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ORIGINAL ARTICLE

AN *IN VITRO* COMPARISON OF TWO TYPES OF IMPLANTS OVER DENTURE RETENTION SYSTEMS

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ABSTRACT

Purpose The McGill Consensus (2002) recommends two-implant over denture as the first choice for treatment for the edentulous mandible. There have been numerous methods described to aid the retention of complete lower dentures. Recently plastic low-profile attachments have become available for use with implant supported dentures. Other than their low profile they are advertised as being simpler to maintain and more economic than their ball and clip or O-ring counterparts. However, there appears to be a lack of data on the retentive forces these for these systems. Two over denture retaining systems - the Locator and the Southern Implant-incorporating plastic retaining components were tested and compared. This in vitro study set out to measure the retentive forces created by the Southern Implant ball and clip and the Zest Anchor Locator press-stud. Each system tested offered several different strengths of attachment.

Methodology: A custom built jig was used to hold the various components for each attachment system and mount the monacyclic testing machine. Thisenabledmeasurementofthe retentive forces created by each attachment system 3,000 cycles of insertion and removal in a simulated oral environment.

Results: The retentive forces created by the Southern Implants plastic clips and Locator nylon inserts fell exponentially with the number of the test cycle. After 100 cycles, the retentive forces created by the Southern Implant plastic clips ranged between 7.5 – 11.0N; for the Locatornyl on inserts the range was between 7.2 – 15.7N.

Conclusion: The retentive forces of the Southern Implant clips and Locator inserts provide values within the range normally suggested as necessary to resisted is placement of a denture when chewing sticky food. However, the data from this study is not entirely consistent with that of the manufacturers.

Key words: Implant retained over denture, attachments, mandibular dentures, locator inserts, and ball & socket attachments.

INTRODUCTION

Osseointegerated dental implants have been demonstrated to provide a long term solution and general improvement in the quality of life of partially dentate and edentulous patients.[1,2] The implants stabilized over dentures have been shown successful in terms of patients at is faction, chewing comfort; nutritional status and social activities.[3-6] The cost of providing an implant retained over denture is greater than that of conventional complete dentures, but this difference is relatively small when calculated over the life time of the prosthesis.[7] The "McGillconsensus" showed that the evidence was now over whelming for a two-implant overdenture to be the treatment of choice for patients with an edentulousmandible[8].

The retention for an implant retained over denture can be achieved by splinting the implants together with a bar and having a retentive clip inside the denture. The bar retainerisrobust and effective, but the clips may require occasional adjustment which may increases the likelihood of breakage.[9-12] Alternatively the separate implants may have their own individual attachment with the mating components in the over denture. The attachment may be a ball and O-ring, a ball and clip, a stud and 'popper', or a magnet and keeper which are simple devices and relatively in expensive.[13,15] Low profile designs are useful for use where inter-arch space is limited, and also have features enabling their use, where the implants are markedly angled to one another.[16,17]

Rare earth magnets have been used inconventional tooth-supported/retained over dentures, but did not achieve wide acceptance because of the low retentive forces generated and the problem of corrosion in the oral environment.[13,16] There is now alarge array of ball and stud type retaining systems available for implant retained/tissue supported over dentures, but there is no conclusive evidence to suggest a better system for a

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particular case.[18] Several studies both *in vivo* and *in vitro* have reported high failure rates with ball and split matrix design with bent or fractured of the leaves within the matrix.[19] The ball or low profile flat head stud designs with rubber O-rings or caps/inserts made up of polymeric materials as retentive elements, appears to be more robust and simpler to maintain. However, there appears to be a lack of *in vitro* studies assessing the newly introduced designs especially the series of dual retention retainers which incorporate the features of ball and O-ring and telescopic retainers[20, 21, 22].Other than the manufacturer's data, there is little information on the performance of these attachment systems, particularly their long-term effectiveness. This *in vitro* study therefore set out to investigate the retention forces provided by two attachment systems, and to establish their performance overthree years of simulated use.

MATERIALS AND METHODS

Two different types of over denture attachment were studied, a ball and clip system, astudor 'Popper' system. The manufacturer of each attachment system provides a variety of color coded retainers to deliver different levels of retention.

The Southern Implant (SI) attachment system (Southern Implants, PO Box 605, Irene 1675, South Africa) has a ball and clip design: the 2.25 mm diameter ballis screwed into the implant body and a four leafed plastic clip is held in a metal housing in the denture base (Figure 1, 2, 3 & Table 1). The clips which are colored yellow, pink and white provide 'normal', 'reduced' and 'increased' retention respectively according to the manufacturer's literature (Table 2).

The Zest Anchors Inc (ZI) Locator system (Zest Anchor Inc, Escondido, CA 92029, USA) is a press stud or 'popper' and cup attachment (Figure 1, 4, 5). The shallow metal female cup is screwed into the implant body while the nylon male studsare retained in a metal cap in the denture (Table 1). There are four types of nylon stud. The clear (white), pink and blue are designed to provided 'normal', 'light' and 'extra light' retention (Table 3). The fourth green insert lacks the central plunger of the other colors, and is designated for use in situations where an 'extended range' is required due to marked inclination of the implants one to another.

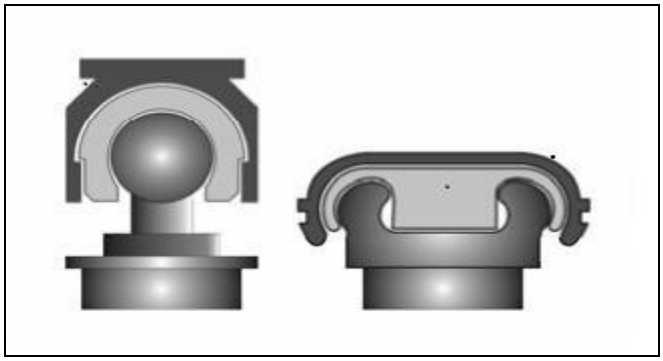

Fig. 1. *A diagram to show:*
a) the Southern Implants ball and plastic clip attachments;
b) the Locator nylon insert in its denture housing and the female implant component.

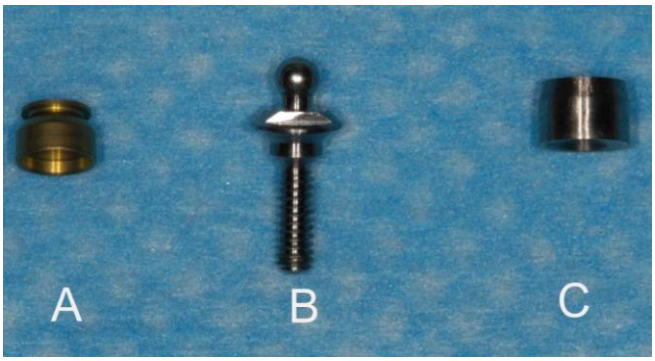

Fig. 2: *Southern Implant ball and socket over denture retaining system, A. denture housing, B. ball, C. collar/TMA.*

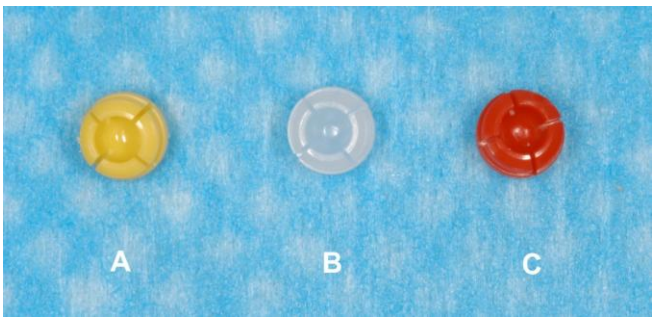

Fig. 3: *Southern Implant's three colour coded denture inserts of varying retention force, A. yellow, B. white, C. red.*

The testing jig design and configuration was based upon earlier work.[23] A regular platform 3.75 mm diameter Nobel Biocare implant laboratory analogue (Nobel Biocare AB, Box 5190, 40226 Göteborg, Sweden) was cemented into the endofanacrylicrod that was held in a plastic block attached to the base of a cyclic testing machine (Model HC 10, Dartec Limited, Stour bridge, West Midlands, DY 98 SH, UK). The implant components for each attachment system were screwed appropriately into the implant body. The housings for the SI clips and the Locator inserts were cemented into individual acrylic rods and could be attached to a1kN load cell (Model F252, Novatech Measurements Ltd, St Leonards-on-Sea, East Sussex, TN 389 NT, UK) bolted to the upper cross-head of the testing machine. The male and female components

were aligned so as to be co-axial. An environmental chamber surrounded the components during the experiment to simulate oral conditions by lubricating them with artificial saliva (Orthana, Kermisk Fabrik, Kastrup, Denmark) at 37°C.

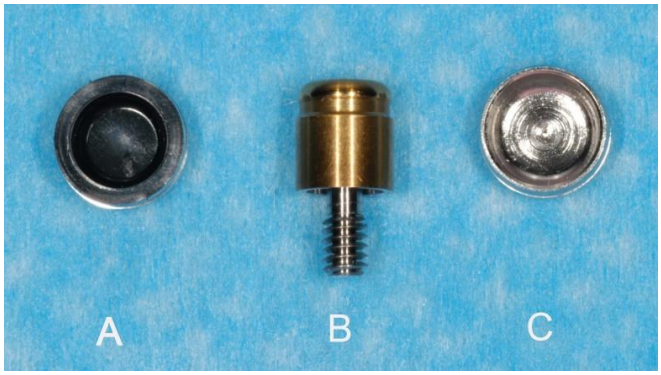

Fig. 4: *The Locator over denture retaining system A. Housing with black processing spacer, B. Locator abutment, C. housing without spacer.*

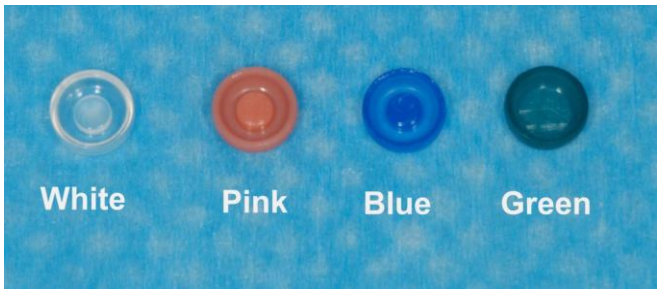

Fig. 5: *Locator's colour coded denture inserts having varying amount of retention force.*

Ten plastic clips for each of the three strengths of SI retainer and ten nylon inserts for each of the four types of Locator retainer were tested. Data from one SI clip of each color became corrupt and was therefore eliminated from this study.

The components were carefully aligned in the testing machine which was programmed to generate a sine wave movement of the cross head at a frequency of 1Hz and with range of movement to allow the attachments to engage and disengage completely. All samples were tested over 3,000 insertion and withdrawal cycles during which the peak insertion and removal forces were recorded. After every 250 cycles the force displacement characteristics were monitored for 10 cycles.

Descriptive statistics were calculated at set intervals over the 3,000 cycles and these data were analyzed using an ANOVA (V13, Minitab Inc, State College, Pa 16801, USA) to establish whether there was any significant variation in removal force between the different types of retainers or the cycle number in the sequence. Bonferroni*posthoc* tests were used to test for significance between data sets. A probability value of $p < 0.05$ was considered to be significant.

Table 1: *Dimensions of the Denture Components for the Various Attachment Systems Tested.*

	Total Height (mm)
Southern Implants	4.8
Locator	3.2

RESULTS

Southern Implant Attachment System

A characteristic plot of force versus displacement for a white plastic SI clip shows that as the clip is lowered there is a steady increase in the measured insertion force which peaks as clip asses over the maximum diameter of the ball (Figure 6). The force then reduces to leave a small residual value when the clipis fully seated. As the clip is slowly removed from the attachment the force rapidly becomes retentive as the leaves of the clip are forced open and this reaches a maximum, or peak force, as it passes over the bulbosity of the ball. The forced rops off rapidly and briefly becomes negative when the clip's plastic leaves momentarily assist the separation before dropping to zero as the clip disengages. This pattern for the force displacement curve was found for all three strengths of clip, which differed only in the absolute magnitude of the peak insertion and removal forces.

The peak retentive force for the three Southern Implant clips fell from its high initial value almost exponentially over the period of the experiment (Figure 7). On average the loss of retention was 8% over the first 100 cycles and 38% by 3,000 cycles (Table 2). At 1st and 100th cycles, the retentive forces provided by the white clips were significantly different from the red and the yellow clips, which were not significantly different from one another.

Table 2: *The Mean Peak Retentive Forces (± 95% CI) Measured from SI Clips on the 1st and 100th and 3,000th Cycle of Simulated Use.*

SI Inserts	*N*	*Manufacturer's Description*	*1st Cycle*	*100th Cycle*	
Pink	9	Increased	13.4 ± 1.08	11.0 ± 0.97	7.3 ± 0.27
Yellow	9	Normal	11.7 ± 1.25	10.3 ± 0.63	6.3 ± 0.21
White	9	Reduced	8.2 ± 0.92	7.5 ± 0.70	5.5 ± 0.25

Table 3: *The mean peak retentive forces (± 95% CI) measured from Locator Inserts on the 1st and 100th and 3,000th cycle of simulated use.*

Locator Inserts	*N*	*Manufacturer's Description*	*1st Cycle*	*100th Cycle*	*3,000th Cycle*
Clear	10	5lb – 22.2N	10.7 ± 2.19	10.3 ± 1.35	7.2 ± 0.37
Pink – Light Retention	10	3lb – 13.3N	15.3 ± 1.80	11.2 ± 1.24	7.9 ± 0.60
Blue – Extra Light	10	1.5lb – 6.7N	8.3 ± 0.45	7.2 ± 0.59	8.2 ± 1.01
Green – Extended Range	10	4lb– 17.8N (10°)	19.6 ± 1.26	15.7 ± 0.81	11.4 ± 0.53

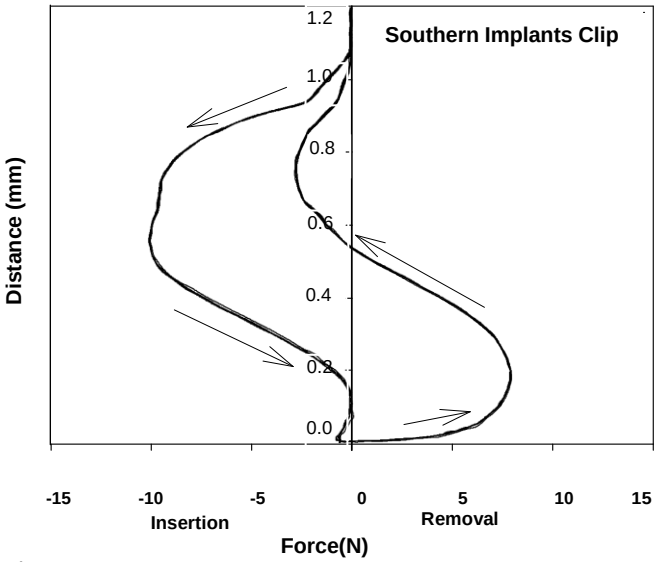

Fig. 6: *A plot of a characteristic force – distance curve for a Southern Implant clip.*

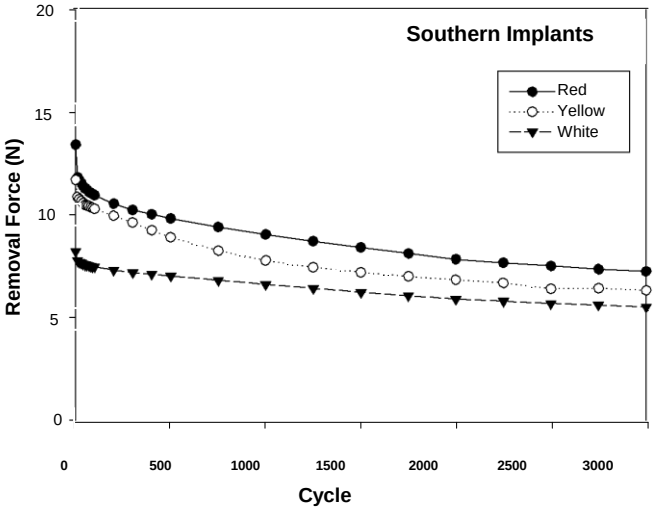

Fig. 7: *A plot of variation in the mean peak removal force for the Southern Implants:, red, yellow and white plastic clips over 3,000 cycles of simulated use.*

The Locator Attachment System

Atypical the force–displacement curve for an insertion and removal cycle for a Locator nylon stud and implant attachment is shown in Figure 8. As the male insert is lowered the insertion force rapidly rises as the outer rim of the insert expands over the female implant component. Within0.5mm the force increases dramatically and then as swiftly diminishes as the stud is fully seated, while leaving as mall residual insertion force. On withdrawal, the retention force rises quickly to a maximum before dropping back through a small negative value to zero force when the stud becomes completely detached.

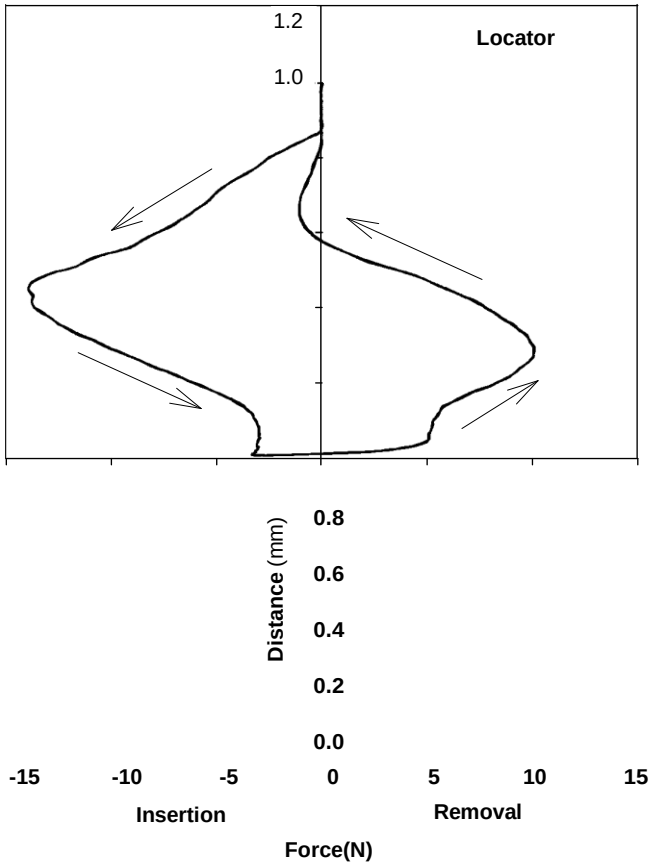

Fig. 8: *A plot of a characteristic force –distance curve for a Locator insert.*

The mean peak removal forces for the Locator inserts again were found to fall from the starting value

throughout the experiment to a moderate level at its end (Figure 9). The average the loss of retention was 22% over the first 100 cycles and 39% over the whole of the 3,000 cycles (Table 3). There was no significant difference in retentive forces of the pink and clear inserts at the 1st and 100th cycles, but they were both significantly different from the blue and green inserts which were themselves significantly different from each other. After the 3,000th cycle, the blue, pink and clear inserts were not significantly different from one another, but all were significantly different ($p < 0.001$) from the green insert.

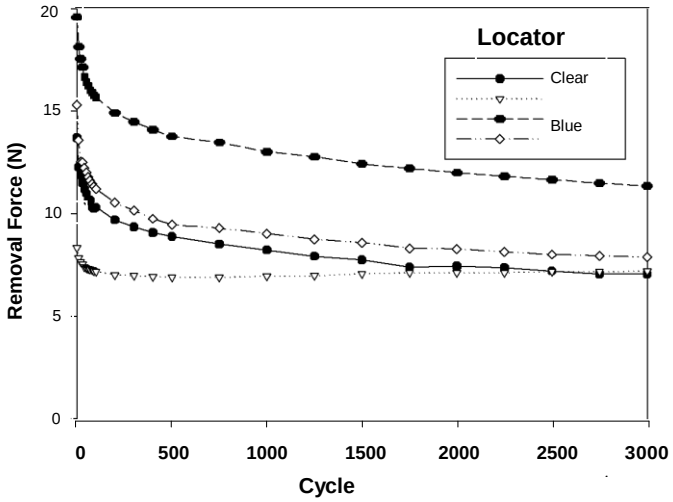

Fig. 9: *A plot of variation in the mean peak removal force for the clear, blue, green and red. Locator nylon inserts over 3,000 cycles of simulated use.*

Comparison between the Retentive Forces of the Two Attachment Systems

The mean peak retentive force provided by the two attachments systems after 100 cycles of simulated use is shown in Figure 10. Of the attachment systems studied, the green nylon Locator inserts showed the greatest retentive force (15.7N). The other blue, clear and pink Locator inserts provided similar retentive forces (7.2 – 11.2N) tothe pink, yellow and white Southern Implant clips (7.5 – 11.0N).

DISCUSSION

The experimental arrangement simulates approximately three years of use of the attachments in an oral environment. This time frame was chosen as it represented areas on able period of clinical use before the attachment might need maintenance. It also establishes changes in retention and likelihood of early failure of any of the component parts.

While the diameter of each attachment system is similar, the height of the SI attachment and denture housing together was 4.8mm and for the Locator 3.2mm. Where vertical space to place an attachment is restricted the thinner Locator has an obvious advantage. The design of the SI and Locator systems makes them self-aligning on insertion.

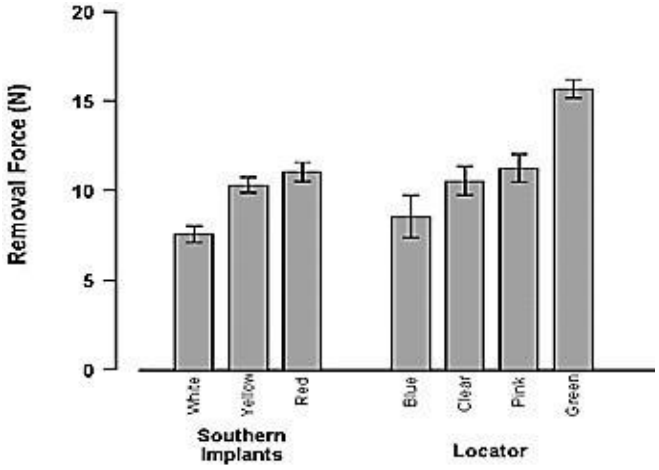

Fig. 10: *A comparison of the mean peak removal forces generated by the different strength attachments for the two over denture attachment systems studied after 100 cycles of simulated use.*

Over the first 100 cycles of simulated use the plastic clips of the SI attachment system lost 8% and the Locator 22% of their initial retentive force, but by the end of the 3,000 cycles of this study both systems had lost approximately 40% of their starting retention. The polymeric inserts of the SI and Locator systems undergo changes in their physical properties as a result of the fatigue experienced during the repeated cycles of insertion and removal during the experiment which would account for the reduction in retentive power. Whether the patient would notice the loss of retention in the first few months of wear would be of interest to establish. With the exception of the green Locator insert, the ranges of retentive forces provided by the various clips and inserts of the SI and Locator attachment systems were similar (7-11N). The forces of the SI & the Locator systems are likely to be sufficient to prevent displacement of an over denture when eating 'sticky' foods.[19]

Although there was a reduction in retentive forces of the plastic clips or inserts over the course of the cyclic testing, none failed in use. In contrast, designs using a metal clip or matrix have been found to require a high post-insertion maintenance with the need for adjustment to improve their retention.[20-24] The plastic clips of the SI and Locator attachment systems cannot be adjusted, but are and inexpensive and easy to replace, should the patient become aware of the reduced retention.

It from the data obtained in this study we may ***conclude*** that:

1. All the plastic SI clips and nylon Locator inserts provided as ubstantial retentive force.
2. Over the three year simulated use, the SI clips and Locator inserts lost approximately 40% of their initial retentive forces.
3. The different colored inserts for the SI & Locator systems provided a range of strengths, but the data presented here does not accurately match the manufacturers' published values.

Authors' Contribution

MZ: Literature search, Materials and methods, Data collection, Data interpretation, writing and proof reading of article, Results and references.

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REFERENCES

1. Sivaramakrishnan, G. and Sridharan, K. Comparison of implant supported mandibular overdentures and conventional dentures on quality of life: A systematic review and meta-analysis of randomized controlled studies. Aust Dent J.2016; 61 (4): 482-488.
2. Cakir, O., Kazancioglu, H. O., Celik, G., Deger, S. and Ak, G. Evaluation of the Efficacy of Mandibular Conventional and Implant Prostheses in a Group of Turkish Patients: A Quality of Life Study. J Prosthodontic. 2014; 23 (5): 390-396.
3. Müller F., Duvernay E., Loup A., Vazquez L., Herrmann F.R., Schimmel M. Implant-supported mandibular over dentures in very old adults: a randomized controlled trial. J Dent Res. 2013; 92 (12 Suppl.): 154–160.
4. MacEntee MI, Walton JN, Glick N. A clinical trial of patient satisfaction and prosthodontic needs with ball and bar attachments for implant-retained complete over dentures: Three-year results. J Prosthet Dent. 2005; 93 (1): 28-37.
5. Schwartz-Arad D, Kidron N, Dolev E.A long-term study of implants supporting overdentures as a model for implant success. J Periodontol. 2005; 76 (9): 1431-1435.
6. Heydecke, G.; Thomason, J.M.; Lund, J.P.; Feine, J.S. The impact of conventional and implant supported prostheseson social and sexual activities inedentulous adults Results froma randomized trial 2 monthsafter treatment. J Dent. 2005; 33 (8): 549-657.
7. Heydecke G, Penrod JR, Takanashi Y, Lund JP, Feine JS, Thomason JM. Cost-effectiveness of mandibular two-implant overdentures and conventional dentures in the edentulous elderly. J Dent Res. 2005; 84 (9): 794-799.
8. Feine JS, Carlsson GE, Awad MA, Chehade A, Duncan WJ, Gizani S, Head T, Lund JP, MacEntee M, Mericske-Stern R, Mojon P, Morais J, Naert I, Payne AG, Penrod J, Stoker GT, Jr., Tawse-Smith A, Taylor TD, Thomason JM, Thomson WM, Wismeijer D. The McGill Consensus Statement on Over dentures. Montreal, Quebec, Canada. Int J Prosthodont. 2002; 15 (4): 413-414.
9. Vahidi F, Pinto-Sinai G. Complications associated with implant-retained removable prostheses. Dent Clin North Am. 2015; 59 (1): 215-26.
10. Kim HY, Shin SW, Lee JY. Standardizing the evaluation criteria on treatment outcomes of mandibular implant over dentures: a systematic review. J Adv Prosthodont. 2014; 6 (5): 325-32.
11. Cune M, Burgers M, van Kampen F, de Putter C, van der Bilt A. Mandibular over dentures retained by two implants: 10-year results from a crossover clinical trial comparing ball-socket and bar-clip attachments. Int J Prosthodont. 2010; 23 (4): 310-7.
12. Walton JN. A randomized clinical trial comparing two mandibular implant over denture designs: 3-year prosthetic outcomes using a six-field protocol Int J Prosthodont. 2003; 16 (6): 255-60.
13. Tokuhisa M, Matsushita Y, Koyano K. Invitro study of a mandibular implant over denture retained with ball, magnet, or bar attachments: comparison of load transfer and denture stability. Int J Prosthodont. 2003; 16 (2): 128-134.
14. Lee E, Shin SY. The influence of the number and the type of magnetic attachment on the retention of mandibular mini implant over denture. J Adv Prosthodont. 2017 Feb; 9 (1): 14-21.
15. Leem HW, Cho IH, Lee JH, Choi YS. A study on the changes in attractive forceof magnetic attachments for over denture. J Adv Prosthodont. 2016; 8 (1): 9-15.
16. Allen PF, Ulhuq A, Kearney J. Strategic use of a new dental magnet system or etain partial and complete over dentures. Eur J Prosthodont Restor Dent. 2005; 13 (2): 81-86.
17. Burns DR, Unger JW, Coffey JP, Waldrop TC, Elswick RK Jr. Randomized, prospective, clinical evaluation of prosthodontic modalities for mandibular implant overdenture treatment. J Prosthet Dent. 2011; 106 (1): 12-22.
18. Meijer HJ, Raghoebar GM, Batenburg RH, Visser A, Vissink A. Mandibularoverdentures supported by two or four endosseous implants: a 10-year clinicaltrial. Clin Oral Implants Res. 2009; 20 (7): 722-8.
19. Davis DM, Packer ME. Mandibular over dentures stabilized by Astra Tech implants with either ball attachments or magnets: 5-year results. Int J Prosthodont. 1999; 12 (3): 222-229.
20. Trakas T, Michalakis K, Kang K, Hirayama H. Attachment systems for implant retained over dentures: a literature review. Implant Dent. 2006; 15 (1): 24-34.
21. Naert I, Alsaadi G, Quirynen M. Prosthetic aspects and patient satisfaction with two-implant-retained mandibular over dentures: a 10-year randomized clinical study. Int J Prosthodont. 2004; 17 (4): 401-410.
22. Lee DJ. Performance of attachments used in implant-supported over dentures: review of trends in the literature. J Periodontal Implant Sci. 2013; 43 (1): 12-7.
23. Invest JCF, Howlett JA, Hobkirk, JA, Howell PGT: An *invitro* comparison of two implant ball attachment systems. MclinDent Thesis Eastman dental hospital london, 2003.