ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at: www.ijdsir.com

Volume – 3, Issue – 3, June - 2020, Page No. : 195 - 202

Screw-Less and Cement-Less Retrievable Implant Prosthetic Systems- A Review

[1]Dr. Shilpi Sanghvi. BDS. Post-graduate student, Department of Prosthodontics, D.Y Patil University School of Dentistry, Navi Mumbai, Maharashtra, India

[2]Dr. Asha M. Rathod. MDS, DNB. Professor, Department of Prosthodontics, D.Y Patil University School of Dentistry, Navi Mumbai, Maharashtra, India

[3]Dr. Gaurang Mistry. MDS. Professor and Head, Department of Prosthodontics, D.Y Patil University School of Dentistry, Navi Mumbai, Maharashtra, India

[4]Dr. Omkar Shetty. MDS. Dean, D.Y Patil University School of Dentistry, Navi Mumbai, Maharashtra, India

Corresponding Author: Dr. Shilpi Sanghvi, BDS. Post-graduate student, Department of Prosthodontics, D.Y Patil University School of Dentistry, Navi Mumbai, Maharashtra, India.

Citation of this Article: Dr. Shilpi Sanghvi, Dr. Asha M. Rathod, Dr. Gaurang Mistry, Dr. Omkar Shetty, "Screw-Less and Cement-Less Retrievable Implant Prosthetic Systems- A Review", IJDSIR- June - 2020, Vol. – 3, Issue -3, P. No. 195 – 202.

Type of Publication: Review Article

Conflicts of Interest: Nil

Abstract

Innovative abutment systems have been developed to address the limitations of conventional screw-retained and cement-retained implant prostheses. These systems utilize the property of elasticity which is characteristic of nickel-titanium alloys to facilitate optimum retention, easy retrieval and re-insertion of the implant-supported fixed dental prostheses without screws or cement. One prosthesis system consists of a precision-machined nickel-titanium sleeve that switches configurations to lock and unlock the implant restoration. The second abutment system offers retention and retrievability by a precision-engineered abutment and an assembly-type attachment that includes zirconia balls and nickel-titanium spring. Technical complications like screw loosening or fracture, and biological complications like peri-implantitis because of excess cement can be overcome with the use of these novel abutment systems. These abutment systems profoundly streamline the procedure for putting and recovering rebuilding efforts by disposing of the requirement for cement or screws for holding the prosthesis.

Keywords: Micro-Locking Abutments, Shape-Memory Abutments, Nitinol Abutments, Superelastic Abutments

Introduction

Implant-supported fixed dental prostheses (FDP) have become well-established treatment options of care in dental practice over the last 40 years.[1] This success is owed to osseointegration, which has been enhanced through progress in surface technology, advanced surgical techniques, the improvement of the implant-abutment interface and dental prosthesis, as well as the meticulous practice of prophylactic methods to prevent biologic complications and failures.[1-7]

Implant-supported fixed dental prostheses can be secured to implants with screws (screw-retained), or they can be cemented to abutments which are attached to implants with screws (cement-retained).[8] Stability and retention in screw-retained prostheses is obtained from the clamping force caused by preload generated by screw extension, and in cement-retained prostheses, from the inherent properties of the cement.[9, 10] The factors that affect the choice of retention of the prostheses to the implants are: ease of fabrication and cost, aesthetics, access, occlusion, retention, incidence of loss of retention, retrievability, passivity of fit, restriction of implant position, effect on peri-implant tissue health, provisionalization, immediate loading, impression procedures, porcelain fracture, and clinical performance.[11]

Misch [12] outlined a series of advantages and disadvantages of screw-retained and cement-retained implant prostheses.

Advantages of screw-retained restorations include excellent retention, predictable retrievability, minimum interocclusal space requirement, easy hygiene maintenance, and effortless inspection of underlying components for repair.[1]

Disadvantages of screw-retained restorations include increased production time and cost, difficulty in achieving a passive fit, therefore causing residual stress from screw tightening. The screw hole design diminishes the physical strength of porcelain, leading to fracture. Also, the composite resin materials covering the screw access hole is prone to wear, not offering stable control over occlusion and the need for axial loading, and aesthetically unsatisfactory restorations.[1, 13-15]

The most common complications to occur with screw-retained prostheses are prosthetic screw loosening, fracture, and prosthesis breakage.[16] Kreissl et al[17] evaluated over 200 implants in a span of 5 years and observed 6.7% screw loosening and 5.7% porcelain fracture. Zurdo et al[18] reported that over 20% of fixed implant restorations fail because of porcelain fracture or screw loosening.

Advantages of cement-retained restorations include ease of use, reduced cost, superior aesthetics, compensation for implants with inappropriate angulations and passive fit. The screw hole-free design helps develop satisfactory occlusion and its control. It also enhances the physical strength of porcelain thereby resisting fracture.[19, 20]

Disadvantages of cement-retained restorations include irretrievability and retained cement. Undetected residual cement and its removal becomes difficult with increasing subgingival depth.[21] The excess cement may precipitate peri-implant diseases like periimplantitis.[15, 22, 23] Korsch et al[24] reported that removal of excess cement led to a 77% reduction in bleeding and a 100% reduction in suppuration. Studies also report that the abutment may be scratched during the removal of excess cement from subgingival margins and that cement removal may be incomplete.[25] Hyperocclusion may result due to hydrostatic pressure which may prevent the crown from seating completely.[26]

To address the complications of conventional implant prosthetic systems, new implant retention technologies have been developed to combine the advantages of screw (retrievability) and cement (occlusion, aesthetics) while eliminating the disadvantages of composite resins and residual cement. Both the systems consist of key components that make use of the property of elasticity and shape memory of Nickel-titanium alloys to revolutionize retention and retrievability in implant restorations.

Discussion

System 1 - [Smileloc®, developed by RODO Medical, San Jose, California]

This system consists of (1) a precision abutment with undercuts which receives (2) a special sleeve (Smileloc®) manufactured using the shape memory alloy nitinol (nickel-titanium Naval Ordnance Laboratory), (3) a titanium coping with precision undercuts and (4) implant crown (**Fig. 1**). The shape memory sleeve is designed to have 2 sets of movable flaps arranged longitudinally, alternately opening in opposite directions (upwards-inwards and downwards-outwards).[27] These flaps switch shapes that engage and disengage the restoration

when electromagnetic energy (induction) is applied.[28] As shown in **Fig. 2 and Fig. 3**, the inner flaps of the sleeve get locked in the abutment undercuts, and the outer flaps engage the coping undercuts. When the crown is seated, it connects the abutment-sleeve-coping into 1 mechanically interlocking system.[27]

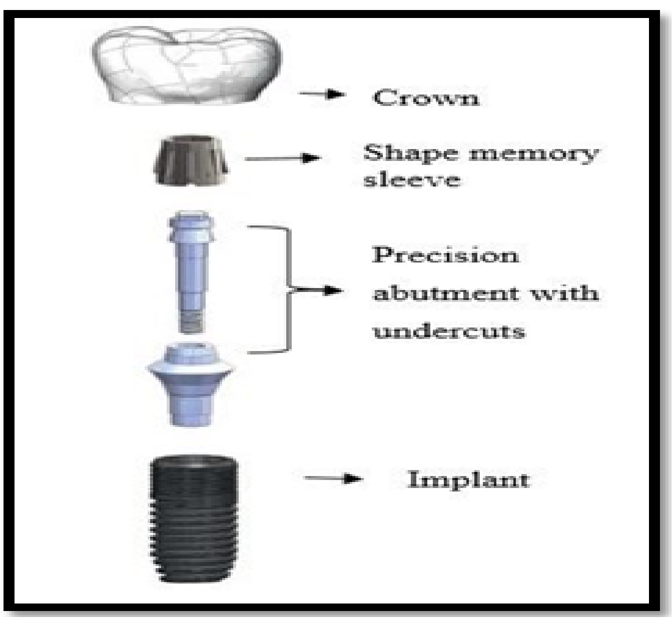

Fig. 1: Overall concept and components of the cement-less, screw-less implant prosthetic system- Smileloc®, developed by Rodo Medical, San Jose, California. (Shah KC, Young SR, Wu BM. Clinical application of a shape memory implant abutment system. J Prosthet Dent 2017;117(1):8-12.)

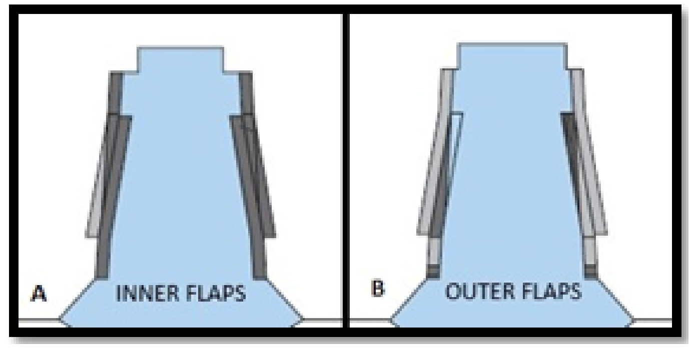

Fig. 2: Cross-section view of flaps engaging undercut in abutment and restoration.

Inner flaps locked on abutment undercut. B. Outer flaps locked on coping undercut. (Shah KC, Young SR, Wu BM. Clinical application of a shape memory implant abutment system. J Prosthet Dent 2017;117(1):8-12.)

Fig. 3: Occlusal and profile view of the shape memory sleeve demonstrating the locked and unlocked configurations.

(Shah KC, Young SR, Wu BM. Clinical application of a shape memory implant abutment system. J Prosthet Dent 2017;117(1):8-12.)

To remove the crown for hygiene purposes or whatever need may arise, electromagnetic energy is provided by the hand-held non-contact intraoral induction device to the restoration coping sleeve complex (Smilekey®) for 8-10 seconds (**Fig. 4**). This returns all flaps to the disengaged position, thus freeing the crown, sleeve, and abutment from the undercuts. The heat induces a change in configuration of the nitinol sleeve that returns all flaps to the disengaged positions, unlocking it from the crown and abutment undercuts. This loss of mechanical interlock allows the prosthesis to be retrieved with finger pressure (**Fig. 5 and Fig. 6**).[27]

Fig. 4: The Smilekey® intraoral induction unit.

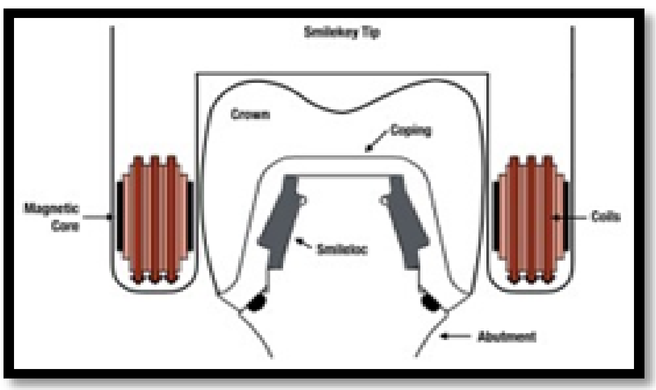

Fig. 5: Diagram showing a cross-section of the Smilekey® paddles in place.

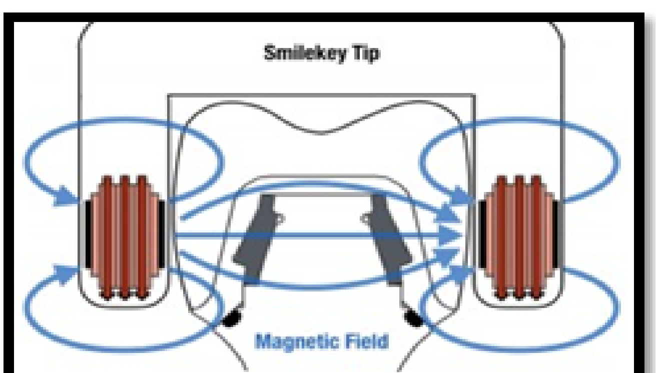

Fig. 6: Diagram showing the induction unit providing electromagnetic energy to disengage or unlock and remove the sleeve.

The Smileloc® abutment system takes advantage of nitinol's shape memory and superelastic properties. The sleeve mechanically deforms to one shape upon heating to above its phase transformation temperature, and recovers its original undeformed form at room temperature.[27]

Property of superelasticity of nickel-titanium alloys- The phase transformation, also known as the martensitic transformation, is a reversible process in nitinol where the austenitic active phase (parent phase) changes to the martensitic active phase (daughter phase). The austenitic phase is the remembered phase after heat treatment during the manufacturing process. On cooling, the phase changes to the martensitic phase without any physical change in shape. On application of external deformation stress, the phase remains as a martensite phase, but owing to the unique property of alloy to undergo twinning, the alloy remains in that deformed shape. Twinning is when the alloy undergoes limited deformation without breaking any atomic bonds, although there is a rearrangement of the ions without any slip.[29, 30]

SYSTEM 2 - [EZ Crown®, Samwon DMP, Yangsan, Korea]

This system consists of (1) a precision-machined abutment with a retention groove, (2) an assembly-type attachment (EZ Crown®) with a specific internal configuration consisting of zirconia balls and nickel-titanium spring and (3) the implant crown with a hole of 1.5mm diameter occlusally to allow access to the tip of the removal driver (**Fig. 7**).[31]

As shown in (**Fig. 8)**, the microlocking implant prosthetic system attachment consists of 3 subcomponents: balls, spring, and a cylinder. The balls, composed of zirconium oxide (ZrO2) are perfect spheres of 0.7mm diameter. They participate directly in the retentive force by being seated in the retention groove on the abutment and also prevent the spring from rotating. The spring is composed of a nickel-titanium alloy called nitinol and is located outside the balls. Both these components are housed in a cylinder.

Zirconia was the material of choice owing to its properties of excellent biocompatibility, flexural strength, fracture strength, wear resistance, and stable holding force.[32] The spring which functions on the principle of non-superelasticity of a specific type of nickel-titanium alloys, allows the ball to be easily placed under the undercut of the retention groove in the abutment by slightly expanding when the attachment is engaged. In addition, after the attachment is engaged with the abutment, the spring exerts a constant external force on the ball.[33]

To remove the crown, a dedicated removal driver is threaded through the hole along the thread of the attachment. The tip of the removal driver pushes the top of the abutment, forcing the zirconia balls against the nitinol spring and ultimately disengaging the prosthesis (**Fig. 9**).

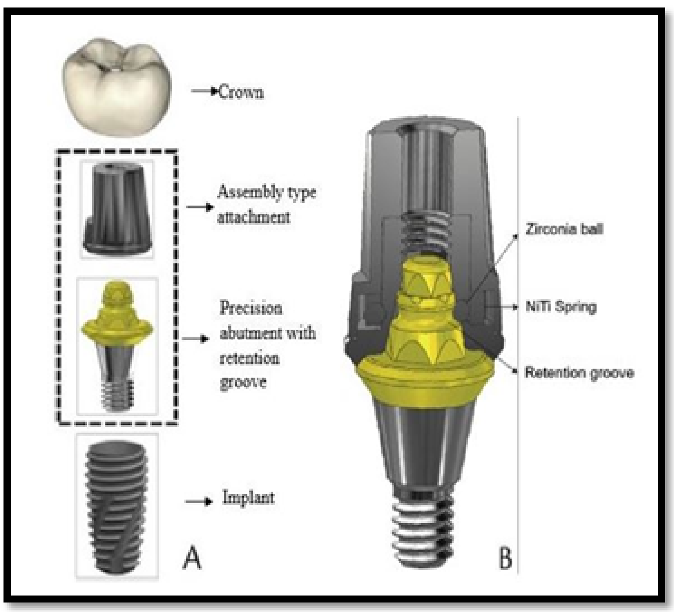

Fig. 7: A. Overall concept and B. components of the cement-less, screw-less implant prosthetic system-EZ Crown®, developed by Samwon DMP, Yangsan, Korea. (Choi JW, Lee JJ, Bae EB, Huh JB. Implant-supported fixed dental prosthesis with a microlocking implant prosthetic system: A clinical report. J Prosthet Dent. 2019 May 7. pii: S0022-3913(19)30014-9)

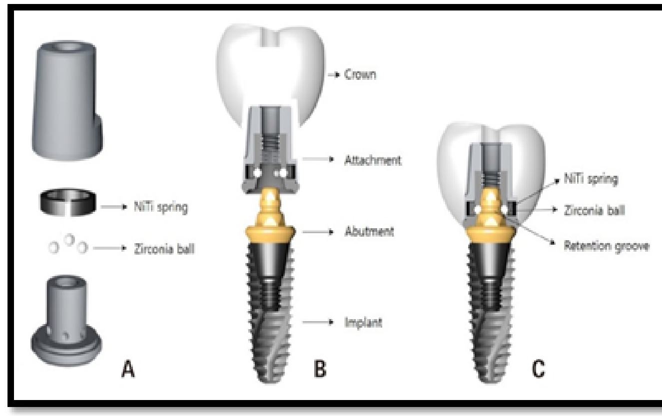

Fig. 8: Schematic representation of the final prosthesis fabricated with EZ Crown®. (Jae-Won Choi, Chan-Hong Song, Jung-Bo Huh. Implant-Supported Fixed Dental Prostheses with New Retention Type Using Zirconia Ball and Nickel-Titanium Spring. The Korean Academy of Oral & Maxillofacial Implantology 2019)

Fig. 9: Removal driver. The tip pushes the top of the abutment, forcing the Zirconia balls against the nitinol spring, thus disengaging the crown.

Property of non-superelasticity of some nickel-titanium alloys-

The EZ Crown® system uses springs that are made of martensitic stabilized nickel-titanium alloys.[30, 34] Martensitic stabilized alloys do not undergo phase transformation, unlike austenitic active and martensitic active alloys because of their stable structure.[35] Thus, they do not exhibit a superelastic or shape memory effect.[36] Non-superelastic alloys exhibit a large working range and low modulus of elasticity.[37] Their low force per unit of activation reduces stiffness and results in excellent spring-back capacity.[35 37] Therefore, after the attachment is engaged in the abutment, the spring is able to provide a light, continuous and constant force on the ball, which is seated in the retention groove of the abutment.[37]

The shape memory implant prosthetic system (Smileloc) is currently compatible with NobelBiocare, Straumann, and Neodent implant systems. For the shape memory sleeve to disengage and release the prosthesis, heat must be applied for some time. When the sleeve does disengage though, there are no visual or acoustic indications. For a prosthesis consisting of multiple implants, a new user may find it difficult to ascertain which implants are still engaged making the removal slightly confusing. More clinical studies are needed to establish the inner workings of these new components.[38]

A study reported the mechanical properties of the microlocking implant prosthetic system (EZ Crowns). The authors concluded that the load-bearing capacity was not significantly different from other commercially available systems. However, increased stability and retention could be achieved due to frictional resistance between the closely contacting implant and abutment surfaces at the internal conical connection interface. A decrease in retention had been reported during the initial 1,000,000 cycles.[39]

Case reports with both these implant prosthetic systems have been very recently published.[40,41] However, the long-term success of implants restored with these novel abutments is yet to be tested.

Conclusion

The new implant prosthetic systems discussed above exhibit retention mechanisms that simplify the implant restoration process by eliminating the complications associated with screws and cement. Fast, easy, safe removal of prosthesis enables the dentist to provide optimal treatment options and maintenance schedules for patients with implants without incurring excessive chairside time and known complications with conventional prosthetic systems.

However, long-term clinical studies with an adequate sample size are needed to determine whether these novel implant prosthetic systems will be successful in clinical applications.

References

1. Wittneben JG, Joda T, Weber HP, Brägger U. Screw retained vs. cement retained implant-supported fixed dental prosthesis. Periodontol 2000 2017;73:141-51.
2. Adell R, Lekholm U, Rockler B, Branemark PI. A 15-year study of osseointegrated implants in the treatment of the edentulous jaw. Int J Oral Surg 1981;10:387–416.
3. Branemark PI, Adell R, Breine U, Hansson BO, Lindstrom J,Ohlsson A. Intra-osseous anchorage of dental prostheses. I. Experimental studies. Scand J Plast Reconstr Surg 1969;3:81–100.
4. Schroeder A, Pohler O, Sutter F. Tissue reaction to an implant of a titanium hollow cylinder with a titanium surface spray layer. SSO Schweiz Monatsschr Zahnheilkd. 1976;86:713-27. German.
5. Schroeder A, van der Zypen E, Stich H, Sutter F. The reactions of bone, connective tissue, and epithelium to

endosteal implants with titanium-sprayed surfaces. J Maxillofac Surg 1981;9:15–25.

6. Taylor TD, Agar JR. Twenty years of progress in implant prosthodontics. J Prosthet Dent 2002;88:89–95.
7. Zarb GA, Schmitt A. Osseointegration and the edentulous predicament. The 10-year old Toronto study. Br Dent J 1991;170:439–44.
8. Millen C, Brägger U, Wittnben JG. Influence of prosthesis type and retention mechanism on complications with fixed implant-supported prostheses: a systematic review applying multivariate analyses. Int J Oral Maxillofac Implants 2015;30:110-24.
9. Levine RA, Clem D, Beagle J, Ganeles J, Johnson P, Solnit G, et al. Multicenter retrospective analysis of the solid-screw ITI implant for posterior single-tooth replacements. Int J Oral Maxillofac Implants 2002;17:550-6.
10. McGlumphy EA, Mendel DA, Holloway JA. Implant screw mechanics. Dent Clin N Am 1998;42:71-89.
11. Rola Shadid, Nasrin Sadaqa, A Comparison Between Screw- and Cement-Retained Implant Prostheses. A Literature Review. J Oral Implantol 2012;38:298-307.
12. Misch CE. Contemporary implant dentistry. 3rd ed. St Louis; CV Mosby; 1993. p. 651-85.
13. Taylor TD. Prosthodontic complications associated with implant therapy. Oral Maxillofac Surg Dent Clin N Am 1991;4:979-91.
14. Goodacre CJ, Bernal G, Rungcharassaeng K, Kan JY. Clinical complications with implants and implant prostheses. J Prosthet Dent 2003;90:121-32.
15. Michalakis KX, Hirayama H, Garefis PD. Cement-retained versus screw-retained implant restorations: a critical review. Int J Oral Maxillofac Implants 2003;18:719-28.
16. Taylor TD. Prosthodontic complications associated with implant therapy. Oral Maxillofac Surg Dent Clin N Am 1991;4:979-91.
17. Kreissl ME, Gerds T, Muche R, Heydecke G, Strub JR. Technical complications of implant-supported fixed partial dentures in partially edentulous cases after an average observation period of 5 years. Clin Oral Implants Res 2007;18:720-6.
18. Zurdo J, Romao C, Wennström JL. Survival and complication rates of implant supported fixed partial dentures with cantilevers: a systematic review. Clin Oral Implants Res 2009;20:59-66.
19. Gervais MJ, Wilson PR. A rationale for retrievability of fixed, implant supported prostheses: a complication-based analysis. Int J Prosthodont 2007;20:13-24.
20. Khraisat A, Jebreen SE, Baqain ZH, Smadi L, Bakaeen L, Abu-Hammad O. Multicenter retrospective study of cement-retained implant-supported anterior partial prostheses: success and restoration evaluation. Int J Oral Maxillofac Implants 2008;23:705-8.
21. Linkevicius T, Vindasiute E, Puisys A, Linkeviciene L, Maslova N, Puriene A. The influence of the cementation margin position on the amount of undetected cement. A prospective clinical study Clin Oral Implants Res 2013;24:71-6.
22. Chee W, Felton DA, Johnson PF, Sullivan DY. Cemented versus screw-retained implant prostheses: which is better? Int J Oral Maxillofac Implants 1999;14:137-41.
23. Wilson TG Jr. The positive relationship between excess cement and periimplant disease: a prospective clinical endoscopic study. J Periodontol 2009;9:1388-92.

24. Korsch M, Obst U, Winfried W. Cement-associated peri-implantitis: a retrospective clinical observational study of fixed implant-supported restorations using a methacrylate cement. Clin Oral Implants Res 2014;7:797-802
25. Agar JR, Cameron SM, Hughbanks JC, Parker MH. Cement removal from restorations luted to titanium abutments with simulated subgingival margins. J Prosthet Dent 1997;78:43-7.
26. Nissan J, Narobai D, Gross O, Ghelfan O, Chaushu G. Long-term outcome of cemented versus screw-retained implant-supported partial restorations Int J Oral Maxillofac Implants 2011;26:1102-7.
27. Shah KC, Young SR, Wu BM. Clinical application of a shape memory implant abutment system. J Prosthet Dent 2017;117:8-12.
28. Urdaneta A, Marincola M, Weed M, Chuang S-K. A screwless and cementless technique for the restoration of single tooth implants: a retrospective cohort study. J Prosthodont 2008;17:562-71.
29. Pelton AR, Dicello J, Miyazaki S. Optimisation of processing and properties of medical grade Nitinol wire. Minim Invasive Ther Allied Technol 2000;9:107-18.
30. Kusy RP. A review of contemporary archwires: their properties and characteristics. Angle Orthod 1997;67:197-207
31. Choi JW, Lee JJ, Bae EB, Huh JB. Implant-supported fixed dental prosthesis with a microlocking implant prosthetic system: A clinical report. J Prosthet Dent 2019.
32. Manicone PF, Rossi Iommetti P, Raffaelli L. An overview of zirconia ceramics: basic properties and clinical applications. J Dent 2007;35:819-26.
33. Wayman, C.M. Shape memory and related phenomena. Prog Mater Sci 1992;36:203–24.
34. Gurgel Jde A, Kerr S, Powers JM, Pinzan A. Torsional properties of commercial nickel-titanium wires during activation and deactivation. Am J Orthod Dentofacial Orthop 2001;120:76-9.
35. Pun DK, Berzins DW. Corrosion behavior of shape memory, superelastic, and nonsuperelastic nickel-titanium-based orthodontic wires at various temperatures. Dent Mater 2008;24:221-7.
36. Ferreira MA, Luersen MA, Borges PC. Nickel-titanium alloys: A systematic review. Dental Press J Orthod 2012;17:71-82.
37. Buehler WJ, Wiley RC. TiNi-Ductile intermetallic compound. Trans ASM 1962;55:269-76.
38. Chao D, Crockett R, Wu B, Shah K. Digital workflow for predictable immediate loading in the mandible by using a shape memory dental implant abutment system: A clinical report. J Prosthet Dent 2019.
39. Choi JW, Choi KH, Chae HJ, Chae SK, Bae EB, Lee JJ et al. Load-bearing capacity and retention of newly developed micro-locking implant prosthetic system: An in vitro pilot study. Materials (Basel). 2018;11:564.
40. Shah KC, Linsley CS, Wu BM. Evaluation of a shape memory implant abutment system: An up to 6-month pilot clinical study. J Prosthet Dent 2019.
41. Choi JW, Song CH, Huh JB. Implant-Supported Fixed Dental Prostheses with New Retention Type Using Zirconia Ball and Nickel-Titanium Spring. Korean Academy of Oral & Maxillofacial Implantology. 2019;23:16-24.