IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

# ORTHODONTIC BRACKETS

*FROM PAST TO PRESENT*

[1]Dr. Ishita Agrawal, [2]Dr. Falguni Mehta, [3]Dr. Renuka Patel, [4]Dr. Rahul Trivedi, [5]Dr. Skanda Keerthana J.

[1]PG Part 3 student, [2]Professor and Head of the Department, [3]Professor, [4]Assistant Professor, [5]PG Part 3 student

[1]Department of Orthodontics and Dentofacial Orthopaedics

[1]Government Dental College and Hospital, Ahmedabad, India

*Abstract:* **It is difficult to imagine that there was a period in orthodontics before the invention of brackets. Brackets had a modest beginning in the form of the Ribbon Arch bracket designed by Angle. The introduction of brackets saw a new era in orthodontics. With time both the Orthodontist and the manufacturers started shouldering the responsibilities for arriving at new bracket designs and different bracket system. The wave of design changes continued to mount with contributions from Angle, Steiner, Holdaway, Jaraback, Fizzell, Ricketts, tweed and many others, which led to the introduction of the standard Edge-wise bracket which was also called as the Siamese or twin bracket. Dr. Ronald H Roth developed an appliance through clinical trial and error, starting with the standard Andrew Brackets and then altering the values and placement of some Anterior brackets. However, the process of the modifying the brackets is still on. Though, we all are using recent brackets which are currently available in the markets, it is important to know the past history of brackets which was used earlier. Thus, this article reviews the history of various orthodontic brackets and its advantages and disadvantages. We suggest that many more review studies should come aiming at the biocompatibility, aesthetics and treatment results of each bracket. Such studies will help the practitioner to decide the bracket selection for his treatment plan.**

*Index Terms* - **Brackets, Preadjusted Edgewise, Lingual, Self-ligating, Customised.**

## I. INTRODUCTION:

Efficiency in" orthodontic appliances and techniques need both optimal rate of tooth movement and prevention of potential damage of tooth and surrounding periodontium. The term bracket was first coined by Dr. E.H. Angle in 1916, when he introduced ribbon arch appliance. He defined brackets as " a simple rigid L shaped structure one arm of which is fixed to a vertical surface the other projecting horizontally to support a weight, as a shelf"[1]. Thus, brackets act a vehicle to incorporate the biomechanical regimen into the tooth undergoing treatment[2]. The evolution of brackets from when introduced by Angle till over the past century has tremendously increased the efficiency of tooth movement, decreased the treatment time and reduced the chair time. The increased demand of aesthetics has led to the development of more tooth coloured or invisible bracket systems, but at the same time not falling short on efficiency.

**II. DEVELPOMENT OF BRACKETS:**

A. E.H. Angle played a pioneering in developing and evolving bracket types from pin and tube appliance to edgewise brackets or "tie-bracket", which gave more control in controlling the tooth movement.

1. Pin and tube appliance: by Angle[3] in 1910, first time gave the axial control in tooth movement. The close fit between the pin on the arch wire and the vertical tube on the band provided axial control in all directions but permitted only limited mesiodistal crown displacement.
2. Ribbon Arch bracket mechanism[4]: given by Angle in 1916, provided the mesiodistal movement of the tooth, with lock pins snugly fit into the slot. Cleats were devised, which were soldered on the arch wire so at to contact the ribbon arch bracket, helping in holding the tooth in upright position. Also, cleats can be soldered at different locations to provide tooth movement.
3. Edgewise Bracket[5]: these were introduced in 1925, by E.H. Angle, by the name of "open face" or "tie-bracket", but presently known as edgewise brackets. These were the first bracket system to have horizontal slot. Thus, giving more control over the tooth movement in all three planes as having the two-point contact. Dimensions of which were 0.022"x0.028." The new appliance facilitated the movement of all malposed teeth into their correct axial inclinations in the "line of occlusion."

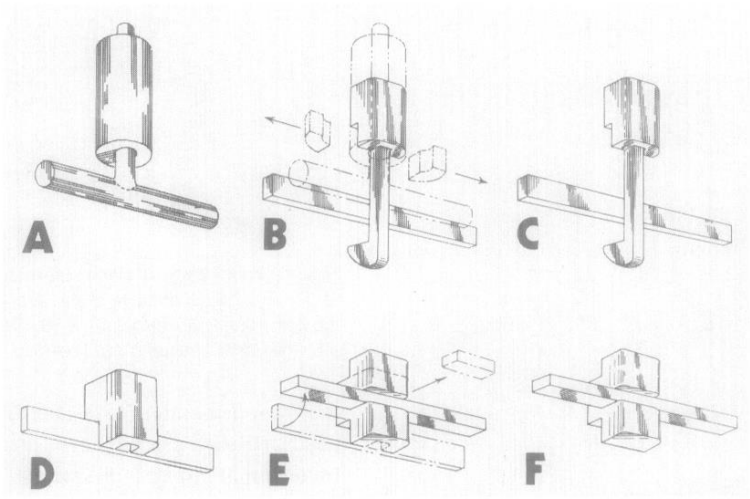


Figure showing development of brackets from pin and tube appliance to standard Edgewise bracket

B. P.R. Beggs, student of Angle school of orthodontic, in early 1930s realised the advantage of first tipping the tooth into the final position and he reverted back to use ribbon arch appliance with bracket modification[1] and developed his own bracket in 1933.

He reducing the slot size to improve rotational control with 0.016 inch (0.406 mm) arch wires and by facing the arch wire slot gingivally. Which came to be known as "modified ribbon arch bracket" or "Begg's bracket." Thus, creating a single point contact between archwire and bracket, thereby, decreasing the resistance to sliding[6]. The decrease in resistance was due to decrease in friction and elimination of binding of arch wire to brackets. This appliance can be known as low friction, free sliding mechanics which gave way for recent development of self-ligating brackets. With the modifications and evolution of Australian wire, Beggs in 1956 introduced his own appliance system known as Beggs appliance or Differential force appliance[7] or light wire appliance.

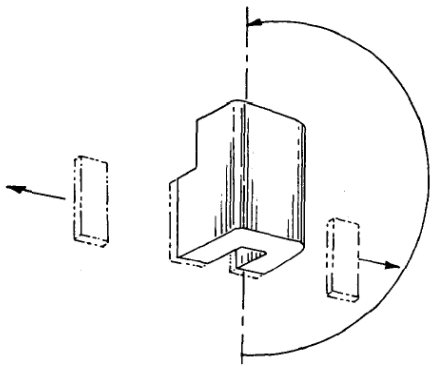

Figure showing Begg's bracket

C. Modifications of Edgewise brackets: there was the continuous attempt to modify the Edgewise bracket to increase the efficiency and more control over tooth movement.

1. Lewis brackets[8]: Paul D. Lewis in 1950, modified the edgewise bracket by soldering a wing or rotation arm to a single bracket that contact the inside of the archwire. Alexander further modified the Lewis bracket by adding a power arm.
2. Siamese Bracket[9]: introduced by Dr. Brainerd Swain in 1949, to overcome the problem of root parallelism in extraction cases. He put the two brackets on a common base in order to assure alinement and facilitate attachment. Thus, these brackets were also known as "Twin Brackets."

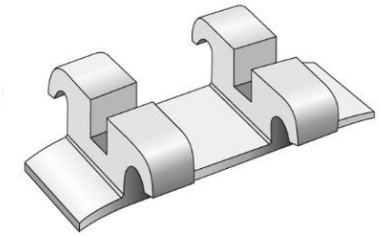

Figure showing Twin Bracket

3. Tip-edge appliance[1]: developed by P.C. Kesling in 1988. Precise removal of diagonally opposed corners of conventional edgewise slots to permit desired initial free crown tipping yet provide predetermined secondary control of root uprighting as required for each tooth. Leading to initial controlled tipping and final edgewise control with straight wires.

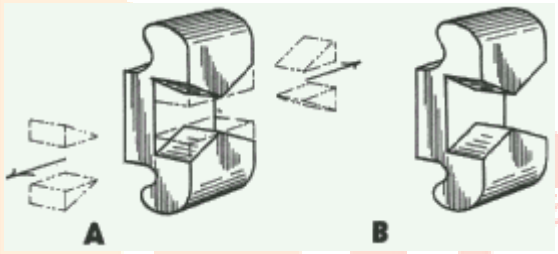


Figure showing Tip-Edge Bracket

D. Jaraback in 1969 introduced the phrase "building treatment into appliance." But, even long before that there was a continuous attempt to incorporate torque and tip into appliance systems by various orthodontists. Holdaway[10] in 1952 suggested the angulated placement of brackets to upright the teeth. Ivan F. Lee in 1959 was the first one to incorporate torque into brackets[11]. Dr. Brainerd Swain also evolved his Siamese brackets to incorporate tip and rotation[9].

E. PRE-ADJUSTED EDGEWISE APPLIANCE:

1. Andrews straight wire Appliance: based on his "six keys to normal occlusion[12]" and development of facial axis center of crown (FACC)[13] he developed the Straight wire appliance. Andrews modified Angle's edgewise brackets by fully programming all adjustments into the bracket and incorporating the principles of torque-in-base and the compound contour base. These complex design features allowed the planes of the slot to indirectly represent the planes of the crown when a bracket was correctly placed, resulting in slot alignment when the tooth was ideally positioned.
2. Roth's modification[14,15]: Ranold Roth modified the original straight wire appliance so that post treatment teeth settle in the position as non-orthodontic normal as studied by Andrews. He proposed the "end of appliance" goal, to put all the teeth in overcorrected position. In maxillary prescription there is increased the torque in anteriors and reduced tip in premolars and canines. But, only 1degree tip reduction in lower premolars. Rotations were introduced into the system. Torque was increased in maxillary molars.
3. MBT system[16]: this was the 3rd generation SWA introduced by McLaughlin, Benett and Trevisi. Richard P. McLaughlin, and John C. Bennett developed the "Recommended Bracket placement chart" to position the brackets in PEA[17]. Later, they modified the prescription chart by increasing torque and decreasing the tip in upper and lower anteriors. Also, torque value was decreased in lower molars. They collaborated with 3M to develop the MBT versatile+ appliance system.

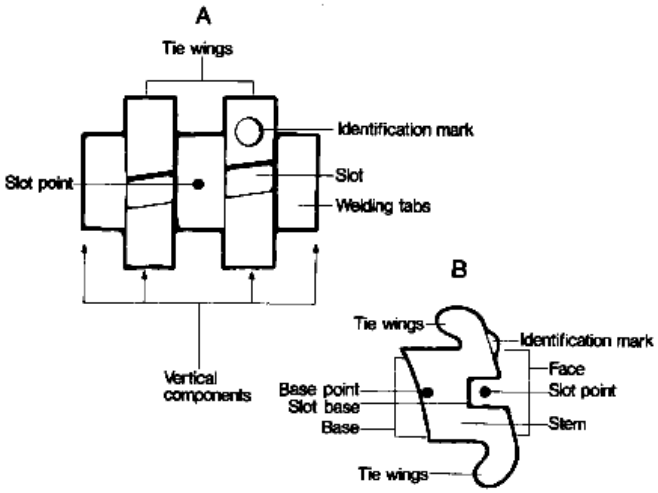


Figure showing Straight Wire appliance Bracket

F. Self-ligating Bracket systems (SLB):

The forces are transmitted to the tooth when the arch wire is secured into bracket slot. In the early 20th century Angle started using gold ligatures. The gold ligatures were replaced by cheap stainless steel ligatures but were to give higher forces of friction thus limiting the tooth movement in initial alignment[11]. With the development of elastomeric ligatures, it has almost completely replaced steel ligatures. But later found to have high force degradation[18] and higher friction with arch wire[19]. To overcome these, there was the constant effort to step up the new ligation system. The self-ligation system defined as in which there is inbuilt archwire locking mechanism[11].

These brackets are been present for more than last 70 years started with the development 'Russell lock' edgewise attachment 1935 by Stolzenberg[20]. It had a flat threaded screw which was used for fixation or removal by turning the key.

In 1971, A.J. Wildman introduce the Edgelok brackets which were passive and were first commercially available SLB[21]. It clicks open and it clicks shut thus, there is no intermediary position. The brackets are converted into tubes after closing of cap.

Figure showing Edgelok Bracket

Mobil-Lock[22] passive SLB system was developed by Franz Sander in 1974, it has a semi-circular labial disk which require a special screw drive to open and close the system. But had the many disadvantages like poor rotational control, and difficulty in opening and closing the bracket.

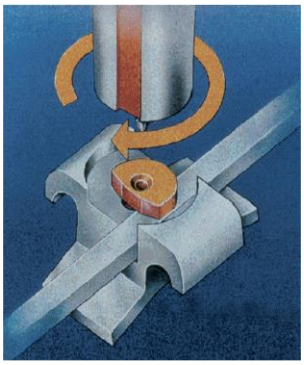

Figure showing Edgelok Bracket SLB

Dr. Herbert Hanson in 1976 created a prototype of first active SLB known as SPEED[22], which was commercialised in 1980. These are miniaturized self-ligating appliance which offers overlapping benefits to both patients and clinicians[23]. SPEED stands for features of the bracket system *spring loaded, precision, edgewise, energy, and delivery*[24]. It has a fully pre adjusted edgewise slot of 0.018 or 0.022 and has super elastic NiTi spring clisp which engages the archwire. All SPEED brackets have a square auxillary slot of 0.016" occlusally which can be used to put different auxiliaries. There is a small hook known as the SPEED Mushroom hook, these are used to hold intraoral elastics.

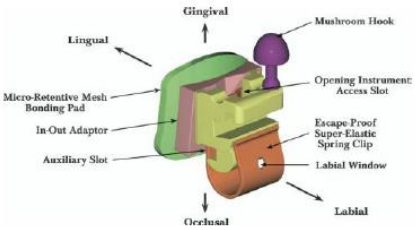


Figure showing SPEED SLB

Activa brackets[25] were developed by Erwin Pletcher in 1986. had a rotating slide, which therefore gave a concave inner radius to the labial surface of the slot. This increased the effective slot depth with small diameter wires, diminishing labiolingual alignment with such wires. The slide was retained on the mesial and distal ends of the slot and this made for a wider than average bracket, which reduced the interbracket span with the consequent disadvantages. A potential advantage of self-ligation is that the good archwire control permits use of narrower brackets and thus greater interbracket span and hence lower forces and a longer range of action with any given archwire during the alignment phase.

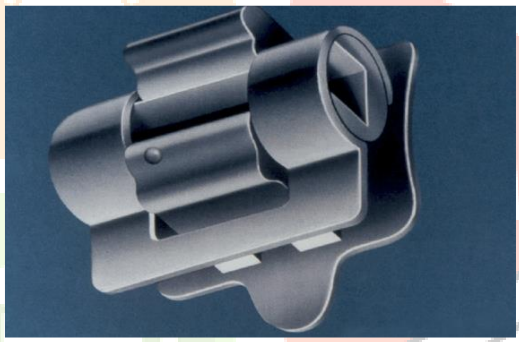

Figure showing Activa Brackets

Time2[26] SLB developed by Wolfgang Heiser in 1994, resembled the SPEED system. the Time clip rotates into position around the gingival tie wing and rotates toward the occlusal rather than the gingival wall of the slot.

Damon System[27,28]: the Damon passive self-ligation system was first introduced by Dr. Damon Dwight in 1994 with first generation Damon SL brackets. The Damon philosophy is based on the principle of using the threshold force i.e. just enough force to initiate tooth movement. These had large sliding doors which sometimes inadvertently due to the exterior position of the slide and become more prone to breakage.

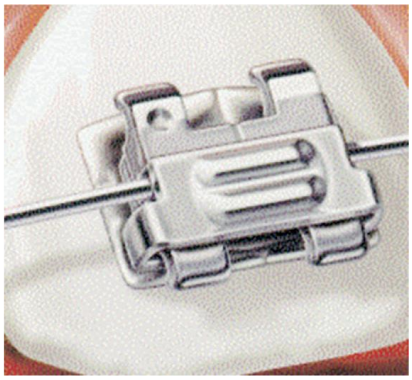

Figure showing 1st generation Damon bracket

This was overcome in 2nd generation Damon 2 SL brackets which were introduced in year 2000. Slide was placed within the shelter of the tie wing to prevent inadvertent opening.

Figure showing 2nd generation Damon bracket

Damon 3 and Damon 3MX were introduced in years 2004 and 2005 respectively. Damon 3 brackets are semi aesthetic brackets i.e. it has clear base and metal slot for archwire. Opening and closing mechanisms were very simple but the separation of metal from reinforced resin component accounts for its major disadvantage. Damon MX and Damon Q (2009) are all metal variants. These has an additional vertical slot permitting use of drop in hooks. Also, these can be open and close using a probe or gentle finger pressure.

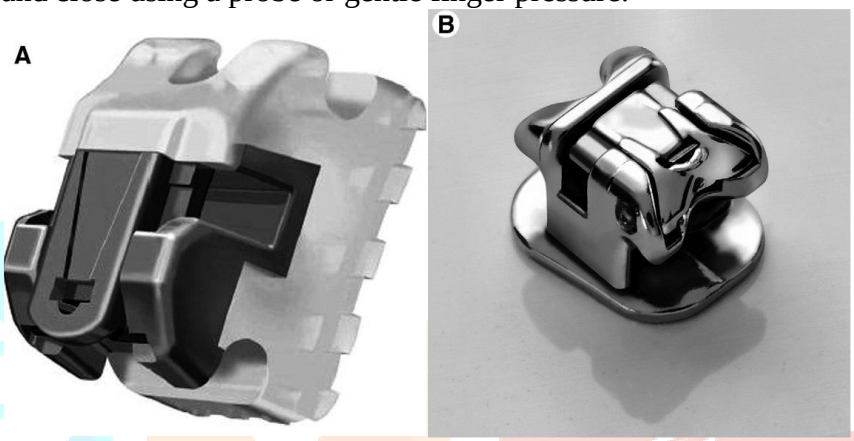


Figure showing Damon 3 and Damon 3MX

In Ovation[25,29]: active SLB system developed by Micheal C. Alpern in 2000. These are very similar to SPEED bracket system but have a true twin design. Because of large size it has difficulty in opening and closing. In 2002 In- Ovation R (reduced) were developed for the anterior region this gave the increased inter bracket distance. The system then known as System R. In-Ovation C are all ceramic SLB which were introduced in 2006.

Figure showing In- ovation bracket

SmartClip: designed by Gary L. Weinberger and introduced by 3M in year2004. it has an the integral nickel-titanium clip that permits simple archwire insertion and removal, yet holding the archwire with a pre-programmed force, avoiding unintentional disengagement[30]. The instrument or finger pressure required to insert or remove an archwire is therefore not applied directly to the clip, but to the archwire, which in turn applies the force to deflect the clips and thus permits archwire insertion or removal. This mechanism therefore has to cope with providing easy insertion and removal through the jaws of the clips but must also prevent inadvertent loss of ligation for both small, flexible archwires and large, stiff archwire. Newer version was introduced in 2009, SmartClip SL3. And esthetic variant was introduced in 2007 known as SmartClip Clarity SL.

Figure showing SmartClip

There has be considerable increase in the use of SLB because it holds many advantages over the conventional ligating systems such as full archwire engagement, low friction, less chairside assistance and faster removal and ligation[26].

G. LINGUAL ORTHODONTICS:

In recent decades there has been higher esthetic demands which have led to the development of various esthetic treatment approaches, including lingual appliances. The advantages of lingual appliances include lower noticeability, fewer white spot lesions and caries, lighter forces being needed because of the smaller interbracket distance, smaller anchorage loss, and increased comfort. Possible disadvantages include practical difficulties in the insertion and handling of these appliances, longer chair times for patients and orthodontists, higher laboratory costs, and poorer outcomes compared with labial appliances.

1. KRUZ lingual appliance[31]: developed the first lingual appliance in 1979
2. CONCEAL system: developed by Thomas Creekmore in 1989. The opening of the arch wire slots is occlusal rather than to the lingual aspect. This occlusal approach makes arch wire insertion, seating, and removal easier than arch wire insertion with lingually opening slots.


Figure showing CONCEAL system

3. FUJITA lingual brackets: first introduced in 1979 and developed mushroom arch wire appliance[32]. Later modified by Ryoon ki Hong and Hee Wook Sohn in 1999[33]. Originally it featured a slot that opened towards the occlusal. A lockpin was inserted mesiodistally in to a groove in the slot to secure the arch wire in conjunction with elastomers and ligatures. Modified to brackets for the anterior teeth and premolars now have three slots: occlusal, lingual, and vertical. Molar brackets have five slots: one occlusal, two lingual, and two verticals. Each of the three types of archwire slots provides different capabilities for efficient tooth movements.

i. Main occlusal slot: 0.019”x0.019”: easier archwire insertion, seating, and removal than with lingually opening slots.
ii. .018" X .018" lingual slot: partial canine retraction.
iii. The molar bracket has .028" X .022" outer and .018" X .018" inner lingual slots ("slot in slot").
iv. The .016" X .016" vertical slot permits the insertion of auxiliary uprighting springs or elastic hooks on one or more teeth at any time during treatment.

4. Self-ligating lingual brackets:

- First presented by Neumann and Holtgrave[34], who suggested the use of SPEED self-ligating labial brackets for application in the lingual technique. He used labial upper incisor brackets upside down for lingual bonding on the bicuspids and for bonding on the lingual of the incisors.
- Macchi et al. in 2002[35] introduced 2D lingual SL brackets by the name of “Philipe self-ligating brackets” It can be directly bonded to the lingual tooth surface because they do not have slots, only 1st and 2nd order movements are possible. Four types are available: a standard medium twin (regular use), a narrow single wing bracket for lower incisors, a large twin and a three-wing bracket for attachment of intermaxillary elastics and application of 3rd order movements.
- Forestadent 3D Torque-Lingual self-ligating brackets: have the similar flat design as the Philippe 2D self-ligating brackets, but have a vertical slot for 3-dimensional control.

- Adenta Evolution lingual bracket[34]: is designed as a one piece bracket with a clip that opens at the incisal edge and allows insertion of the archwire from the occlusal direction.
- Latest lingual SLB includes In-ovation -L and ceramic Phantom SLB brackets.'

Figure showing various SL Lingual Brackets

H. AESTHETIC BRACKETS: the demand of aesthetic not only led to rise in development of Lingual orthodontic system but also in labial appliance system with the development and advancement of materials such as ceramic brackets, and plastic brackets.

1. Plastic bracket[36]: developed in 1970s. initially it was made from acrylic then later polycarbonate was used. But later it was found to have shown staining and odours but more importantly their lack of strength and stiffness resulting in bonding problems, tie wing fractures and permanent deformation. To compensate for the lack of strength and rigidity of the original polycarbonate brackets, high-grade medical polyurethane brackets and polycarbonate brackets reinforced with ceramic or fibreglass fillers and/or metal slots have
2. been recently introduced and are becoming increasingly popular. Currently available plastic brackets include Aesthetic-line, Alexander spirit-MB, Avalon, Brilliant, Classic, Damon 3, OrthoFlex, etc.
3. Ceramic brackets: introduced in 1980s. they are made of either polycrystalline or monocrystalline aluminium oxide as per manufacturing process. But first ceramic bracket was a monocrystalline bracket. Ceramic brackets provide higher strength, more resistance to wear and deformation, better colour stability and, most important to the patient superior aesthetics. Polycrystalline zirconia brackets (ZrO2), which reportedly have the greatest toughness amongst all ceramics, have been offered as an alternative to alumina ceramic brackets. Acclaim, Allure, Clarity, Encore!, Transcend, an Virage are few of currently available ceramic bracket systems.


Figure showing Ceramic bracket (Clarity)

I. CUSTOMISED TOOTH MOVEMENT:

Dynamic bracket customisation, concept whereby each functions of the bracket can be enhanced as and when needed during course of treatment[11]. A novel customized system allows for assessment of changes in 3D and customization of treatment planning brackets, and wires by means of intraoral scanning, cone-beam computed tomography (CBCT), three-dimensional (3D) photography, and computer-aided design and computer-aided manufacturing (CAD/CAM) technologies[37]. Newer technologies can be summed to "improving reproducibility, efficiency, and quality of orthodontic treatment[38]."

1. SureSmile[39]:

The SureSmile technology was developed and is owned by OraMetrix, a company founded in 1998 by Friedrich (Fritz) Riemeier and Dr. Rohit Sachdeva. It uses robotics to customize fixed orthodontic appliances. The archwires are produced with a wire-bending robot in the sizes and shapes selected by the orthodontist. The investigations into the precision of the bends with stainless steel wire show less than 1° of error in bends and twists.

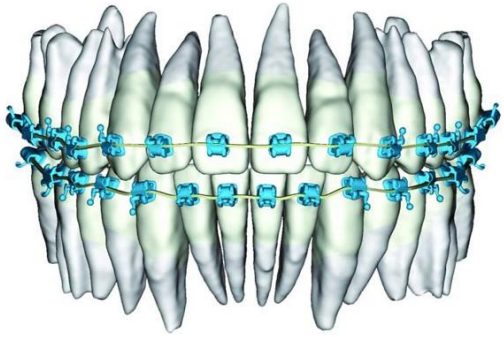

Figure showing SureSmile system

2. Insignia[40]: Dr. Wittenberger customized Damon Braces by using 3D technology in late 1990s. Insignia specialized braces specifically take your unique anatomy into account for a more precise, fast, and comfortable experience in braces[41]. It is a precise, start-to-finish process that works with Damon, Inspire ICE, and conventional appliances. Insignia software incorporates the clinician's treatment plan into a virtual 3-dimensional model of each patient's ideal occlusion and delivers a complete custom solution: patient-specific brackets, precision (computer-assisted) bracket placement, and custom wires to eliminate time-consuming adjustments in all phases of treatment[42]. The Insignia system reverse-engineers the brackets themselves to the correct specifications in one of two ways, depending on the type of brackets selected by the orthodontist[43]. One important feature recently added to the Insignia system is called "Overcorrection". This program tracks the three-dimensional movements of the center of resistance of the roots and the center of the bracket slot for each tooth, then calculates the tooth's direction of rotation with respect to 3rd-order constraints. It also allows customization of archform, based on skeletal mapping of the mandibular bone's cortical limits at the level of the center of resistance of the teeth.
3. The Incognito™ Appliance System[44]: developed by 3M Unitek. It is a fully customized brackets, archwires and bonding trays to deliver predictable, to provide efficient and aesthetic treatment.


Figure showing INCOGNITO system

4. Harmony[45]: it is also a fully customised self-ligating lingual orthodontic system developed by ASO international inc.
5. Lightforce orthodontics[46]: it is a new customised orthodontics system by Dr. Alfred Griffin III given in year 2015 and was approved by AAO in 2019.
6. Customised ceramic brackets (CCB)[37]: : in vitro studies demonstrated CCB to be an applicable labial orthodontic bracket system with optimized aesthetics and biomechanics. Thus, it would be an ideal alternative for patients who pursue aesthetic orthodontic treatment.

## III. CONCLUSION:

Since the time of Angle to present, orthodontic brackets have been used to transmit forces for tooth movement. With the development of technologies in materials and engineering, along with the constant efforts from orthodontists, there has been a continuous evolution of orthodontic appliance systems which has increased the efficiency, decreased discomfort and decreased treatment time. The growing concerns for aesthetics have further modified appliance systems from being metal to invisible system but along taking care not to cost efficiency. With the development advanced technologies in last two decades has led to development of customised orthodontic treatment not only for individual patient but for individual tooth. All the development has made the work of orthodontists very easy not only in terms of manual wire bending but also in term of treatment planning and thus, outcome

REFERENCES


1. Kesling PC. Expanding the horizons of the edgewise arch wire slot. American Journal of Orthodontics and Dentofacial Orthopedics. 1988 Jul;94(1):26–37.
2. Iijima M, Zinelis S, Papageorgiou SN, Brantley W, Eliades T. Orthodontic brackets. In: Orthodontic Applications of Biomaterials [Internet]. Elsevier; 2017 [cited 2020 Aug 1]. p. 75–96. Available from: https://linkinghub.elsevier.com/retrieve/pii/B9780081003831000047
3. Angle EH. Original Communications. Some New Forms of Orthodontic Mechanism, and the Reasons for Their Introduction. [Volume 58, Issue 9, September, 1916, pp. 969-994]. The Dental cosmos; a monthly record of dental science [Vol 58] [Internet]. 1916; Available from: http://name.umdl.umich.edu/0527912.0058.001
4. Angle EH. Orthodontia-The Ribbon-Arch Mechanism and Some New Auxiliary Instruments. [Volume 62, Issue 10, October, 1920, pp. 1157-1176]. The Dental cosmos; a monthly record of dental science [Vol 62] [Internet]. 1920; Available from: http://name.umdl.umich.edu/0527912.0062.001
5. Angle EH. The latest and best in orthodontic mechanism [Volume 71, Issue 2, February, 1929, pp. 164-174]. The Dental cosmos; a monthly record of dental science [Vol 71] [Internet]. 1929; Available from: http://name.umdl.umich.edu/0527912.0071.001
6. The Begg Appliance [Internet]. Australasian Begg Society of Orthodontists. [cited 2020 Aug 2]. Available from: https://www.beggsociety.org/the-begg-appliance
7. Begg PR. Differential force in orthodontic treatment. American Journal of Orthodontics. 1956 Jul 1;42(7):481–510.
8. Lewis PD. Space closure in extraction cases. American Journal of Orthodontics. 1950 Mar 1;36(3):172–91.
9. JCO Interviews Dr. Brainerd F. Swain on Current Appliance Therapy - JCO Online - Journal of Clinical Orthodontics [Internet]. [cited 2020 Aug 2]. Available from: https://www.jco-online.com/archive/1980/04/250/
10. Holdaway RA. Bracket angulation as applied to the edgewise appliance. Angle Orthod. 1952 Oct 1;22(4):227–36.
11. KHARBANDA OP. ORTHODONTICS: diagnosis of & management of malocclusion & dentofacial deformities. Place of publication not identified: ELSEVIER INDIA; 2019.
12. Andrews LF. The six keys to normal occlusion. Am J Orthod. 1972 Sep;62(3):296–309.
13. COMMENTARY The Straight-Wire Appliance - JCO Online - Journal of Clinical Orthodontics [Internet]. [cited 2020 Aug 2]. Available from: https://www.jco-online.com/archive/2017/09/520-commentary-the-straight-wire-appliance/
14. The Straight-Wire Appliance 17 Years Later - JCO Online - Journal of Clinical Orthodontics [Internet]. [cited 2020 Aug 2]. Available from: https://www.jco-online.com/archive/1987/09/632-the-straight-wire-appliance-17-years-later/
15. Five Year Clinical Evaluation of the Andrews Straight-Wire Appliance - JCO Online - Journal of Clinical Orthodontics [Internet]. [cited 2020 Aug 2]. Available from: https://www.jco-online.com/archive/1976/11/836/
16. mbtsystem-handbook-70-2021-4902-0.pdf [Internet]. [cited 2020 Aug 2]. Available from: https://multimedia.3m.com/mws/media/641581O/mbtsystem-handbook-70-2021-4902-0.pdf
17. Bracket Placement with the Preadjusted Appliance - JCO Online - Journal of Clinical Orthodontics [Internet]. [cited 2020 Aug 2]. Available from: https://www.jco-online.com/archive/1995/05/302-bracket-placement-with-the-preadjusted-appliance/
18. Taloumis LJ, Smith TM, Hondrum SO, Lorton L. Force decay and deformation of orthodontic elastomeric ligatures. American Journal of Orthodontics and Dentofacial Orthopedics. 1997 Jan 1;111(1):1–11.
19. Bednar JR, Gruendeman GW, Sandrik JL. A comparative study of frictional forces between orthodontic brackets and arch wires. Am J Orthod Dentofacial Orthop. 1991 Dec;100(6):513–22.
20. Stolzenberg J. The Russell attachment and its improved advantages. International Journal of Orthodontia and Dentistry for Children. 1935 Sep 1;21(9):837–40.
21. ROUND TABLE The Edgelok Bracket - JCO Online - Journal of Clinical Orthodontics [Internet]. [cited 2020 Aug 2]. Available from: https://www.jco-online.com/archive/1972/11/613/
22. Self-Ligation in the Year 2000 - JCO Online - Journal of Clinical Orthodontics [Internet]. [cited 2020 Aug 2]. Available from: https://www.jco-online.com/archive/2000/02/74-self-ligation-in-the-year-2000/
23. SPEED System Orthodontics [Internet]. [cited 2020 Aug 2]. Available from: http://speedsystem.com/HTML/clinician/what_is_SPEED.html
24. Hanson GH. The SPEED system: a report on the development of a new edgewise appliance. Am J Orthod. 1980 Sep;78(3):243–65.
25. Harradine NWT, Birnie DJ. The clinical use of Activa self-ligating brackets. American Journal of Orthodontics and Dentofacial Orthopedics. 1996 Mar 1;109(3):319–28.
26. Harradine N. The History and Development of Self-Ligating Brackets. Seminars in Orthodontics. 2008 Mar;14(1):5–18.
27. Birnie D. The Damon Passive Self-Ligating Appliance System. Seminars in Orthodontics. 2008 Mar 1;14(1):19–35.
28. The Damon Low-Friction Bracket: A Biologically Compatible Straight-Wire System - JCO Online - Journal of Clinical Orthodontics [Internet]. [cited 2020 Aug 3]. Available from: https://www.jco-online.com/archive/1998/11/670-the-damon-low-friction-bracket-a-biologically-compatible-straight-wire-system/
29. In-Ovation® Self-Ligating Brackets | Dentsply Sirona [Internet]. [cited 2020 Aug 3]. Available from: https://www.dentsplysirona.com/en-us/categories/orthodontics/self-ligating-brackets.html
30. SmartClipTM SL3 Self-Ligating Appliance System: Metal passive braces - 3M Unitek United States and Canada [Internet]. [cited 2020 Aug 3]. Available from: https://www.3m.com/3M/en_US/company-us/all-3m-products/~/3M-SmartClip-SL3-Self-Ligating-Brackets/?N=5002385+3290412469&rt=rud
31. Keys to Success in Lingual Therapy Part 1 - JCO Online - Journal of Clinical Orthodontics [Internet]. [cited 2020 Aug 3]. Available from: https://www.jco-online.com/archive/1986/04/252-keys-to-success-in-lingual-therapy-part-1/
32. Fujita K. New orthodontic treatment with lingual bracket mushroom arch wire appliance. American Journal of Orthodontics. 1979 Dec;76(6):657–75.
33. Update on the Fujita Lingual Bracket - JCO Online - Journal of Clinical Orthodontics [Internet]. [cited 2020 Aug 3]. Available from: https://www.jco-online.com/archive/1999/03/136-update-on-the-fujita-lingual-bracket/
34. Geron S. Self-Ligating Brackets in Lingual Orthodontics. Seminars in Orthodontics. 2008 Mar;14(1):64–72.

35. Philippe Self-Ligating Lingual Brackets - JCO Online - Journal of Clinical Orthodontics [Internet]. [cited 2020 Aug 3]. Available from: https://www.jco-online.com/archive/2002/01/42-philippe-self-ligating-lingual-brackets/
36. Russell JS. Current Products and Practice: Aesthetic Orthodontic Brackets. Journal of Orthodontics. 2005 Jun;32(2):146–63.
37. Yang L, Yin G, Liao X, Yin X, Ye N. A novel customized ceramic bracket for esthetic orthodontics: in vitro study. Prog Orthod. 2019 Dec;20(1):39.
38. Brown MW, Koroluk L, Ko C-C, Zhang K, Chen M, Nguyen T. Effectiveness and efficiency of a CAD/CAM orthodontic bracket system. Am J Orthod Dentofacial Orthop. 2015 Dec;148(6):1067–74.
39. Mah J, Sachdeva R. Computer-assisted orthodontic treatment: The SureSmile process. American Journal of Orthodontics and Dentofacial Orthopedics. 2001 Jul;120(1):85–7.
40. InsigniaTM Advantage | Digital Orthodontics | Ormco Supplies [Internet]. [cited 2020 Aug 4]. Available from: https://ormco.com/products/digital-orthodontics/insignia/insignia-advantage/
41. What are Insignia Braces [Internet]. Advance Orthodontics. [cited 2020 Aug 4]. Available from: https://advanceortho.com/columbia-missouri-insignia-braces/
42. Scholz RP, Sarver DM. Interview with an Insignia doctor: David M. Sarver. American Journal of Orthodontics and Dentofacial Orthopedics. 2009 Dec;136(6):853–6.
43. Gracco A, Tracey S. The Insignia System of Customized Orthodontics. 2011;(8):10.
44. incognitoappliance-brochure-70-2021-4920-2.pdf [Internet]. [cited 2020 Aug 4]. Available from: https://multimedia.3m.com/mws/media/733295O/incognitoappliance-brochure-70-2021-4920-2.pdf
45. Media | ASO International [Internet]. [cited 2020 Aug 4]. Available from: https://www.aso-inter.co.jp/en/info/media.html
46. Company - LightForce Ortho [Internet]. LightForce. [cited 2020 Aug 4]. Available from: https://lightforceortho.com/sp/company