (vr0006.6)

Confidence in the dentist's work

Some patients explained the fact that they did not have any preference in relation to the dentist's work. They considered that the dentist's choice was the best option of treatment for them: "and that, you're the doctor, you know what you're doing, that's why I don't have any preference. Whatever you

have to do, just go ahead and I am sure you are doing your work, I trust you" (vr0006.6).

Esthetic

The esthetic (the type of attachment) was not a reason to justify the patient's preference between the 2 attachments once they affirmed that the shape, whether ball or cylindrical, was not important to them:

First of all the shapes are different, one is a little ball and looks higher in my mouth. But this is not so important because no one can see the shape of them because they are underneath the dentures. So it is hard to say which one I prefer most, because I have no preference for now. (vr0004.4)

DISCUSSION

The present qualitative study was developed to assess patient perceptions of ball and cylindrical (Locator) attachment systems used to retain/support implant overdentures. A qualitative approach including semistructured interviews with patients was used to achieve a level of understanding and interpretation of the associated conditions and psychosocial aspects, which are rarely obtained using only the quantitative methods currently available. Moreover, very few studies have analyzed patients' preferences between ball and Locator attachment systems and their impact on quality of life by means of quantitative methods,^{11,15,16} and there are no qualitative studies on this topic. The preference for one of the two types of attachment was balanced in the present study, so neither could be elected as the most suitable for most patients. These results corroborate quantitative findings from Kleis et al,¹¹ who reported a nonsignificant influence of the attachment type on patients' oral health-related quality of life. However, in a crossover study, Bilhan et al¹⁵ found different results after 3 months of function, with the Locator being equal or superior to the traditional ball attachments in all of the evaluated domains: functional limitation, psychological discomfort, physical disability, and psychological disability.

Difficulty of cleaning the Locator attachment, particularly the small space on the top of the abutment component, was a problem raised by some patients. We noticed that small seeds and food particles may get trapped in that space and be difficult to remove, sometimes interfering with the proper fitting of matrices and patrices. In a few cases, even the dentist using an explorer had some difficulty removing the particles, as they were strongly compacted into the space. Although no great importance was given to this aspect by most of the study's participants, it may become an important issue, especially if the patient has limited dexterity to clean the attachment adequately or if the components or denture get damaged by improper fitting.

Together with denture stability and fitting, the retention provided by the attachments in phase II, compared with phase I, was an important aspect of the treatment that affected the patients' perceptions and guided preferences between the attachments. Quantitative studies show that the Locator

attachment has higher initial retentiveness than ball attachments because of its extended retentive areas on both internal and external surfaces and the resiliency of its nylon components.^{11,12,20} In this study, it was expected that this characteristic would have a higher impact on patients' preferences. However, we could not detect a preference for the Locator attachment or perceptions of higher retention associated with this system. Paradoxically, patients realized that the denture retention/stability in phase II, after 1 week with new attachments, was higher than the retention provided by the previous attachment, which had been in function for 1 year. This fact demonstrates patients' ability to perceive changes in the attachment retention and also identify consequences. It is worth noting that increased retention has sometimes been considered a positive and other times a negative aspect of the attachment, independently of its type. However, loss of attachment retention overtime, after the patients had become adapted to their new attachments, was often perceived as a negative factor. Meijer et al²¹ found that the decrease in retention had an impact on the denture's stability and patient satisfaction, which was also reported by most patients in the present study.

Nevertheless, perception of retention loss varied to some extent, possibly because of many factors that influence attachment degradation. These factors have been identified in other studies at variable rates, such as masticatory load, insertion/removal pathway, number of insertion/removal cycles, between-implant angulations, implant angulation to the occlusal plane, parafunctional habits, composition and temperature of saliva, muscular strength, denture cleansers, and diet habits.^{2,22-24}

The interview data also showed that most patients linked denture stability and improvements in functional and social activities, such as eating and talking, with higher attachment retention. An increase in retention was also associated with less food underneath the dentures. However, some patients could not perceive much difference between the attachments from phases I and II, perhaps because of the fact that after 1 year in function, certain attachments may still maintain considerable serviceability.²⁵ Chaffe et al,²⁵ in a prospective study concerning prosthetic complications, reported that the mean time from baseline to the first adjustment of the same type of ball attachment tested in our study was 9.9 months. According to Payne and Solomons,²⁶ it appears difficult to predict the exact frequency of attachment replacement because it depends on an objective functionality assessment by the dentist and/or subjective assessment by the patient. A significant advance would be to determine the ideal level of retention for removable prostheses at delivery and how much patients can adapt to a decrease in retention over time. Based on this study, there is no standard of treatment with respect to the level of retention provided by attachment systems for implant overdentures, as some patients were pleased and others displeased with the level of retention of the evaluated attachments after 1 year of wearing their overdentures, irrespective of the type. Installing new attachments pleased patients who were dissatisfied with lack of retention and displeased the ones who were satisfied with the lower levels of retention provided by their previous, worn attachments.

Interviewing patients within 1 week after wearing new attachments might be considered too soon and a potential limitation of this study. However, the short period could also be regarded as an advantage, as patients' memory of the previous attachment was still fresh, allowing a more accurate comparison between the 2 types of attachments. Quantitative data from these patients were also collected and are presently being analyzed. Although the qualitative nature of the study prevents us from generalizing the results to the whole population of denture wearers, we believe that the insights obtained raise new relevant questions and have clinical applicability. Not less important, this study also showed patients' confidence in the quality of the dentist's work. The choice of attachment systems should be guided by individual clinical circumstances and, above all, the patient's needs and preferences.

CONCLUSIONS

Retention is the most important issue associated with attachment systems for implant overdenture as it affects the prosthesis's stability and function, regardless of the type. An adequate retention level should be identified and adjusted on an individual basis and maintained over time as much as possible. Therefore, follow-up appointments should be planned for readjustment of the attachment's retention. Overretention should be avoided.

NOTE

The authors declare no conflict of interest.

REFERENCES

1. Ellis JS, Levine A, Bedos C, et al. Refusal of implant supported mandibular overdentures by elderly patients. *Gerodontology*. 2011;28:62-68.
2. Naert I, Alsaadi G, Quirynen M. Prosthetic aspects and patient satisfaction with two-implant-retained mandibular overdentures: a 10-year randomized clinical study. *Int J Prosthodont*. 2004;17:401-410.
3. Buttel AE, Buhler NM, Marinello CP. Locator or ball attachment: a guide for clinical decision making [in French, German]. *Schweiz Monatsschr Zahnmed*. 2009;119:901-918.
4. Alsiyabi AS, Felton DA, Cooper LF. The role of abutment-attachment selection in resolving inadequate interarch distance: a clinical report. *J Prosthodont*. 2005;14:184-190.
5. Gulizio MP, Agar JR, Kelly JR, Taylor TD. Effect of implant angulation upon retention of overdenture attachments. *J Prosthodont*. 2005;14:3-11.
6. Krennmaier G, Weinlander M, Krainhofner M, Piehslinger E. Implant-supported mandibular overdentures retained with ball or telescopic crown attachments: a 3-year prospective study. *Int J Prosthodont*. 2006;19:164-170.
7. Winkler S, Piermatti J, Rothman A, Siamos G. An overview of the O-ring implant overdenture attachment: clinical reports. *J Oral Implantol*. 2002;28:82-86.
8. Martinez-Lage-Azorin JF, Segura-Andres G, Faus-Lopez J, Agustin-Panadero R. Rehabilitation with implant-supported overdentures in total edentulous patients: a review. *J Clin Exp Dent*. 2013;5:e267-e272.
9. Alsabeeha NH, Payne AG, De Silva RK, Thomson WM. Mandibular single-implant overdentures: preliminary results of a randomised-control trial on early loading with different implant diameters and attachment systems. *Clin Oral Implants Res*. 2011;22:330-337.
10. Bilhan H, Geckili O, Mumcu E, Bilmengoglu C. Maintenance requirements associated with mandibular implant overdentures: clinical results after first year of service. *J Oral Implantol*. 2011;37:697-704.
11. Kleis WK, Kammerer PW, Hartmann S, Al-Nawas B, Wagner W. A

comparison of three different attachment systems for mandibular two-implant overdentures: one-year report. *Clin Implant Dent Relat Res*. 2010;12:209–218.

12. Chung KH, Chung CY, Cagna DR, Cronin RJ Jr. Retention characteristics of attachment systems for implant overdentures. *J Prosthodont*. 2004;13:221–226.

13. Evtimovska E, Masri R, Driscoll CF, Romberg E. The change in retentive values of locator attachments and hader clips over time. *J Prosthodont*. 2009;18:479–483.

14. Rutkunas V, Mizutani H, Takahashi H. Evaluation of stable retentive properties of overdenture attachments. *Stomatologija*. 2005;7:115–120.

15. Bilhan H, Geckili O, Sulun T, Bilgin T. A quality-of-life comparison between self-aligning and ball attachment systems for 2-implant-retained mandibular overdentures. *J Oral Implantol*. 2011;37 Spec No:167–173.

16. Hyland R, Ellis J, Thomason M, El-Feky A, Moynihan P. A qualitative study on patient perspectives of how conventional and implant-supported dentures affect eating. *J Dent*. 2009;37:718–723.

17. Smith PA, Entwistle VA, Nuttall N. Patients' experiences with partial dentures: a qualitative study. *Gerodontology*. 2005;22:187–192.

18. Ritchie J, Spencer L. Qualitative data analysis for applied policy research. In: Bryman A, Burgess R, eds. *Analysing Qualitative Data*. London: Routledge; 1994:173–194.

19. Fulop N, Allen P, Clarke A, Black N. Issues in studying the

organization and delivery of health services. In: Fulop N, Allen P, Clarke A, Black N, eds. *Studying the Organization and Delivery of Health Services*. London: Sage; 2001:1–23.

20. Sadig W. A comparative in vitro study on the retention and stability of implant-supported overdentures. *Quintessence Int*. 2009;40:313–319.

21. Meijer HJ, Raghoobar GM, Batenburg RH, Visser A, Vissink A. Mandibular overdentures supported by two or four endosseous implants: a 10-year clinical trial. *Clin Oral Implants Res*. 2009;20:722–728.

22. Nguyen CT, Masri R, Driscoll CF, Romberg E. The effect of denture cleansing solutions on the retention of pink Locator attachments: an in vitro study. *J Prosthodont*. 2010;19:226–230.

23. Rodrigues RC, Faria AC, Macedo AP, Sartori IA, de Mattos Mda G, Ribeiro RF. An in vitro study of non-axial forces upon the retention of an O-ring attachment. *Clin Oral Implants Res*. 2009;20:1314–1319.

24. Turssi CP, Faraoni JJ, de Menezes M, Serra MC. Analysis of potential lubricants for in vitro wear testing. *Dent Mater*. 2006;22:77–83.

25. Chaffee NR, Felton DA, Cooper LF, Palmqvist U, Smith R. Prosthetic complications in an implant-retained mandibular overdenture population: initial analysis of a prospective study. *J Prosthet Dent*. 2002;87:40–44.

26. Payne AG, Solomons YF. The prosthodontic maintenance requirements of mandibular mucosa- and implant-supported overdentures: a review of the literature. *Int J Prosthodont*. 2000;13:238–243.