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STUDY COMPARING THE CHEWING ABILITY OF DENTATE SUBJECTS, COMPLETE REMOVABLE DENTURES, AND MAXILLARY MINI DENTAL IMPLANT OVERDENTURES

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Abstract:
Rehabilitation of an edentulous maxilla using mini dental implants (MDIs) is a cost-effective, less invasive alternative to traditional removable full dentures (CRD). Quantitative studies comparing masticatory ability under different oral circumstances are rare, however. Studying how dentate groups, maxillary complete removable dentures (CRD), and full upper dentures fared in terms of both subjective and objective masticatory performance was the focus of this study (MDI). Toolkits and Methods: Complete dentate subjects (DP), Dentate dental students (DS), maxillary CRD or MDI overdentures (MDI), and dentate mandible (DM) are all participants in this research. Their ages range from 20 to 50 years old. Using a circular Variance of Hue (VOH meter (Hue-check View Gum® Test), a scientific investigation was carried out to determine whether or not it is possible to mix two different colors of chewing gum. Subjective masticatory experiences were also compared between the CRD group and the MDI group using OHRQL, OHIP-14 questionnaire, and a visual analog scale (VAS) for various food consistencies. The mean VOH for dentate dental 20+ students was 0.11 (standard deviation = 0.50 & range = 0.05-0.27), while the mean VOH for dentate dental 50+ students was 0.13 (standard deviation = 0.08 & range = 0.03-0.31) (p = 0.774). Dentate dental CRD patients had a mean VOH of 0.41 (standard deviation = 0.41, range = 0.14-0.76). It is important to note that the difference in VAS ratings between the groups who received CRD or MDI overdentures (p > 0.050) is not significant. The average OHIP-14 total score for patients with CRD was 12.10 (SD 15.87, range 0-56), although this significantly decreased to 2.85 (p = 0.039) for those who received MDI. (Standard Deviation: 2.8, Interquartile Range: 0-15) Those aged 20 and up and those aged 50 and up showed similar outcomes in terms of objective masticatory skills, but those with CRD and MDI fared far worse. It was shown that both subjective and objective masticatory performance was not significantly better with MDI overdentures than with CRD. A significant improvement in OHRQL was seen, however, for MDI.
Keywords: dental implants, oral, mastication

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INTRODUCTION:

Dentists often treat individuals with complete maxillary eventually who also have dentures and dentate mandibles [1]. Kelly Syndrome [2] describes the gradual bone resorption of the front edentulous maxilla that may develop over time. Implants might be used to alleviate this issue by reducing the compressive tension on the mucosa and bone underneath. This might help slow or stop the loss of alveolar bone in the jaws' vertical and horizontal axes [3]. However, if the maxilla has undergone severe resorption, the lack of appropriate bone volume may prevent the insertion of standard-diameter (>3.5 mm) implants, necessitating further bone grafting surgeries. Pneumatization of the maxillary sinus complicates rehabilitation of the distal edentulous maxilla, and the anterior maxilla becomes overly thin (knife edge) as a consequence of the resorption process [4,5]. Onlay bone grafts in the front region of the maxis have been used in combination with a variety of methods for increasing the size of the maxillary sinus. Several biomaterials have joined the gold standard of autologous bone, either as a substitute for or in addition to autologous bone, and all are protected by either resorbable or non-resorbable membranes [6]. This has greatly complicated the standard implant treatment. Withdrawal from implant therapy is common due to patients' deteriorating health, dread of reconstructive surgery, and inability to afford the procedure. Traditional implant therapy is also rejected by the elderly for similar reasons [7]. The micro dental implants (MDI) one-piece usage to maintain overdentures may be a good option for rehabilitating the edentulous atrophic maxilla since it is the simplest, least invasive, and least complex operation that can be performed for this purpose. MDI are preferred because of its morbidity, it's cost effectiveness, surgical time reduction, and because they may prevent the need for sinus augmentation or bone restoration. One-piece implants reduce screw-held abutment-related bone resorption [8]. Mini-implants, or minimally invasive dental implant procedures (MDI), have a diameter of less than 2.5 mm. Maxillary MDIs have a higher failure rate [12], although this may be countered by their lower prices, less invasive surgical process, and enhanced Oral Health Re-linked Quality of Life [13].
Implant therapy in the edentulous maxillary jaw aims to restore dental and oral function, particularly masticatory skills [14]. Chewing food thoroughly before swallowing and digesting is called mastication [15]. Maximum biting force on occlusal contacts (masticatory force) is much lower, occlusal force is the consequence of teeth and jaw movement during chewing. Selecting the food to be put between the teeth and then breaking it down into smaller pieces (breakage) are two distinct steps in the mastication process [17]. Efficiency and effectiveness in chewing are indicators of masticatory ability [18]. The ability to mash or chop test food into smaller pieces is used to evaluate mastication performance under controlled laboratory circumstances, whereas efficiency is defined as the amount of work needed to accomplish a certain degree of comminution [19]. Masticatory performance has previously been evaluated only on the basis of patient satisfaction or ad hoc generally approved techniques [20] before the year 1950. The comminution method and the colorimetric method [21,22] are only two examples of the many newly developed objective tests. The first method considers how small the particles of the test meal get during digestion. The ability to chew increases as the particles get smaller. This mixing degree may be determined visually with the help of color scales [23] or digitally with the assistance of software [24,25]. Based on the available evidence [21], it seems that both methods produced similarly reliable results during testing.

The use of mini dental implants (MDIs) to stabilize an overdenture in a patient with an edentulous maxilla has the potential to restore masticatory function and make it functionally equivalent to a dentate state. However, we must stress that a comparison enumeration has never been undertaken and cannot be inferred from the existing research. The goal of this research was to examine the differences in masticatory function between dentate dental students aged 20 and up, dentate subjects aged 50 and up, and dentate subjects aged 50 and up who wore maxillary complete removable dentures (CRD) and removable partial dental implants (MDI). After considering the following null hypotheses (H0),
Hypothesis 1: With MDI overdentures, mastication is more efficient than in patients with CRD.
Hypothesis 2: 50+ dentate participants and 20+ dental students show similar masticatory performance;
Hypothesis 3: Ones with MDI overdentures have the similar masticatory performance to dentate subjects.

MATERIALS AND METHODS:

Study Design: We defined 4 groups. Group 1 consisted of 20 or more dentate dental students (DS), Group 2 consisted of 50 or more dentate adults (DP), Group 3 consisted of 50 or more dentate maxillae and dentate mandibles (CRD), and Group 4 consisted of 50 or more dentate maxillae and dentate mandibles with impacted wisdom teeth (MDI).

Dentate participants had both the upper and lower arches of their jaws fully developed, with at least five teeth present in each quadrant. Previous publications

[12,13,26,27] detailed the MDI patients' treatment procedures and clinical results. Twenty participants from the MDI clinical prospective trial were selected at random to take part in the masticatory study during the study's annual follow-up. TMJ dysfunction, uncontrolled systemic disease, advanced osteoporosis, bisphosphonate treatment, mental or physical illness, and patients receiving radiation were all disqualifying factors for participation in any of the study groups. The clinical research was approved by the Mayo Hospital's Ethical Committee.

MDI Overdenture Treatment: The free-handed flapless surgery was guided by a preoperative CBCT and was performed by the same surgeon, L.V.D., who was responsible for inserting all of the MDI implants in the maxilla. A fitted denture was also inserted during this procedure. For this study, researchers relied on metal-on-diamond (MDI) implants made by ILZ Southern Implants of Irene, Gauteng, SA. These MDIs were either 10 or 11.5 mm in length and had a 2.4 mm diameter; they were made of pure grade 4 titanium, which is known for its strength. There was one machined surface with 0.4a mm Sa value and one roughened surface with 1.5 mm Sa value on the MDIs. A length of 4.8 mm was achieved when the surface was machined. The denture was modified using a soft tissue reliner called Coesoft gel, allowing for early loading (GC America, Chicago, Illinois, United States). The United States was the location of this operation. Six months later, the patient got his permanent horseshoe denture, which included metal support in the palatal area. Clinical intraoral situation shown visually in Figure 1.

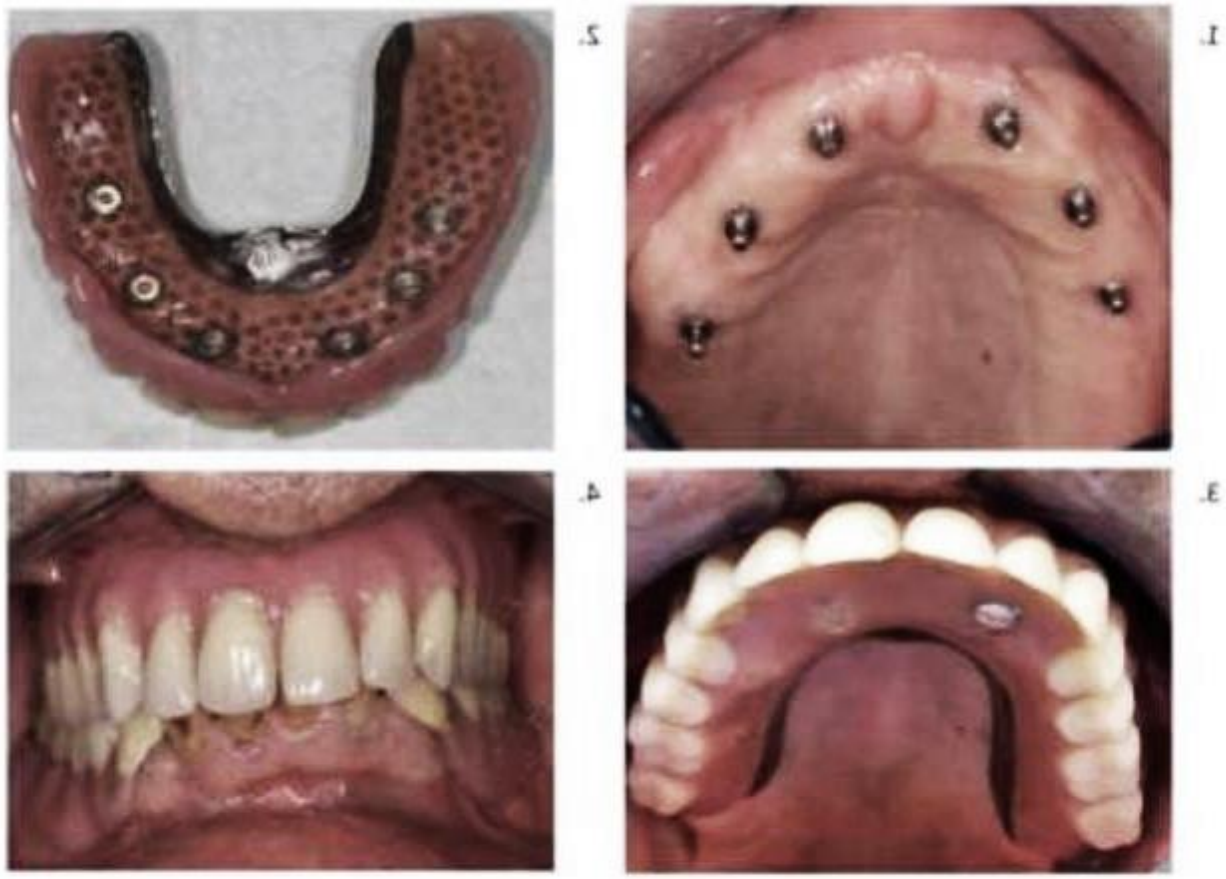

Figure 1: (1) MDI in atrophic maxillary jaw; (2) MDI overdenture mucosal side; (3) MDI overdenture in situ; (4) MDI overdenture in occlusion.

Objective Masticatory Performance Test: The Hue-check View Gum® Test, which measures the ease with which two different coloured gums may be mixed together, was used to evaluate masticatory function (Orophys, Bern, Switzerland). This test was described in detail and shown to be accurate by Schimmel et al. [25,28] and Halazonetish et al. [29, 30]. Performance in terms of objective mastication was measured across all four of the newly established groups. Every participant was given the exact identical instructions from the same operator (B.D.B), which included having them chew gum for 20 cycles on the side that was most comfortable to them. After the gum had been chewed to its completion, it was placed in a clear plastic bag, and the date as well as the person's name were written on the bag. The Digital View gum analysis is shown in Figure 2.

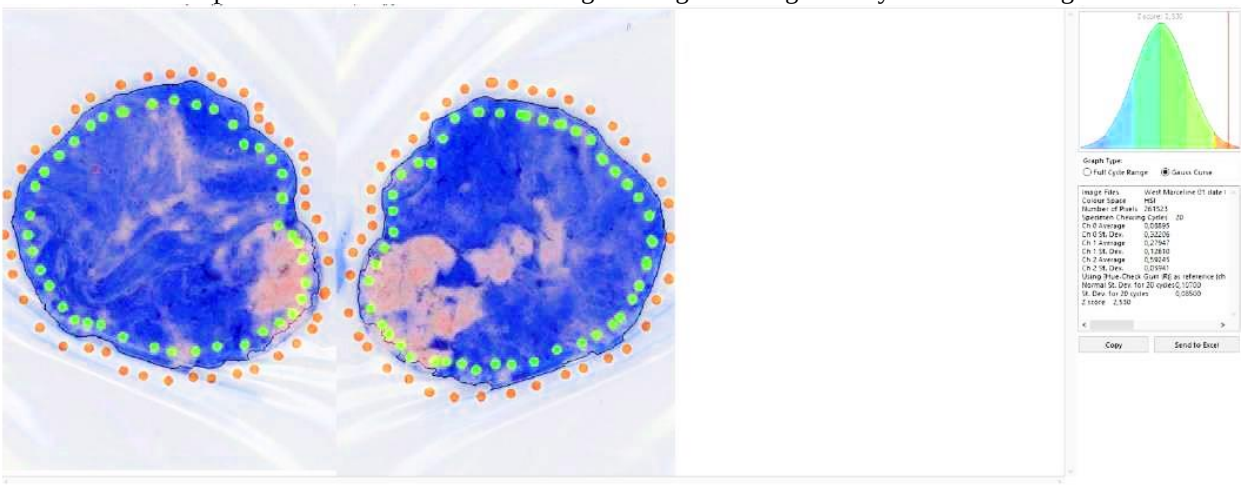

Figure 2. Analysis of flattened two-color chewing gum

Subjective Masticatory Evaluation: Only CRD and MDI had subjective masticatory evaluations. Subjects rated their ability to chew soft white bread, hard cheese, dry sausage, apple, and carrot on a 100 mm VAS [31]. Patients were also given the validated Dutch version of the OHIP-14 questionnaire to complete out [32-34]. The latter has been found to have excellent reliability, validity, and accuracy, making it suitable for use in clinical settings [35] and allowing for comparisons to be conducted across various studies [36]. The questions are structured on the seven predefined characteristics of oral health in Locker's theoretical model [37,38,39]. Functional impairment, physical pain, emotional distress, actual disability, perceived disability, social handicap, and actual handicap. It's important to cite this phrase.

Statistical Analysis: The most recent version of SPSS was used to carry out the statistical analysis. The Mann–Whitney U test was used to evaluate the significant levels of the study groups, and p = 0.050 was chosen as the level of significance for each group.

Results: All the groups' demographics information is given in table 1 below.

Table 1: Groups' Demographics

Group	No.	Avg Age	St. Dev	Male	Female
MDI	20	65.75	8.21	9	11
CRD	20	68.4	6.86	2	8
DP	19	60.53	8.29	11	8
DS	22	24.18	2.37	10	12

The objective masticatory assessment was carried out on each and every participant that belonged to one of the four groups that were specified. Boxplots in Figure3 illustrate each group's mean VOH, which may be found in the accompanying table.

After comparing the MDI and CRD groups, it was found that both dentate populations displayed a significantly improved ability to chew (p 0.001) than the latter two groups. There was no correlation found between the kind of dentition in the lower jaw and the capacity to chew (p = 0.642). This study of subjective masticatory performance utilizing a visual analog scale and the OHIP-14 questionnaire was limited to those who wear maxillary detachable dentures (CRD and MDI). The visual depiction of VAS results for different meal consistencies is shown in Figure 4.

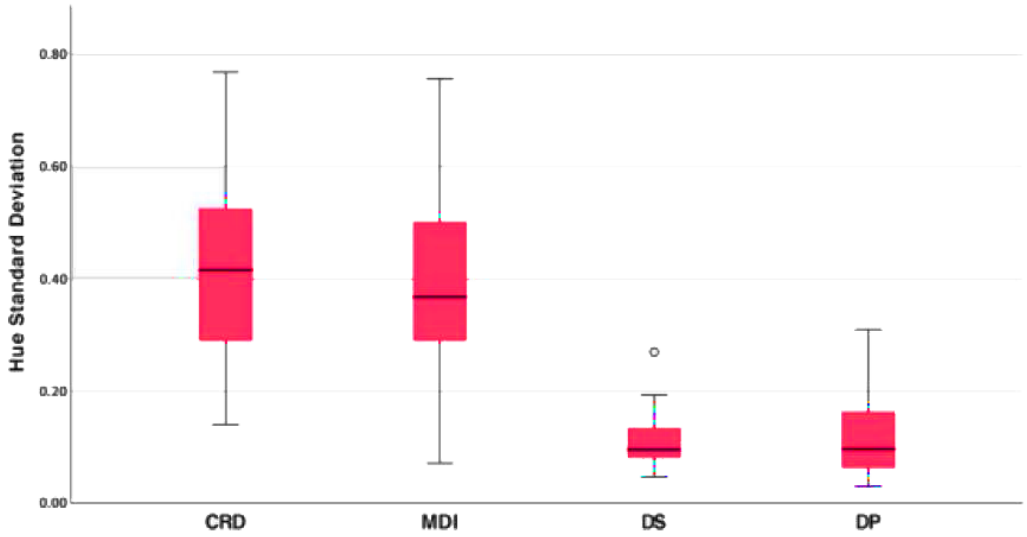

Figure 3. Boxplot of the mean VOH in 4 different groups: (CRD) complete removable denture maxilla/dentate mandible; (MDI) mini dental implant overdenture maxilla/dentate mandible; (DS) dental students; (DP) dentate subjects.

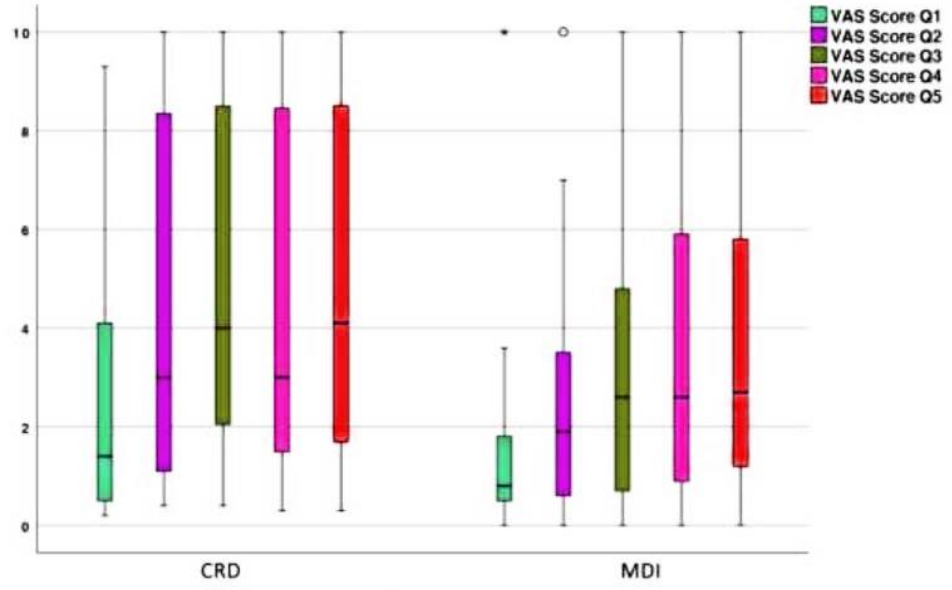

Figure 4. Mean VAS score outcome for masticating food with different con-sistencies

In a test of the CRD group's and the MDI group's ability to chew food of gradually greater difficulty, neither group showed statistically significant improvement (p > 0.050). On the other side, a large drop in the Total OHIP-14 number showed an increase in overall health and wellness. When compared to the CRD group, which had a 12.10 mean and a 15.87 of ndard deviation and a range of 0–56, the MDI group's mean was 2.85 and had a range of 0–15 (p = 0.039). Figure 5 illustrates the overall OHIP-14 score, which is calculated by adding together the average points earned in

each of the 14 subdomains. There were significant differences between the groups with regard to the levels of psychological anguish (p = 0.028), physical impairment (p = 0.006), and social incapacity (p = 0.020).

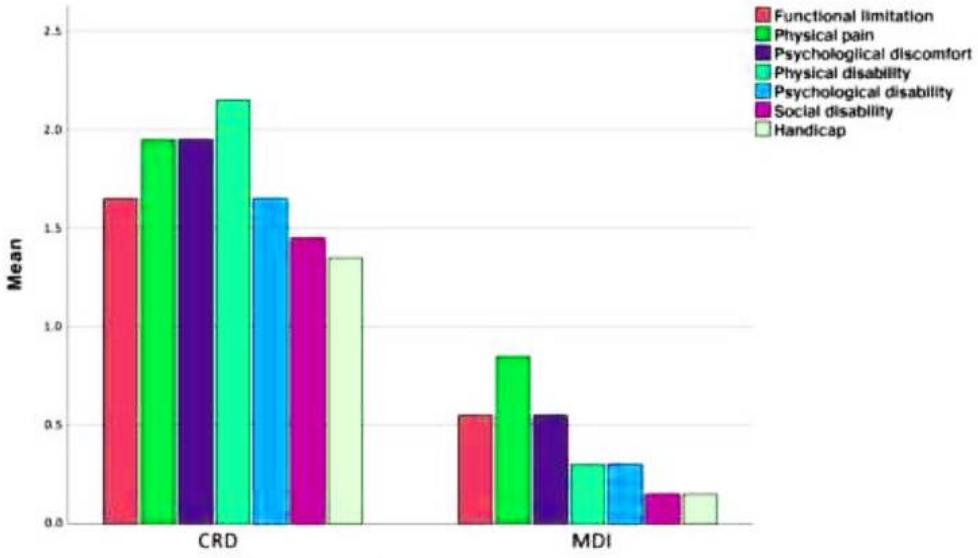

Figure 5. OHIP-14 outcome in different domains in CRD and MDI group

DISCUSSIONS:

This is the only research that we are aware of that compares the masticatory performance of people of varied ages who have dentition, as well as those who have maxillary MDI overdentures, people who are maxillarily edentulous as a result of CRD, and people who have dentition owing to CRD. The motoric activity of the masticatory organs, which includes the lips, tongue, mandible, and cheeks tends to vary with age, which may have an influence on masticatory performance [40]. When we compared patients who had full dentition at over 20 years of age and those who had complete dentition at over 50 years of age, statistically speaking, no changes were seen in masticatory ability linked to age. On the other hand, if the maxilla is missing teeth yet the patient has CRD or MDI overdentures, this indicates that there is a major disruption in masticatory function. The patient's ability to objectively chew food did not significantly improve despite the fact that MDI improved retention of the maxillary denture. Similar results were seen when denture adhesives were utilised [41]. The inability to properly manipulate food while chewing has been linked to decreased sensitivity in the organs responsible for doing so, according to preliminary study [42]. The process of mastication is a difficult one that involves cooperation from a number of distinct components. It's possible that improving denture retention on its own won't be enough to bring masticatory performance up to par. For the purpose of mastication, a study depicted that denture retention is less compulsory than denture stability [43]. There is some disagreement on the effect that the shape of the ridge has on denture stability, how well it performs during mastication, and how satisfied the patient is [44]. Because of this, it is generally accepted that the adaptability of the patient as well as the flow of saliva plays a significant role in determining masticatory function [45,46]. A significant distinction between implants and normal teeth is that implants do not have a periodontal ligament as natural teeth do. This is another key characteristic of implants. The term "proprioception" refers to the input that is sent to the central nervous system by the periodontal ligament. This feedback is used for both sensory perception and motor control. On the other hand, a loss of such proprioception results in decreased tactile sensitivity as well as less coordinated action in the muscles used for mastication [47]. Also, the test may not have shown a substantial difference with the overdenture since masticatory performance increases with continuing use of newly implanted detachable dentures [48].

It might be difficult to provide an impartial assessment of a person's masticatory performance. Tarkowska et al. [49] reviewed the literature and found that measuring masticatory function using color-changing gum is a practical and effective technique. View Gum®, a software programme created by M. Schimmel and now in use, has been deemed the "gold

standard technique" and is preferred as a viable option for individuals with poor mastication [19,50].

When comparing CRD with MDI in terms of the subjective masticatory result, it was shown that there was no significant improvement in the VAS ratings. On the other hand, the MDI therapy seems to be responsible for a significant rise in either the OHIP-14 or the OHRQL scores. Findings by J. Feine et al[31] suggest that patients' own assessments of their own skills are the most reliable basis for evaluating masticatory function. The disparities that were found in our investigation between the participants' reported capacity to function and their performance in the laboratory partly corroborate these results. An objective result is not always the most reliable indicator of whether or not therapy was successful for the patient.

The current clinical trial had certain limitations, including the fact that factors such as orofacial discomfort, occlusal pressures, or the function of other components were not investigated [51].

Before this study, a larger sample size of 31 people in the MDI group had longitudinal OHRQoL evaluations commencing at baseline, and the findings were published elsewhere [13]. Because of the MDI overdenture, the patient's final OHIP-14 score reduced from 21.3 (standard deviation: 13.1) with the initial denture to 6.5 (standard deviation: 8.9) after three years of usage. The OHIP-14 score at the time of this group's baseline evaluation may be interpreted in a way that is similar to that of the group that received complete dentures; however, we have to confess that these dentures had already been improved before to the surgical intervention so that they could be used as a surgical guide. As a result, we decided to include a new control group in our investigation consisting of full removable dentures. When contrasted with the score of 12.10 achieved by our newly formed CRD group, the MDI group's high OHIP-14 baseline value of 21.3 (standard deviation: 13.1), it is obvious that the MDI trial treatment protocol included participants who complained of instability and pain caused by their upper conventional denture (SD 15.87). The current denture quality was not evaluated objectively for the purpose of the CRD group's objective masticatory test. According to Carlsson and Omar [52], this has very little of an impact on the level of satisfaction experienced by patients.

CONCLUSIONS:

The following findings were arrived at after conducting an objective test of masticatory performance:
There was no significant difference in masticatory ability between dentate participants and maxillary MDI overdenture wearers;

Masticatory performance that is comparable in dentate persons who are at least 20 years old and elderly adults who are at least 50 years old; Individuals who had maxillary MDI overdentures did not demonstrate a statistically significant increase in their masticatory performance when compared to patients who had maxillary CRD.

On the other hand, an objective result is not always the greatest indicator of whether or not therapy was successful for the patient. After getting MDI overdentures, it is essential for patients to report better perceptions of masticatory performance, and the outcomes of the subjective masticatory assessment in our study give some support for this conclusion. When applied to all of the different meal consistencies, the use of the VAS did not result in any discernible improvement in the subjects' subjective ratings of their ability to chew their food. As a result, it is clear that the OHIP-14 questionnaire has contributed to a considerable improvement in OHRQL.

REFERENCES:

1. Zitzmann, N.U.; Hagmann, E.; Weiger, R. What is the prevalence of various types of prosthetic dental restorations in Europe?*Clin. Oral Implant. Res.* **2007**, *18*, 20–33. [CrossRef] [PubMed]
2. Kelly, E. Changes caused by a mandibular removable partial denture opposing a maxillary complete denture. *J. Prosthet. Dent.***2003**, *90*, 213–219. [CrossRef]
3. Polzer, I.; Schimmel, M.; Müller, F.; Biffar, R. Edentulism as part of the general health problems of elderly adults. *Int. Dent. J.* **2010**,*60*, 143–155.
4. Cawood, J.I.; Howell, R.A. A Classification of the edentulous jaws. *Int. J. Oral Maxillofac. Surg.* **1988**, *17*, 232–236. [CrossRef]
5. Cassetta, M.; Perrotti, V.; Calasso, S.; Piattelli, A.; Sinjari, B.; Iezzi, G. Bone formation in sinus augmentation procedures using autologous bone, porcine bone, and a 50: 50 mixture: A human clinical and histological evaluation at 2 months. *Clin. Oral Implant. Res.* **2015**, *26*, 1180–1184. [CrossRef]
6. Baj, A.; Lauritano, D.T.G.; Candotto, V.; Mancini, G.E.; Gianni, A.B. An overview on bone reconstruction of atrophic maxilla: Succes parameters and critical issues. *J. Biol. Regul.*

Homeost. Agents **2016**, *30,* 209–215.
7. Ellis, J.S.; Levine, A.; Bedos, C.; Mojon, P.; Rosberger, Z.; Feine, J.S.; Thomason, J.M. Refusal of implant supported mandibular overdentures by elderly patients. *Gerodontology* **2011**, *28*, 62–68. [CrossRef]
8. Sinjari, B.; D'Addazio, G.; Traini, T.; Varvara, G.; Scarano, A.; Murmura, G.; Caputi, S. A 10-year retrospective comparative human study on screw-retained versus cemented dental implant abutments. *J. Biol. Regul. Homeost. Agents* **2019**, *33*, 787–797. [PubMed]
9. Klein, M.O.; Schiegnitz, E.; Al-Nawas, B. Systematic Review on Success of Narrow-Diameter Dental Implants. *Int. J. Oral Maxillofac. Implant.* **2014**, *29*, 43–54. [CrossRef]
10. Jung, R.E.; Al-Nawas, B.; Araujo, M.; Ortiz, G.A.; Barter, S.; Brodala, N.; Chappuis, V.; Chen, B.; De Souza, A.; Faria-Almeida, R.; et al. Group 1 ITI Consensus Report: The influence of implant length and design and medications on clinical and patient-reported outcomes. *Clin. Oral Implant. Res.* **2018**, *29* (Suppl. 16), 69–77. [CrossRef] [PubMed]
11. Schiegnitz, E.; Al-Nawas, B. Narrow-diameter implants: A systematic review and meta-analysis. *Clin. Oral Implant. Res.* **2018**, *29*(Suppl. 16), 21–40. [CrossRef] [PubMed]
12. Van Doorne, L.; De Kock, L.; De Moor, A.; Shtino, R.; Bronkhorst, E.; Meijer, G.; De Bruyn, H. Flaplessly placed 2.4-mm mini-implants for maxillary overdentures: A prospective multicentre clinical cohort study. *Int. J. Oral Maxillofac. Surg.* **2020**, *49*, 384–391. [CrossRef]
13. Van Doorne, L.; Fonteyne, E.; Matthys, C.; Bronkhorst, E.; Meijer, G.; De Bruyn, H. Longitudinal Oral Health-Related Quality of Life in maxillary mini dental implant overdentures after 3 years in function. *Clin. Oral Implant. Res.* **2021**, *32*, 23–36. [CrossRef]
14. Elgestad Stjernfeldt, P.; Sjögren, P.; Wårdh, I.; Boström, A.M. Systematic review of measurement properties of methods for objectively assessing masticatory performance. *Clin. Exp. Dent. Res.* **2019**, *5*, 76–104. [CrossRef]
15. Ahmad, S.F. An insight into the masticatory performance of complete denture wearer. *Ann. Dent.* **2006**, *13*, 24–33. [CrossRef]
16. Gu, Y.; Bai, Y.; Xie, X. Bite Force Transducers and Measurement Devices. *Front. Bioeng. Biotechnol.* **2021**, *9*, 665081. [CrossRef] [PubMed]
17. Lucas, P.W.; Luke, D.A.; Voon, F.C.T.; Chew, C.L.; Ow, R. Food breakdown patterns produced by human subjects possessing artificial and natural teeth. *J. Oral Rehabil.* **1986**, *13*, 205–214. [CrossRef] [PubMed]
18. Bates, J.F.; Stafford, G.D.; Harrison, A. Masticatory function-a review of the literature. III. Masticatory performance and efficiency.*J. Oral Rehabil.* **1976**, *3*, 57–67. [CrossRef] [PubMed]
19. Van der Bilt, A.; Mojet, J.; Tekamp, F.A.; Abbink, J.H. Comparing masticatory performance and mixing ability. *J. Oral Rehabil.***2010**, *37*, 79–84. [CrossRef]
20. Manly, R.S.; Braley, L.C. Masticatory performance and efficiency. *J. Dent. Res.* **1950**, *29*, 448–462. [CrossRef] [PubMed]
21. Van der Bilt, A.; Van der Glas, H.W.; Mowlana, F.; Heath, M.R. A comparison between sieving and optical scanning for the determination of particle size distributions obtained by mastication in man. *Arch. Oral Biol.* **1993**, *38*, 159–163. [CrossRef]
22. Speksnijder, C.M.; Abbink, J.H.; van der Glas, H.W.; Janssen, N.G.; van der Bilt, A. Mixing ability test compared with a comminution test in persons with normal and compromised masticatory performance. *Eur. J. Oral Sci.* **2009**, *117*, 580–586. [CrossRef] [PubMed]
23. Nokubi, T.; Nokubi, F.; Yoshimuta, Y.; Ikebe, K.; Ono, T.; Maeda, Y. Measuring masticatory performance using a new device and β-carotene in test gummy jelly. *J. Oral Rehabil.* **2010**, *37*, 820–826. [CrossRef]
24. Montero, J.; Leiva, L.A.; Martín-Quintero, I.; Rosel, E.; Barrios-Rodriguez, R. Determinants of masticatory performance assessed by mixing ability tests. *J. Prosthet. Dent.* **2021**. [CrossRef] [PubMed]
25. Schimmel, M.; Christou, P.; Miyazaki, H.; Halazonetis, D.; Herrmann, F.R.; Müller, F. A novel colourimetric technique to assess chewing function using two-coloured specimens: Validation and application. *J. Dent.* **2015**, *43*, 955–964. [CrossRef]
26. Van Doorne, L.; Gholami, P.; D'Haese, J.; Hommez, G.; Meijer, G.; De Bruyn, H. Three-Dimensional Radiographic Outcome of Free-Handed Flaplessly Placed Mini Dental Implants in Edentulous Maxillae after 2-Years Function. *J. Clin. Med.* **2020**, *9*, 2120. [CrossRef] [PubMed]
27. Fonteyne, E.; Van Doorne, L.; Becue, L.; Matthys, C.; Bronckhorst, E.; De Bruyn, H. Speech evaluation during maxillary mini-dental implant overdenture treatment: A prospective study. *J. Oral Rehabil.* **2019**, *46*, 1151–1160. [CrossRef]
28. Schimmel, M.; Christou, P.; Herrmann, F.; Muller, F. A two-colour chewing gum test for masticatory efficiency: Development of different assessment

methods. *J. Oral Rehabil.* **2007**, *34*, 671–678. [CrossRef]

29. Halazonetis, D.J.; Schimmel, M.; Antonarakis, G.; Christou, P. Novel software for quantitative evaluation and graphical represen- tation of masticatory efficiency. *J. Oral Rehabil.* **2013**, *40*, 329–335. [CrossRef]
30. Silva, L.C.; Nogueira, T.E.; Rios, L.F.; Schimmel, M.; Leles, C.R. Reliability of a two-colour chewing gum test to assess masticatory performance in complete denture wearers. *J. Oral Rehabil.* **2018**, *45*, 301–307. [CrossRef] [PubMed]
31. Feine, J.S.; Lund, J.P. Measuring chewing ability in randomized controlled trials with edentulous populations wearing implant prostheses. *J. Oral Rehabil.* **2006**, *33*, 301–308. [CrossRef] [PubMed]
32. Slade, G.D. Assessing change in quality of life using the Oral Health Impact Profile. *Community Dent. Oral Epidemiol.* **1998**, *26*, 52–61. [CrossRef] [PubMed]
33. McGrath, C.; Bedi, R. Measuring the impact of oral health on life quality in two national surveys-functionalist versus hermeneutic approaches. *Community Dent. Oral Epidemiol.* **2002**, *30*, 254–259. [CrossRef]
34. Pommer, B. Use of the Oral Health Impact Profile (OHIP) in clinical oral implant research. *J. Dent. Oral Craniofac. Epidemiol.* **2013**,*1*, 3–10.
35. Raes, S.; Raes, F.; Cooper, L.; Giner-Tarrida, L.; Vervaeke, S.; Cosyn, J.; De Bruyn, H. Oral health-related quality of life changes after placement of immediately loaded single implants in healed alveolar ridges or extraction sockets: A 5-year prospective follow-up study. *Clin. Oral Implant. Res.* **2017**, *28*, 662–667. [CrossRef]
36. Slade, G.D. Derivation and validation of a short-form oral health impact profile. *Community Dent. Oral Epidemiol.* **1997**, *25*, 284–290. [CrossRef]
37. Locker, D. Measuring oral health: A conceptual framework. *Community Dent. Health* **1988**, *5*, 3–18.
38. Van Der Meulen, M.J.; John, M.T.; Naeije, M.; Lobbezoo, F. The Dutch version of the Oral Health Impact Profile (OHIP-NL): Translation, reliability and construct validity. *BMC Oral Health* **2008**, *8*, 11. [CrossRef]
39. Kuoppala, R.; Napankangas, R.; Raustia, A. Quality of Life of Patients Treated With Implant-Supported Mandibular Overdentures Evaluated With the Oral Health Impact Profile (OHIP-14): A Survey of 58 Patients. *J. Oral Maxillofac. Res.* **2013**, *4*, e4. [CrossRef]
40. Yamada, A.; Kanazawa, M.; Komagamine, Y.; Minakuchi, S. Association between tongue and lip functions and masticatory performance in young dentate adults. *J. Oral Rehabil.* **2015**, *42*, 833–839. [CrossRef] [PubMed]
41. Shu, X.; Fan, Y.; Lo, E.C.M.; Leung, K.C.M. A systematic review and meta-analysis to evaluate the efficacy of denture adhesives. *J. Dent.* **2021**, *108*, 103638. [CrossRef]
42. Kapur, K.K. A clinical evaluation of denture adhesives. *J. Prosthet. Dent.* **1967**, *18*, 550–558. [CrossRef]
43. Yamaga, E.; Sato, Y.; Minakuchi, S. A structural equation model relating oral condition, denture quality, chewing ability, satisfaction, and oral health-related quality of life in complete denture wearers. *J. Dent.* **2013**, *41*, 710–717. [CrossRef] [PubMed]
44. Heydecke, G.; Klemetti, E.; Awad, M.A.; Lund, J.P.; Feine, J.S. Relationship between prosthodontic evaluation and patient ratings of mandibular conventional and implant prostheses. *Int. J. Prosthodont.* **2003**, *16*, 307–312. [CrossRef]
45. Ikebe, K.; Amemiya, M.; Morii, K.; Matsuda, K.-I.; Furuya-Yoshinaka, M.; Yoshinaka, M.; Nokubi, T. Association between oral stereognostic ability and masticatory performance in aged complete denture wearers. *Int. J. Prosthodont.* **2007**, *20*, 245–250.
46. Ikebe, K.; Matsuda, K.-I.; Kagawa, R.; Enoki, K.; Okada, T.; Yoshida, M.; Maeda, Y. Masticatory performance in older subjects with varying degrees of tooth loss. *J. Dent.* **2012**, *40*, 71–76. [CrossRef] [PubMed]
47. Meyer, G.; Fanghänel, J.; Proff, P. Morphofunctional aspects of dental implants. *Ann. Anat.* **2012**, *194*, 190–194. [CrossRef]
48. Leles, C.R.; Oliveira, T.M.C.; De Araújo, S.C.; Nogueira, T.E.; Schimmel, M. Individual factors associated with masticatory performance of complete denture wearers: A cross-sectional study. *J. Oral Rehabil.* **2019**, *46*, 903–911. [CrossRef] [PubMed]
49. Tarkowska, A.; Katzer, L.; Ahlers, M.O. Assessment of masticatory performance by means of a color-changeable chewing gum. *J. Prosthodont. Res.* **2017**, *61*, 9–19. [CrossRef] [PubMed]
50. Sato, S.; Fueki, K.; Sato, H.; Sueda, S.; Shiozaki, T.; Kato, M.; Ohyama, T. Validity and reliability of a newly developed method for evaluating masticatory function using discriminant analysis. *J. Oral Rehabil.* **2003**, *30*, 146–151. [CrossRef]
51. Morita, K.; Tsuka, H.; Kato, K.; Mori, T.;

Nishimura, R.; Yoshida, M.; Tsuga, K. Factors related to masticatory performance in healthy elderly individuals. *J. Prosthet. Dent.* **2018**, *120*, 35–42. [CrossRef] [PubMed]

52. Carlsson, G.E.; Omar, R. The future of complete dentures in oral rehabilitation. A critical review. *J. Oral Rehabil.* **2010**, *37*, 143–156. [CrossRef] [PubMed]