Insertion and removal effects of tooth supported overdentures on retention strength and fatigue resistance of attachment systems: An in vivo study

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Introduction

Over the years, fabrication of an adequately retentive mandibular complete denture has remained a challenge when compared to its maxillary counterpart with an optimum denture bearing foundation.1 It was the evolution of the concept of tooth-supported overdentures that markedly increased the retention and stability component. With the advent of implant-supported overdentures, the aesthetic, phonetic, and maintenance factors can be dealt with even in those patients with a neuromuscular compromise.2,3 It is always a justifiable fact that retaining the healthy roots of natural teeth is a better option that placing implants, thereby stressing the importance of understanding various facets of tooth supported overdentures and its clinical applications.

Various attachment systems are commercially available but little or no data is available correlating the attachment used and the overdenture support configuration especially of the tooth supported overdentures. The major problem being the wear of the elastic component, which requires regular replacement. There is no established data available that would help us identify the average life of the components, time-frame of its replacement or repair due to its usage in the oral environment. Lehmann and Arnim4 stated that during the function, stabilization of the overdenture can occur when the retention forces of attachment systems varied between 5 and 7 N whereas daily insertion and removal, the oral environment can result in the wear and loss of the prosthetic system.

Aim

Therefore, this study was conducted to find out the retention strength and fatigue resistance of two attachment systems

Keywords
Attachments, fatigue, retention, tooth supported overdentures

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Abstract

Background: Semi-precision attachments require repeated replacements and servicing in use, so it is important to understand the time frame of this wear and its possible replacement for better patient compliance. This study was aimed to assess the retention strength and fatigue resistance of Rhein OT caps and Ceka sagix attachment in the patients.

Materials and Methods: Those patients who had tooth supported overdentures incorporating Sagix and Rhein attachments were shortlisted and classified based on the time frame of denture insertion into 0, 1, 2, 3, and 4 years. An indigenous retention tester equipment (KS Enterprises, Bengaluru, India) was fabricated and calibrated to measure the force required to displace the overdenture giving the value of its retention which was further compared with the value of retention strength of newly inserted overdentures using both Sagix and Ceka attachment systems individually.

Results: The values were noted and subjected to statistical analysis for evaluating the retention loss and development of fatigue. Repeated measures of ANOVA were used which provided a statistically significant relation between the retention values of both the attachment systems on tooth supported overdentures when compared with the time period of its use in the oral cavity.

Conclusion: Sagix and Rhein attachment systems showed adequate retention values up to the period of 2-3-year with a subsequent reduction in the retention values but no component fracture of the attachment systems.
on tooth supported dentures when observed in a section of population spanning a period of 0-4 year.

Materials and Methods

Study location
This study was a simple randomized, double-blind parallel group study that was conducted in the post-graduate section, Department of Prosthodontics, SDM College of Dental Sciences and Hospital, Dharwad over the period of October 2012 to December 2012.

Sample size
Based on the sample size calculation using Open Epi, Version 2, open source calculator-SSPropor keeping the parameters of the number of patients treated with tooth supported overdentures using attachments over the last 5 years with 95% confidence interval; the sample size came to be 10 patients in each category for each of the attachment systems. The patient selection was carried out in two steps - First, a screening visit followed by an inclusion visit.

Participant selection and recruitment
Those patients who needed dentures were categorized whether tooth supported overdentures can be a treatment option with the usage of attachments. If yes, the patients underwent scaling and root canal therapy by undergraduate students (unaware about the study and inclusion criteria) who also recorded the complete details of the patient.

These shortlisted patients were then to report to verify whether the inclusion criteria fell within the scope of the study.

Exclusion criteria being
- Patients having acute pain, infection
- Patient should not have undergone a prosthetic tooth placement on the same tooth before
- Tooth should be sound periodontally
- Patient not willing to participate in the study
- Patients having difficulty in understanding instructions given in English or Hindi
- Patients aged below 18 and above 50 years are excluded from the study
- Patient having a clinical crown height of <5 mm post-root canal treatment should be excluded
- Patient having mouth opening of <15 mm should be excluded
- Patients having inadequate apical and coronal seal should be excluded.

Inclusion criteria
- No prior crown placement on the tooth
- Tooth should be periodontally healthy with good oral hygiene
- Patient who have consented to participate in the study and have given written informed consent
- Age group of the patients varying between 18 and 50 years
- Patient having mouth opening >15 mm, clinical crown height of more than 5 mm post-endodontic treatment with optimum coronal and apical seal.

The patients who met the criteria were selected, a tag number was assigned to them and computer generated random numbers to allocate them into two different groups on the category of the attachment to be used for the fabrication of tooth supported overdentures.

Those participants who already had tooth supported overdentures using the two attachments under study over the period of 1, 2, 3, and 4 years were also selected and randomly assigned a tag number to prevent any bias in the measurement of their retention values.

The investigator had a discussion with the selected patients explaining them about the study – what the study would comprise, what would be the role of patients, how the blinding will be carried out and how the bias will be avoided. They were also informed that should they decide to leave the study midways, and they were free to do so and the proposed treatment would still be provided. It was also explained to them about the traveling expenses and the daily allowance they would be getting for being a part of the study group. Once the patient had completely understood and was willing to participate, an informed consent by the study participants was taken.

Grouping
As mentioned earlier, the study comprised five groups:
- 0 years – Tooth supported overdentures will be fabricated during the study using the attachments
- 1 year – Tooth supported overdentures using attachments fabricated 1 year ago
- 2 years – Tooth supported overdentures using attachments fabricated 2 years ago
- 3 years - Tooth supported overdentures using attachments fabricated 3 years ago
- 4 years – Tooth supported overdentures using attachments fabricated 4 years ago.

Randomization
The computer generated random numbers for each of the participants who were allocated into various groups so that no selection and measurement bias occurred while recording the measurements.

An independent data monitoring committee comprised the principal investigator, chief technician and dental staff not participating in the study reviewed the unblinded data for patient safety.

Procedure
The patients with a mandibular overdenture with attachments were seated on a dental chair (including those patients for whom the overdentures were fabricated as part of the study).
Indigenously, fabricated retention testing apparatus (KS Enterprises, Bengaluru, India) [Figure 1] was used for finding the values of the retention strength in terms of the force applied to dislodge the denture. The apparatus consists of a stainless steel vertical arm to which horizontal arm is suspended at four levels: At the first level, a tooth forceps is used as a clamp for engaging the overdenture in the mouth which is suspended by a nylon string. The string passes over the pulleys attached at both the ends and connected to a force meter gauge (readings in mm and N). This force meter gauge is suspended by another string which can be rolled over a metal disc thereby engaging the wire over it, increasing the force over the pulleys, tightening and lifting the forceps that have clamped the overdentures. The calibration was carried out using weights of 50 and 100 kg to ensure the weight applied is equal to the reading noted and avoid any discrepancy. All the measurements were taken by a staff member who was unaware about the study - thereby maintaining the validity and reliability of the measurements.

The second horizontal arm of the apparatus was used as a chin-rest for stabilizing the position of the mandible before clamping the denture and applying force.

The third horizontal arm held the force gauge meter in place to prevent its untoward movement while the force is applied.

The fourth horizontal arm acts as a clamp over which the nylon wire rolls over thereby pulling the force gauge downward, applying the force transferring it over the pulley and onto the forceps that clamped the denture.

The patients and the non-teaching staff were unaware of the allocated arm, outcome assessors and data analysts were kept blinded about this allocation. The study made sure that clear demarcation was made between the member who delivered intervention and members who recorded the measurements.

Data management, quality assurance, and statistical analysis

Data collection comprised case history recording followed by a complete clinical examination. Data entry comprised both - data entered in the computer software and that marked on the case history proforma.

Data entry was carried out with the help of intercooled stata version 9. The computer generated random numbers and patients were assigned for retention testing measurement. The researchers were kept unaware of the entire allocation process to prevent any selection and measurement bias. Nominal numbers were assigned to every individual for their identification purpose during the entire course of the study. The name, age, and other personal details were recorded in the patient’s case history form during the screening visit.

An independent data monitoring committee reviewed unblinded data for patient safety in addition to a data manager who managed the entire data during the study and made sure that the working was in harmony with the study protocol. The data monitoring committee also had a quality check for the verification of the data and had the authority to revert back to the original data to test its accuracy.

An arithmetic mean of all the values in every group was taken, the minimum and maximum values defined the upper and lower limits. Then, the standard deviation was calculated followed by statistical analysis [Table 1].

The primary endpoint was the dislodgement of the overdenture thereby signifying the loss of retention component which comprised the measurement value. The measurements were taken thrice, and the average of those three values was selected.

Results

Repeated measures of ANOVA were used as part of the statistical analysis to compare the retention strength and fatigue resistance of Sagix and Rhein attachments. The results indicated that the retention values of both the attachment systems of the tooth supported overdentures had a significant variation with an increase in the duration of usage in the mouth.

<table>
<thead>
<tr>
<th>Years</th>
<th>Attachments</th>
<th>Mean±SE</th>
<th>95% CI Lower bound</th>
<th>95% CI Upper bound</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (day of insertion)</td>
<td>Sagix</td>
<td>401.00±3.81</td>
<td>392.38</td>
<td>409.62</td>
</tr>
<tr>
<td></td>
<td>Rhein</td>
<td>401.00±1.72</td>
<td>397.11</td>
<td>404.89</td>
</tr>
<tr>
<td>1</td>
<td>Sagix</td>
<td>401.50±2.30</td>
<td>396.31</td>
<td>406.69</td>
</tr>
<tr>
<td></td>
<td>Rhein</td>
<td>399.60±1.33</td>
<td>396.60</td>
<td>402.60</td>
</tr>
<tr>
<td>2</td>
<td>Sagix</td>
<td>371.00±1.83</td>
<td>335.45</td>
<td>343.75</td>
</tr>
<tr>
<td></td>
<td>Rhein</td>
<td>350.30±0.84</td>
<td>348.39</td>
<td>352.21</td>
</tr>
<tr>
<td>3</td>
<td>Sagix</td>
<td>271.20±1.20</td>
<td>268.49</td>
<td>273.92</td>
</tr>
<tr>
<td></td>
<td>Rhein</td>
<td>255.20±0.73</td>
<td>253.56</td>
<td>256.85</td>
</tr>
</tbody>
</table>

CI: Confidence interval, SE: Standard error, SD: Standard deviation
For Sagix attachment (1.7 mm) [Figure 2b], the observed mean of the removal force (g) obtained at 0 year was 401 g which remained almost the same as seen in the individual wearing the overdenture with attachment for a year, reduced to 371 g in those of 2 years usage, reduced to 340 g with 3 years usage, and finally became 270 g as seen in the individuals with 4 years of usage. On the contrary, Rhein 83 attachment [Figure 2a] has a similar value of 401 g in a newly inserted overdenture with underlying attachments which dropped to 400 g after 1 year of usage, showed a reduction to 360 g as seen in retention values for dislodging a 2-year-old overdenture, further dropped to 350 g when seen after 3 years usage and finally became 255 g as seen in a 4 years overdenture usage individual.

Repeated measures of ANOVA stated that retention loss were not significant for both the attachment systems at 0 and 1st year after usage when compared to each other but was highly significant when compared to the values seen in those of 3 and 4 years usage [Table 2 and Graph 1].

Pair-wise comparison of different cycles by Bonferroni multiple post-hoc test also confirmed statistically significant correlation between the two attachment systems when compared to 2, 3, and 4 years [Table 3].

**Discussion**

Over the past few decades, importance has been attached in conservation and preservation of the natural tooth using it as an overdenture abutment and with the availability of attachments; it has become one of the most sought after treatment modalities.[5]

The retention of various attachment systems remains more or less similar over the initial period of usage in the oral cavity, thereby increasing the patient compliance. However, what was important to know whether these retention values remain the same constantly, what is the amount of reduction that occurs subsequently warranting a replacement or repair thereby accounting for the loss of retention and development of fatigue due to constant insertion and removal cycles as seen in a patient after every meal.

So keeping that factor in mind, it was noted that the retention values remained more or less the same and comparable for both the attachment systems after 1 year of usage in the oral cavity but reduced subsequently with increased usage due to the development of fatigue. However, no fracture of the components was noted even after 4 years of usage in the oral cavity.

**Table 2: Comparison of attachments for five different time periods with retention scores by repeated measures of ANOVA**

<table>
<thead>
<tr>
<th>Attachments</th>
<th>Years</th>
<th>Mean±SD</th>
<th>SE</th>
<th>F value</th>
<th>P value</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sagix</td>
<td>0 years</td>
<td>401.00±12.05</td>
<td>3.81</td>
<td>698.7301</td>
<td>0.0000*</td>
<td>0.9984</td>
</tr>
<tr>
<td></td>
<td>1 year</td>
<td>401.50±7.26</td>
<td>2.30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 years</td>
<td>371.00±4.74</td>
<td>1.50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3 years</td>
<td>339.60±5.80</td>
<td>1.83</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4 years</td>
<td>271.20±3.79</td>
<td>1.20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rhein</td>
<td>0 years</td>
<td>401.00±5.44</td>
<td>1.72</td>
<td>2601.9670</td>
<td>0.0000*</td>
<td>0.9971</td>
</tr>
<tr>
<td></td>
<td>1 year</td>
<td>399.60±4.20</td>
<td>1.33</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 years</td>
<td>360.20±3.33</td>
<td>1.05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3 years</td>
<td>350.30±2.67</td>
<td>0.84</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4 years</td>
<td>255.20±2.30</td>
<td>0.73</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 0 years Sagix versus Rhein | P=1.0000 |
| 1 year Sagix versus Rhein  | P=0.4830 |
| 2 years Sagix versus Rhein  | P=0.0000* |
| 3 years Sagix versus Rhein  | P=0.0000* |
| 4 years Sagix versus Rhein  | P=0.0000* |

*P<0.05. SE: Standard error, SD: Standard deviation
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Graph 1: Comparison of two materials in five different cycles with retention scores

Table 3: Pair wise comparison of different time periods by Bonferroni multiple post hoc procedures

<table>
<thead>
<tr>
<th>Attachments</th>
<th>(I) factor</th>
<th>(J) factor</th>
<th>Mean difference (I-J)</th>
<th>SE</th>
<th>P value</th>
<th>95% CI difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sagix</td>
<td>0 years versus 1 year</td>
<td>−0.50</td>
<td>3.60</td>
<td>1.0000</td>
<td>−13.7830</td>
<td>12.7830</td>
</tr>
<tr>
<td></td>
<td>2 years</td>
<td>30.00</td>
<td>2.82</td>
<td>0.0000*</td>
<td>19.5930</td>
<td>40.4070</td>
</tr>
<tr>
<td></td>
<td>3 years</td>
<td>61.40</td>
<td>3.93</td>
<td>0.0000*</td>
<td>46.9080</td>
<td>75.8920</td>
</tr>
<tr>
<td></td>
<td>4 years</td>
<td>129.80</td>
<td>3.81</td>
<td>0.0000*</td>
<td>115.7360</td>
<td>143.8640</td>
</tr>
<tr>
<td>Rhein</td>
<td>0 years versus 1 year</td>
<td>1.40</td>
<td>1.79</td>
<td>1.0000</td>
<td>−5.2050</td>
<td>8.0050</td>
</tr>
<tr>
<td></td>
<td>2 years</td>
<td>40.80</td>
<td>1.67</td>
<td>0.0000*</td>
<td>34.6550</td>
<td>46.9450</td>
</tr>
<tr>
<td></td>
<td>3 years</td>
<td>50.70</td>
<td>2.11</td>
<td>0.0000*</td>
<td>42.9210</td>
<td>58.4790</td>
</tr>
<tr>
<td></td>
<td>4 years</td>
<td>145.80</td>
<td>1.76</td>
<td>0.0000*</td>
<td>139.3200</td>
<td>152.2800</td>
</tr>
<tr>
<td></td>
<td>1 year versus 2 years</td>
<td>39.40</td>
<td>1.37</td>
<td>0.0000*</td>
<td>34.3530</td>
<td>44.4470</td>
</tr>
<tr>
<td></td>
<td>3 years</td>
<td>49.30</td>
<td>1.81</td>
<td>0.0000*</td>
<td>42.6800</td>
<td>55.9920</td>
</tr>
<tr>
<td></td>
<td>4 years</td>
<td>144.40</td>
<td>1.77</td>
<td>0.0000*</td>
<td>137.8870</td>
<td>150.9130</td>
</tr>
<tr>
<td></td>
<td>2 years versus 3 years</td>
<td>9.90</td>
<td>1.52</td>
<td>0.0010*</td>
<td>4.2790</td>
<td>15.5210</td>
</tr>
<tr>
<td></td>
<td>4 years</td>
<td>105.00</td>
<td>1.37</td>
<td>0.0000*</td>
<td>99.9590</td>
<td>110.0410</td>
</tr>
<tr>
<td></td>
<td>3 years versus 4 years</td>
<td>95.10</td>
<td>1.06</td>
<td>0.0000*</td>
<td>91.1930</td>
<td>99.0070</td>
</tr>
</tbody>
</table>

*P<0.05. CI: Confidence interval, SE: Standard error, SD: Standard deviation

It was seen that the retention values reduced to about 35% of its original value in both the attachment systems over 4 years of usage which can be attributed to constant wear (P < 0.01). Wichmann and Kuntze[6] stated that any attachment system is capable of constant wear due to repeated cycles of insertion and removal in addition to the functional loads which are attributed to the frictional load occurring between the attachment and the base leading to a reduction of the retention values.

Craig[7] stated that if any material is subjected to constant stress below its yield strength, no permanent deformation...
occurs. However, constant repetitive stress as seen in fatigue test,[8-10] permanent deformation can occur.

**Conclusion**

It can be concluded that:
- Both Sagix and Rhein attachment systems showed adequate retention values up to the first 2-3 years of usage in the oral cavity
- Fatigue of about 4 years of usage in the form of repeated insertion and removal did cause subsequent reduction in the retention values but no subsequent fractures of the component systems.

**References**
