Treatment of an edentulous patient with a conventional complete denture is a challenge for both the clinician and the patient, because of the difficulty in ensuring denture stability, masticatory efficiency, and patient satisfaction. In many cases, these patients show different degrees of alveolar atrophy, especially in the mandible. As a result, some complete dentures have insufficient retention and stability that do not satisfy the needs of the patients. Moreover, implantation of such prostheses requires great technical skill.

The use of dental implants to provide retention for a dental prosthesis, together with their high survival rate, predictability, and frequent use by clinicians, has addressed the limitations of conventional complete dentures. Overdentures retained by one, two, three, or more implants have shown high implant and prosthesis survival rates but require a frequent prosthetic maintenance program.1–5 Moreover, in comparison with a conventional complete denture, two-implant–retained overdentures improve the quality of life, satisfaction, and patient occlusal force. They also delay residual bone resorption and provide higher prosthesis stability and retention while favoring psychologic response and functional masticatory ability.6–9

**Purpose:** The aim of this study was to measure and compare the retention degrees of different attachment systems before and after 1 year of mastication and removal/insertion simulations. **Materials and Methods:** A 4 × 10-mm implant embedded in self-curing acrylic resin was placed inside a rectangular metal frame installed in a plastic container with artificial saliva at 37°C. Three different attachment systems were connected to the implants: Dalbo Classic, Locator (with blue, pink, and clear inserts), and Klockner Rotula. A loading test at 100 N and 1.25 Hz frequency was repeated 10 times for each attachment (changing the matrix component or plastic insert) until a total of 300,000 cycles and 1,095 removal/insertion sequences. The retention force was assessed at baseline until the end of the test (1 year) after 3-month intervals of simulation. One-way analysis of variance (ANOVA) and post hoc Tukey test (P < .05) were performed for statistical analyses. **Results:** Klockner Rotula showed the highest retention values at the beginning (69.6 ± 9.2 N; 7.1 ± 0.9 kg) and the end of the test (51.4 ± 5.4 N; 5.2 ± 0.6 kg), while Dalbo Classic showed the lowest values both at the beginning (13.1 ± 1.7 N; 1.3 ± 0.2 kg) and the end of the test (6.7 ± 1.6 N; 0.7 ± 0.2 kg). Locator with clear insert exhibited the lowest retention loss ratio (20.4%), while Locator with blue insert showed the highest (50.8%). At the end of the test, all attachment systems showed a significant decrease in retention force in comparison with the initial retention (P < .001). **Conclusion:** Locator attachments with clear and pink inserts and the Klockner Rotula attachment system showed retention forces > 20 N (2 kg) after 1 year of mastication and prosthesis insertion/removal simulation. All attachment systems showed a progressive loss of retention, which was higher for Locator attachments with blue and pink inserts and Dalbo Classic. The Klockner Rotula attachment system showed the highest retention values both at the beginning and the end of the test. Int J Oral Maxillofac Implants 2022;37:556–562. doi: 10.11607/jomi.8908

**Keywords:** attachment, dental implants, overdenture, retention
ranging from bars of different shapes to stud- or ball-attachment systems. However, there is still controversy regarding the use of bar- or other-attachment systems. The benefits of both systems have been evaluated with no clear conclusions. Recent systematic reviews with and without meta-analysis related that there is insufficient evidence to demonstrate the superiority of one system over the other in terms of marginal bone loss, prosthetic complications, implant survival rates, overdenture retention, and patient satisfaction.\textsuperscript{10–14} Both types of retentions have advantages and limitations that clinicians have to consider before choosing the optimal system. The current trend is to select attachment systems because of their lower cost, technical simplicity, easier repairs and access to hygiene, lower prevalence of gingival hyperplasia, and requirement of lower prosthetic space. However, the attachment definition involves concepts such as fixation, retention, and stabilization of a prosthesis that often necessitate the selection of a specific kind of attachment system. Many commercial brands distribute attachment systems of different designs and retentive forces that may not necessarily be known by the clinician, in addition to their efficiency in the oral environment. In general, clinicians often choose an attachment system with sufficient retentive force empirically, only taking account of patient comfort and satisfaction. Clinical evidence shows that patients feel more confident and satisfied with attachment systems that are more retentive but do not show excessive retention.\textsuperscript{15,16} However, how much force is necessary to ensure good prosthetic retention, and what are the factors that could modify it? In theory, the response would be a force equal to or greater than the opposing masticatory extrusive forces, but attachment systems suffer structural changes in the oral environment, since chewing forces with plaque accumulation and removal/insertion movements cause wear of the attachments and reduce their retentive force. Retention values between 4 and 20 N (0.4 to 2 kg) are known to be enough to achieve overdenture stabilization and patient comfort and satisfaction.\textsuperscript{5,16,17} However, the retentive capacity of different attachment systems in functional conditions is not well known. Therefore, clinicians need further clarification before choosing an attachment system with adequate retention and lower retentive loss in the medium term.

Some in vitro studies, which were conducted under different experimental conditions and are not strictly comparable, have been performed to evaluate the influence of simulated mastication and overdenture insertion/removal with different ball and stud attachment systems, including Locator and Dalbo, with a wide range of initial and postloading retentive values.\textsuperscript{18–22} Other factors influencing overdenture attachment systems related to the distance and angulation between implants, direction of the exerted forces, and attachment dimensions and designs have also been studied.\textsuperscript{23–30} Although all these factors have clinical relevance, it is important to determine the behavior and the aging of the attachment systems subjected to habitual mastication in the oral environment. However, the variability of the loading test conditions related to applied force, number, and frequency of mastication cycles reduced the comparability of the findings.\textsuperscript{18–21} Moreover, the effect of the oral environment (saliva) on the wear and the loss of retention of the attachment systems has not been taken into account.\textsuperscript{31,32}

Among the different attachment systems, Locator (Zest Anchors), Dalbo Classic (Condres++Métaux), and Klockner Rotula (Soadco) are commonly used in daily practice, with the Locator attachment system being used often. Locator is the most used within the stud attachment systems. It offers a variety of patrix element heights from 1 to 6 mm and allows correction of an angulation between two implants of up to 40 degrees. Some in vitro studies on two Locator attachment-retained overdentures with simulated mastication between 100,000 and 400,000 cycles showed mean initial retention values between 9.9 and 66.4 N (1 to 6.8 kg) and between 6.23 and 44.63 N (0.6 to 4.6 kg) postloading.\textsuperscript{18,19,21} Another study performed in oral environment conditions (deionized water and temperature control) showed that the Locator attachment with clear inserts showed a retention value of 42.56 N (4.4 kg) in comparison to 20.58 N (2.1 kg) and 37.48 N (3.8 kg) for blue and pink inserts, respectively, after 1 year of simulated mastication. Another study performed in similar conditions showed different degrees of loss or gain in removal force percentages depending on the Locator insert used.\textsuperscript{33} Dalbo Classic is a ball attachment system. It is associated with an Elitor precious metal retention element to reduce wear of this matrix component. Another study performed with artificial saliva and the Dalbo Classic ball attachment showed mean retention values of 3.1 N after 10,000 insertion/removal cycles.\textsuperscript{22} The Klockner Rotula is a special ball attachment with a higher diameter and friction surface than other similar spherical attachment systems, with its retention being attributed to the friction and sealing of the matrix component over the maximum contour line. This special design allows disparallelism between implants until 15 degrees. However, there is no scientific literature available about this attachment system.

The heterogeneity in the existing studies and the lack of retention loss data of these different attachment systems, especially in an oral environment (saliva and temperature control), have necessitated the provision of adequate information to help clinicians choose the adequate attachment system. Therefore, the aim of this study was to evaluate and compare the retentive force of three
different attachment systems (one stud and two ball), used in implant-retained overdentures after a year of simulated dynamic mastication and insertion/removal of the prosthesis in an oral environment with artificial saliva and controlled temperature at 37°C. The null hypotheses were that the initial retentive force of the three attachments was similar and that the percentage of retention loss after the insertion and removal cycles was < 50%.

MATERIALS AND METHODS

Working Model
The working model consisted of a Klockner Essential Cone 4 × 10–mm implant (Soadco) embedded in an autopolymerizable acrylic resin (Unifast Trad, GC Europe) that filled an ad hoc rectangular metal frame. The implant was placed perpendicular to the horizontal plane of the metal frame with the aid of a parallelometer. Before the resin polymerization, the implant was placed on the center of the metal frame, leaving the machined collar outside. This position was maintained until completion of acrylic resin polymerization (Fig 1). The metal frame with the implant was fixed to a transparent plastic recipient filled with artificial saliva (Fusayama-Meyer, Pickering Laboratories) at a constant temperature of 37°C controlled with a water heater (Fig 2). This artificial saliva is similar to natural saliva and has been used in previous studies; its composition is shown in Table 1.

Then, the patrix component of the three studied attachment systems (Dalbo Classic ball attachment, 2-mm-high Locator stud attachment, and 2.85-mm-high, 4.2-mm-diameter Klockner Rotula spherical attachment) were fastened to the implant at 30 Ncm². For Dalbo Classic, a metallic matrix component was used; the Klockner Rotula matrix is made of a high-stiffness plastic, POM C (polyoxymethylene copolymer), with a retentive surface of 27.5 mm²; and for the Locator attachment group, three nylon inserts of different retentive forces were used: blue, pink, and clear (Fig 3). The matrix of each attachment was placed on its corresponding patrix, and similar to the clinical protocol, it was embedded in an autopolymerizable acrylic resin that filled another rectangular metal frame that was placed over the metal frame with the implant/patrix complex (Fig 4). After resin polymerization, the metal frame with the matrix was dislodged, and excess material was removed. Once the loading/
traction test was ended for a determined patrinx/matrix complex, the matrix component was removed from the framework with the aid of a micromotor and a round tungsten bar and was replaced for another new matrix; at the same time, the patrinx component was fastened to the implant. The metal framework with the matrix component was fixed to the loading machine using a thread system.

Loading/Traction Test and Registration and Measurement Procedures

The working model was transferred to an EM1/5FR universal loading test machine (Microtest; Fig 5). Each attachment system was subjected to dynamic loading that simulated habitual mastication and use by a patient, consisting of axial loading cycles of 100 N at a frequency of 1.25 Hz and insertion/removal cycles (performed automatically by the loading machine).

The loading machine was programmed to first perform 274 compression loading cycles, followed by matrix removal, with recordings obtained at the moment of the dislodging force. This sequence of loading/removal was repeated 1,095 times. Thus, a total of 300,000 cycles of simulated mastication and 1,095 removal/insertion cycles were performed. This process was performed 10 times for the Dalbo Classic and Klockner Rotula attachment systems and 30 times for the Locator attachment system (10 for each insert: blue, pink, and clear). Even considering the wide interindividual variabilities in mastication and usage, 1,095 removal/insertion was repeated 1,095 times. Thus, a total of 300,000 cycles of simulated mastication and 1,095 removal/insertion cycles were performed. This process was performed 10 times for the Dalbo Classic and Klockner Rotula attachment systems and 30 times for the Locator attachment system (10 for each insert: blue, pink, and clear). Even considering the wide interindividual variabilities in mastication and usage, 1,095 removal/insertion cycles were estimated to equal a year of insertion/removal of the prosthesis 3 times a day, and 300,000 loading cycles are considered to be equal to the mastication of an individual during a year. However, dislodging force values were registered at the start of the test and at 75,000, 150,000, 225,000, and 300,000 cycles, which correspond to 3, 6, 9, and 12 months of simulated mastication. The SCM3000 software (Microtest) was used to perform all the loading and removal/insertion tests.

Statistical Analysis

The Shapiro-Wilk test was used to examine the adjustment between the variables to a normal distribution with homogenous results. As parametric tests, one-way analysis of variance (ANOVA) and post hoc Tukey tests were performed to evaluate the statistical significance between and within groups related to the retention force changes registered in the study. The level of significance was determined at \( P < .05 \) for all comparisons in the study. Statistical analysis was performed using Minitab 19.2 software (Minitab).

RESULTS

Mean retention values, statistical significance, and retention loss percentage, determined as the Retention Index (1−Retention after load/Retention before load \times 100), of different attachment systems are shown in Table 2.

The Klockner Rotula attachment system showed the highest retention force before the loading test as well as at the end of the 300,000 simulated mastication cycles and at all the intermediate times registered \( P < .001 \). However, at the end of the test, this attachment lost approximately one-fourth of its initial retention force, which was behind that of Locator with the clear insert (Retention Index, 19.8%). In contrast, the Dalbo Classic attachment showed the lowest retentive force at the start and at the end of the test, with force values far below the other attachment systems and a retention loss close to 50%, similar to the 50.5% retention loss for the Locator with blue insert attachment.

After the simulated mastication test, Dalbo Classic and Locator with blue and pink insert attachments showed lower retentive values and lower retention indices of approximately 50%, in comparison with the 20% to 25% indices of Locator with clear insert and Klockner Rotula attachments, respectively, although
the values were not significantly different. Likewise, all the attachment systems showed statistically significant differences between the final and initial retention force values ($P < .001$; Table 2, Fig 6).

**DISCUSSION**

This study evaluated the retention loss of three different attachment systems (two ball and one stud attachment) used as retentive systems in implant-retained overdentures after 300,000 loading cycles and 1,095 dislodges, equaling 1 year of simulated mastication and removal/insertion of the prosthesis, respectively. One of the null hypotheses must be rejected given that the differences in initial retention between the three attachments were significant; the other one cannot be rejected, however, as the attachments showed a percentage of loss of retention force < 50%, with the exception of the Locator blue insert, which was slightly higher (50.5%).

Scientific evidence endorses the use of implant-retained overdentures to improve masticatory function, quality of life, and satisfaction in edentulous patients.5–9 However, attachment retention loss could jeopardize all these advantages. Hence, to choose the most suitable attachment system despite the variabilities across different systems, clinicians should have information regarding retention loss and the period of time in which this could happen. Although there is abundant literature related to the retention of different attachment systems under different experimental conditions,18–24,28–30 information about the minimum retention value required to maintain the function of an implant-retained overdenture with satisfaction for the patient is insufficient. Patients often ask clinicians for a solution to this problem, which is a frequent mechanical-technical complication.2,5,16 Retention values between 4 and 20 N (0.4 to 2 kg) have been considered to be sufficient to ensure patient comfort and stabilization for overdentures,5,16 while those between 5 and 7 N (0.5 to 0.7 kg) are considered adequate for bar attachment systems.17 If the data obtained in this study are reliable, the Klockner Rotula and Locator attachment with clear and pink inserts could be considered capable of overcoming 20 N (2 kg) of retentive capacity after a year of simulated mastication, according to other studies performed with Locator and clear insert.21 On the other hand, Locator with blue insert and Dalbo Classic attachments with retention loss indexes of 50% could need more frequent activation or replacement of the matrix component. This study showed a progressive loss

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**Table 2 Values of Retention (in Newtons)**

<table>
<thead>
<tr>
<th>Thousand cycles</th>
<th>Locator blue insert RI (%)</th>
<th>Locator pink insert RI (%)</th>
<th>Locator clear insert RI (%)</th>
<th>Dalbo Classic RI (%)</th>
<th>Klockner Rotula RI (%)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>22.10 (1.30)</td>
<td>36.46 (3.46)</td>
<td>50.95 (5.08)</td>
<td>13.10 (1.74)</td>
<td>69.64A (9.16)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>75</td>
<td>18.99 (1.13)</td>
<td>32.40 (4.07)</td>
<td>48.97 (4.62)A</td>
<td>10.96 (2.13)</td>
<td>65.62A (8.22)</td>
<td>5.7 &lt; .001</td>
</tr>
<tr>
<td>150</td>
<td>15.80 (0.99)</td>
<td>27.81 (3.18)</td>
<td>46.19 (4.81)</td>
<td>9.4</td>
<td>9.11 (1.38)</td>
<td>30.5</td>
</tr>
<tr>
<td>225</td>
<td>12.96 (0.65)</td>
<td>23.51 (2.00)</td>
<td>44.74 (4.68)</td>
<td>12.3</td>
<td>7.89 (1.54)</td>
<td>39.7</td>
</tr>
<tr>
<td>300</td>
<td>10.06B (0.97)</td>
<td>20.40 (2.34)</td>
<td>40.93 (6.22)</td>
<td>19.8</td>
<td>6.72B (1.64)</td>
<td>48.8</td>
</tr>
<tr>
<td>450</td>
<td>7.29B (1.40)</td>
<td>17.71 (2.96)</td>
<td>38.04 (6.94)</td>
<td>17.6</td>
<td>5.71B (1.69)</td>
<td>46.8</td>
</tr>
<tr>
<td>600</td>
<td>5.90B (1.20)</td>
<td>15.41 (2.64)</td>
<td>35.38 (6.82)</td>
<td>15.4</td>
<td>4.90B (1.25)</td>
<td>44.6</td>
</tr>
<tr>
<td>750</td>
<td>4.70B (1.00)</td>
<td>13.21 (2.34)</td>
<td>32.82 (6.68)</td>
<td>13.2</td>
<td>4.10B (1.10)</td>
<td>42.5</td>
</tr>
<tr>
<td>900</td>
<td>3.70B (0.80)</td>
<td>11.01 (2.06)</td>
<td>30.33 (6.54)</td>
<td>11.0</td>
<td>3.30B (0.95)</td>
<td>40.3</td>
</tr>
<tr>
<td>1050</td>
<td>2.90B (0.60)</td>
<td>9.80 (1.78)</td>
<td>28.78 (6.40)</td>
<td>9.8</td>
<td>2.80B (0.80)</td>
<td>38.1</td>
</tr>
<tr>
<td>1200</td>
<td>2.20B (0.40)</td>
<td>8.60 (1.48)</td>
<td>27.24 (6.26)</td>
<td>8.6</td>
<td>2.30B (0.70)</td>
<td>35.9</td>
</tr>
<tr>
<td>1350</td>
<td>1.60B (0.20)</td>
<td>7.40 (1.18)</td>
<td>25.69 (6.12)</td>
<td>7.4</td>
<td>1.80B (0.60)</td>
<td>33.7</td>
</tr>
<tr>
<td>1500</td>
<td>1.10B (0.00)</td>
<td>6.20 (0.88)</td>
<td>24.15 (5.98)</td>
<td>6.2</td>
<td>1.40B (0.50)</td>
<td>31.5</td>
</tr>
<tr>
<td>1650</td>
<td>0.70B (0.00)</td>
<td>5.00 (0.58)</td>
<td>22.60 (5.84)</td>
<td>5.0</td>
<td>1.00B (0.40)</td>
<td>29.3</td>
</tr>
<tr>
<td>1800</td>
<td>0.30B (0.00)</td>
<td>3.80 (0.28)</td>
<td>21.05 (5.70)</td>
<td>3.8</td>
<td>0.60B (0.30)</td>
<td>27.1</td>
</tr>
<tr>
<td>1950</td>
<td>0.10B (0.00)</td>
<td>2.60 (0.18)</td>
<td>19.50 (5.56)</td>
<td>2.6</td>
<td>0.30B (0.20)</td>
<td>24.9</td>
</tr>
<tr>
<td>2100</td>
<td>0.00B (0.00)</td>
<td>1.40 (0.08)</td>
<td>18.05 (5.42)</td>
<td>1.4</td>
<td>0.10B (0.10)</td>
<td>22.7</td>
</tr>
</tbody>
</table>

Standard deviation in brackets. Months of simulated mastication in bold. Tukey test: A statistically significant differences compared with the rest of the attachments and vice versa; B statistically significant differences compared with the rest of the attachments except Dalbo Classic. RI = Retention Index.
of retention capacity, which is consistent with previous studies and also with the clinical reality of replacement or periodic activation of the attachment retention system. However, other in vitro studies noted fluctuations in postloading retention forces on Locator attachment systems with blue, pink, and clear inserts.\(^2^\)\(^9^\),\(^2^0^\)

Furthermore, although the number of mastication cycles per day may vary depending on the employed time, the kind of food, and the masticatory efficiency of each individual, the experimental conditions in this study (number of cycles, artificial saliva, and \(37^\circ\)C controlled temperature) were very similar to the oral environment. The combination of these factors and the heterogeneity of experimental conditions in similar previous studies make comparisons difficult. However, the initial retention of Locator attachments with all plastic inserts was higher than the values reported by the manufacturer and shown by other studies.\(^1^9^\),\(^2^0^\),\(^3^3^\)

This could be explained by the differences in the study design and the manufacturing process of the plastic insert. Likewise, if it is not contraindicated by clinical reasons, clear and pink inserts are the most suitable in terms of retention for the Locator attachment system.

Furthermore, although the Dalbo attachment system, including Dalbo Classic, is a commonly clinically used system, there are no comparable studies in the literature for this system. To address this limitation, Bayer et al.\(^2^2^\) tested some Dalbo attachment types and showed that for Dalbo Classic, the retention values at the start (5.3 N/0.5 kg) and at the end of the test (3.1 N/0.3 kg) were approximately 50% lower than those obtained in this study. However, these retention values are lower than the minimum recommended for patient satisfaction and overdenture stabilization, and they could be indicated for elderly people with decreased muscle strength. Thus, insertion/removal of the prosthesis with this attachment system would be easier from the beginning, but they would involve a higher replacement/activation index of the matrix components. These results agree with the initial lower retention values registered by some authors for Dalbo attachment systems: between 9.93 and 15.71 N (1 to 1.6 kg) depending on the angulation between the components and even lower, between 5.2 and 5.4 N (0.5 to 0.6 kg), for the Dalbo Z attachment.\(^2^2^\) In addition, the present study showed the progressive loss of retention in all the tested attachment systems over time, which is also observed in actual clinical practice. These results contradict the findings of other similar studies with Locator, Dalbo, and other ball attachment systems that assessed the fluctuations of the retention values during the insertion/removal cycles.\(^1^9^\),\(^2^0^\),\(^2^2^\),\(^2^5^\),\(^2^6^\),\(^2^7^\),\(^3^3^\)

On the other hand, there is a lack of evidence about the in vivo or in vitro clinical performance of the Klockner Rotula attachment system. A priori, it is an effective attachment with an initial and postloading retention force higher than the minimum of 4 to 20 N (0.4 to 2 Kg) described earlier.\(^5^\),\(^1^6^\),\(^1^7^\) The higher initial and final retention values of this attachment system favor its use in patients with higher muscular activity or with a reabsorbed alveolar bone with a lower replacement index of the matrix component. This advantage could be the result of the rigidity and the abrasion and chemical resistance of the crystalline copolymer of the matrix component. However, more investigations with similar experimental conditions are needed to confirm the results shown in this study. Furthermore, although the available data are not strictly comparable, initial and postloading retention values of this attachment are notably higher than those of other similar systems (ball, ball-socket, spherical, etc.\(^1^6^\),\(^2^1^\),\(^2^2^\),\(^2^4^\),\(^2^6^\),\(^2^7^\),\(^3^3^\)

Furthermore, the differences between plastic and metal matrices must be taken into account. It is true that plastic elements can degrade earlier; however, their replacement is easier than that of a metallic one, reducing the clinical time needed and the economic cost for the patient. Although this study provided some information for the clinical use in relation to the time of use and the retention of three attachment systems for implant-retained overdentures, it is not free from limitations. During the tests, only one implant with axial loading cycles of 100 N was used. Although this approach helped avoid biases related to distances and angulations between implants, it limited the comparability of this study with others that employed a habitual design of overdentures retained by two implants. The use of two implants placed at different angulations between them, simulating a common clinical situation, could have changed the results of this study. However, single-implant–retained overdentures have shown a good effectiveness/cost relationship and high implant and prosthesis survival rates.\(^1^\) The axial direction and force employed in this study could be another limitation, because masticatory cycles are a complex process and there is a wide range of variability in both the magnitude and direction of the occlusal forces as well as the amount and direction of the applied force by an individual in the insertion/removal of the prosthesis. Despite control of the humidity and temperature (artificial saliva at \(37^\circ\)C), there were individual factors related to the presence of different types of bacteria in the oral environment that could have an effect on the attachment retention loss.\(^3^1^\),\(^3^2^\) This could be another limitation of the study. Another limitation of the study could be the use of a constant temperature of \(37^\circ\)C, since most of the experimental studies are designed in a thermocyclic way, constantly varying the temperature from \(5^\circ\)C to \(55^\circ\)C. Accordingly, more investigations considering all these factors, with standard experimental conditions, more simulated mastication time, and clinical studies, are needed.
CONCLUSIONS

Within the limitations of this in vitro experimental study and according to the obtained results, it can be concluded that all the attachment systems evaluated showed adequate clinical behavior. However, Dalbo Classic system and Locator attachments with blue and pink inserts showed a higher rate of progressive retention loss in comparison with the rest of the evaluated systems. The higher retention value at all test stages was found using the Klockner Rotula attachment system.

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REFERENCES