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Evolution of Orthodontic Brackets

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Abstract

Brackets occupy a central place in the orthodontic armamentarium today. Orthodontic brackets are important part of fixed appliances which are attached to the teeth to deliver forces from the wires or other power modules to the teeth. 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 appliance designed by Angle. This introduction of brackets saw a new era in orthodontics which was expanded by the introduction of the edgewise brackets by Angle in the early quarter of the twentieth century. The wave of design changes has continued to mount with contributions from both orthodontists and manufacturers. This has also led to the introduction of newer trends in fixed orthodontic treatment using self-ligating, lingual and other customizable bracket appliances. With endless modification possibilities due to advances in material science and clinical techniques, newer generation of brackets are regularly being introduced. One must be aware of all the latest developments to give best functional and esthetic results

to the patients. The purpose of this article is to highlight the evolution of orthodontic brackets and outline recent advancements to help the orthodontist select optimum bracket design for better treatment results.

Keywords: Brackets, Preadjusted Edgewise, Lingual, Self-ligating

Introduction

The specialty of orthodontics has continued to evolve since its advent in the early 20th century. Changes in treatment philosophy, mechanics, and appliances have helped shape our understanding of orthodontic tooth movement.[1] Efficiency in orthodontic appliances and techniques need both optimal rate of tooth movement and prevention of potential damage of tooth and surrounding periodontium.[2]

The first scientific attempt at tooth movement occurred when in 1728, the French physician, Pierre Fauchard made use of a flat metal strip pierced with holes suitably placed and formed into an arch to which crooked teeth were secured by means of threads passed around them and tied (Figure 1). The appliance was called the Bandelette' and was probably the first true expansion arch to be employed in orthodontia.[3]

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'.[4] Thus, brackets act a vehicle to incorporate the biomechanical regimen into the tooth undergoing treatment.[5] 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.[2]

The Evolution of Brackets

A. Development of the Edgewise appliance and bracket

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

Pin and tube appliance: Introduced by Angle in 1910, this appliance for the first time gave the axial control in tooth movement. It consisted of small tubes soldered perpendicularly to labial surface of bands fitted on tooth crowns with pins closely telescoping the tubes (Figure 2). 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.[6]

Ribbon Arch appliance: The term bracket was first coined by Dr. E.H. Angle in 1916, when he introduced ribbon arch appliance, He described the bracket as a delicate block of metal with rounded sides & corners, with a deep transverse slot extending half the length of the bracket and perpendicular groove passing downward through the floor of the bracket (Figure 3). The ribbon arch was 0.022" thick & 0.036" wide. With this appliance, forces began to be transmitted to the teeth through brackets rather than any other attachment.[7]

Edgewise Appliance: Introduced in 1925 by E.H. Angle, the appliance was essentially a band with bracket brazed to the center of its labial surface. The brackets had a horizontal slot with slot dimension 0.022" × 0.028" using gold alloy archwires (Figure 4). Two types of 'open-face' brackets were described, one for anterior and

another for buccal teeth.[8] This bracket was made of soft gold and was also known as 'soft' bracket or 'bracket 447'. Steiner modified it using harder metals which was named 'hard' bracket of 'bracket 452.[9]

B. Modifications of Edgewise brackets

There has been a continuous attempt to modify the Edgewise bracket to increase the efficiency and gain more control over tooth movement.

Universal bracket: Introduced by Spencer Atkinson in 1929.[10] The bracket was a combination of edgewise & ribbon arch attachment that made possible the combined use of rectangular & round archwires (Figure 5).

Twin-wire bracket: Developed by Joseph Johnson in1934.[11] It was based on the philosophy that two light wires in one bracket produced more physiologic tooth movement than one heavy wire (Figure 6). It allowed rapid rotation with minimum patient discomfort but suffered anchorage and post correction stability problems.

Siamese Bracket: Introduced by Dr. Brainerd Swain in 1949, to overcome the problem of root parallelism in extraction cases[12]. He put the two brackets on a common base in order to assure alignment and facilitate attachment (Figure 7). These brackets were also known as "Twin Brackets."

Lewis brackets: Introduced by Paul D. Lewis in 1950, this was a one-piece bracket with integral rotation wings (Figure 8). The bracket can be bent to effect rotation.[13] This was accomplished by bending one wing closer to the tooth & opposite wing further away. The bracket does not reduce inter-bracket span and does not interfere with activation of closing loops.

Jar aback 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. Hold away (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.[2]

Tip-Edge appliance: Originally named Differential Straight-Arch technique, the Tip-edge bracket was developed by P.C. Kesling in 1988.[4] Tip-Edge combines an initial degree of tooth tipping on round wires during early treatment followed by accurate tooth positioning on rectangular wires for 'edgewise' precision finishing. This was achieved by precise removal of diagonally opposed corners of conventional edgewise slots (Figure 9).

C. Begg's bracket and Light Wire Appliance

P.R. Beggs, in early 1930s realized the advantage of first tipping the tooth into the final position and he reverted back to use ribbon arch appliance with bracket modification and developed his own technique in 1933.[14] It was based on Angle's ribbon arch appliance but rotated 180°with the slot guide oriented to the gingival. Begg brackets incorporate a narrow open-ended slot. Round archwire is placed from the gingival aspect that is held in position by small metallic auxiliary lock pin (Figure 10).

The technique uses the concept of light forces to retract anterior teeth. This appliance possessed 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 Begg's appliance or Differential force appliance or light wire appliance.[15]

D. Preadjusted Edgewise Appliances

Andrews straight wire Appliance (SWA): Based on his "six keys to normal occlusion" and development of facial axis center of crown (FACC), 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.[16]

Roth's prescription: Ronald 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 1° tip reduction in lower premolars. Rotations were introduced into the system. Torque was increased in maxillary molars.[17]

MBT prescription: 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. 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.[18]

E. Self-ligating Bracket systems (SLB)

The self-ligation system defined as in which there is inbuilt archwire locking mechanism. Active SL brackets refers to SLBs where the clip actively "presses" the wire into the bracket slot on locking. Passive SLBs refer to brackets where no force is exerted by the clip when the archwire is ligated.

Russell Lock

These brackets were developed in 1935 by Stolzenberg. It had a flat threaded screw which was used for fixation or removal by turning the key (Figure 11).[19]

Edge Lok

In 1971, A.J. Wildman introduce the Edge Lok brackets which were passive and were first commercially available SLB. The bracket has a round body with labial sliding door (Figure 12).[20]

Mobil lock

Mobil-Lock 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 (Figure 13).[21]

Speed

Dr. Herbert Hanson in 1976 created a prototype of first active SLB known as SPEED22, which was commercialized in 1980. SPEED stands for features of the bracket system: spring loaded, precision, edgewise, energy, and delivery. It has a fully pre adjusted edgewise slot of 0.018 or 0.022 and has super elastic NiTi spring clip which engages the archwire (Figure 14). All SPEED brackets have a square auxiliary slot of 0.016" occlusally which can be used to put different auxiliaries. There is a small hook known as the SPEED Mushroom hook used to hold intraoral elastics.[22]

Activa

In 1986, Dr. Er win Pletcher developed Activa bracket. Activa bracket had an inflexible, curved arm that rotates occluso-gingivally around the cylindrical bracket body. The arch wire is held by a strong clip that turns into a holding groove gingival to the arch wire, situating two

straps labial to the wire and making a bracket that is fundamentally the same as mechanically to a molar tube with twin channel tops. All brackets have vertical slots behind the arch wire channel (Figure 15).[23]

Time

In 1994 Dr. Wolfgang Heiser, developed the Time bracket which is similar in appearance to the SPEED bracket. It is described as hybrid self-ligating bracket. The Time bracket can be opened either with a dental probe or with its special instrument. The time bracket has a clip that turns into position around the gingival tie wing and pivots towards the occlusal rather than the gingival wall of the slot (Figure 16).[24]

Damon System[24]

The Damon passive self-ligation system was first introduced by Dr. Dwight Damon 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 17). This was overcome in second 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 18).

Damon 3 (Figure 19) and Damon 3MX (Figure 20) 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 have an additional vertical slot permitting use of drop in hooks.

System R

System R brackets (GAC International) originally called In-ovation brackets were developed by Micheal C. Alpern in 2000 and are very similar to the speed brackets in conception and design, but of a twin configuration with tie wings (Figure 21). In 2002, smaller brackets for the lower anterior teeth became available. In-Ovation R (Reduce, referring to the reduced brackets width) and this narrower width was effective in terms of greater inter bracket span. The bracket subsequently became known as system R.[25] Some brackets of this type are difficult to open and this is more common in the lower arch where the gingival end of the spring clip is difficult to visualize. Both Speed and System R and also the similar and recently released Quick brackets (Forest dent) have addressed this difficulty by providing a labial hole or notch in the clip in which a probe or similar instrument can be inserted to open the brackets.

Smart Clip

This was designed by Gary L. Weinberger and introduced by 3M in year2004.

it has an integral nickel-titanium clip that permits simple archwire insertion and removal, yet holding the arch wire with a pre-programmed force, avoiding unintentional disengagement (Figure 22).[26]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, Smart Clip SL3. And esthetic variant was introduced in 2007 known as Smart Clip Clarity SL.

In-Ovation X (2017)

In-Ovation X, Dentsply Sirona's most recent expansion to its self-ligating In-Ovation line, holds a similar core design and treatment standards, with improvements including a streamlined shape and a diminished profile and occlusal impression. There is an updated encased-clip system and shut gingival bracket base will decrease the calculus develop that can hinder with clip function (Figure 23).[25]

F. Lingual Orthodontics

Kruz developed the first lingual appliance in 1971. 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 inter-bracket 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.[2]

Fujita lingual brackets

These were first introduced in 1979 and used mushroom arch wire appliance.[27] They were later modified by Hong and Sohn in 1999.[28] Originally it featured a slot that opened towards the occlusal. A lock pin was inserted mesiodistally in to a groove in the slot to secure the arch wire in conjunction with elastomers and ligatures. Brackets for 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 (Figure 24).

Conceal system

The Conceal system was developed by Thomas Creekmore in 1989. The opening of the arch wire slots is occlusal rather than to the lingual aspect (Figure 25). This occlusal approach makes arch wire insertion, seating, and removal easier than arch wire insertion with lingually opening slots.[2]

Self-ligating lingual brackets

They were first presented by Neumann and Holtgrave[29], 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.

2D Lingual SLB

Macchi et al in 2002[30] introduced 2D lingual SL brackets by the name of Philippe 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 (Figure 26).

Forest dent 3D Torque

These have the similar flat design as the Philippe 2D self-ligating brackets, but have a vertical slot for 3-dimensional control (Figure 27).[2]

Adenta Evolution lingual SLB

This bracket 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 (Figure 28).[29]

In-ovation L

These lingual brackets are recently developed low profile twin, horizontal slot brackets, with an interactive clip with very easy effortless opening (Figure 29).[29]

Phantom SLB

Phantom SL bracket is a recent polyceramic self-ligating bracket (Fig 30).[29] These brackets are bonded directly in the mouth after preparation of the lingual surfaces of the teeth by reshaping and filling all irregularities with flowable composite.

G. Aesthetic Brackets

Influenced by public demand, aesthetic brackets made from ceramics and plastics have become widely used in clinical orthodontics.

Plastic Brackets

Plastic brackets were developed in 1970s. Initially they were made from acrylic but later unfilled polyurethane & polycarbonate were used. Plastic brackets have staining and odour problems but more importantly their lack of strength and stiffness results 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 fiberglass fillers and/or metal slots have been recently introduced and are becoming increasingly popular.[31] Currently available plastic brackets include Aesthetic-line, Alexander spirit-MB, Avalon, Brilliant, Classic, Damon 3 etc.

Ceramic Brackets

These were introduced in early 1980s and are made of either polycrystalline or monocrystalline (Sapphire) aluminum oxide. 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. Polycrystalline alumina brackets have higher fracture toughness than monocrystalline alumina brackets. Monocrystalline alumina brackets have higher translucency and less friction than polycrystalline ones (Figure 30).[32]

Conclusion

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 systems but taking care not to affect their efficiency. Orthodontic brackets have evolved from Angle's era to the sophisticated bracket systems today. The advancements in bracket design & technology have helped ensure fast, efficient, and effective treatment to patients.

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Legend Figures

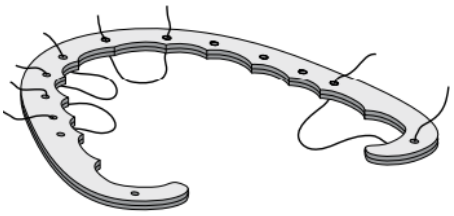

Figure 1: 'Bandelette' Appliance

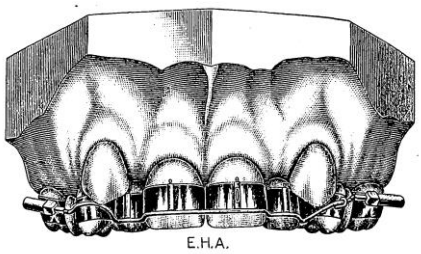

Figure 2: Pin and Tube Appliance

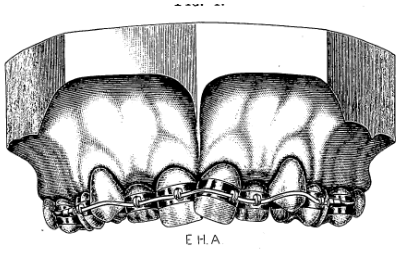

Figure 3: Ribbon Arch Appliance

Figure 4: Edgewise Brackets

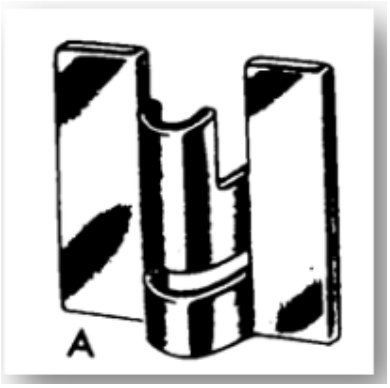

Figure 5: Universal Bracket

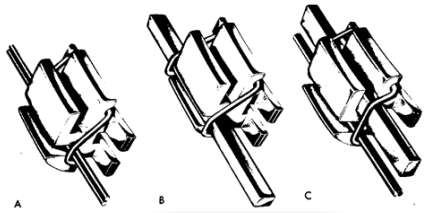

Figure 6: Twin-wire bracket with different wire combinations

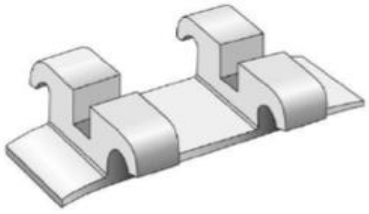

Figure 7: Siamese Twin Bracket

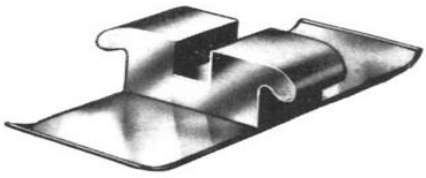

Figure 8: Lewis Bracket

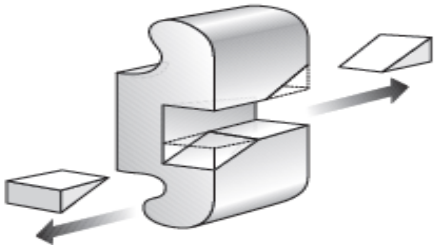

Figure 9: Tip-Edge Bracket

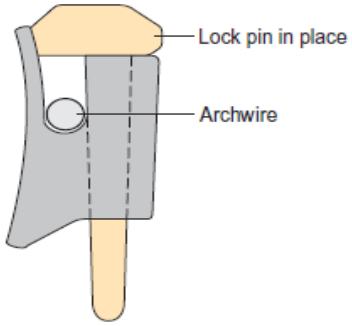

Figure 10: Begg's Bracket

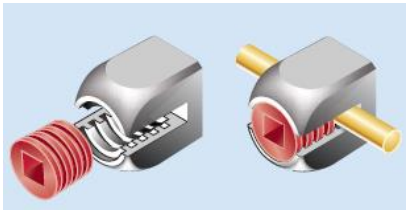

Figure 11: Russell SLB

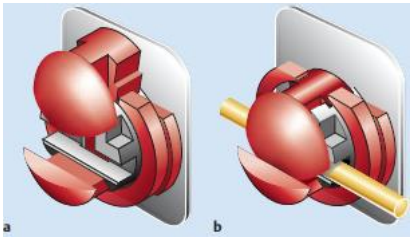

Figure 12: EdgeLok SLB

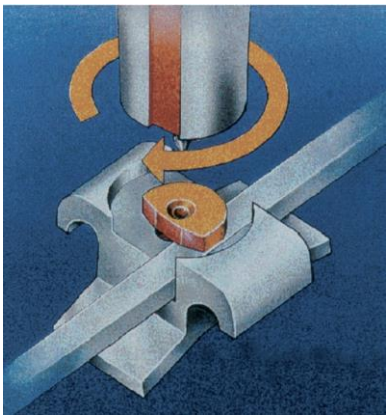

Figure 13: Mobi Lock SLB

Figure 14: SPEED SLB

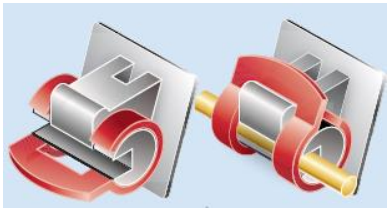

Figure 15: Activa SLB

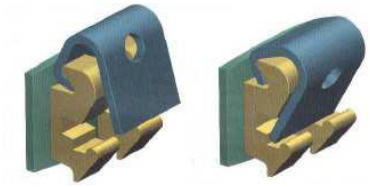

Figure 16: Time SLB

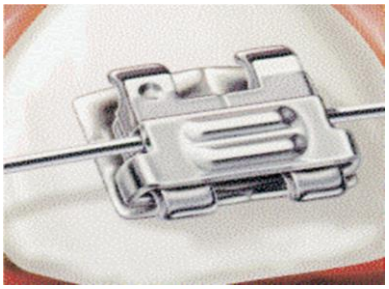

Figure 17: Damon SL

Figure 18: Damon 2

Figure 19: Damon 3

Figure 20: Damon 3 MX

Figure 21: In-Ovation SLB

Figure 22: Smart Clip SLB

Figure 23: In-Ovation X SLB

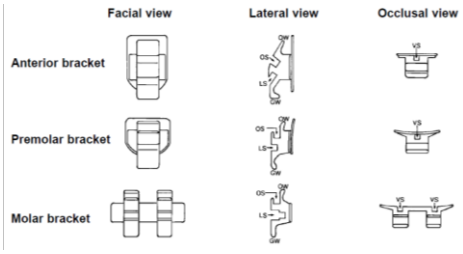

Figure 24: Fujita Lingual Brackets (Modified)

Figure 25: CONCEAL system

Figure 26: 2D Lingual Brackets

Figure 27: Forest dent Lingual Bracket

Figure 28: Adenta Evolution

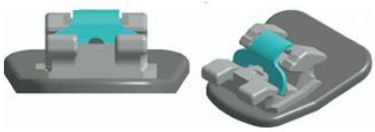

Figure 29: In-Ovation L

Figure 30: Phantom ceramic Lingual Brackets

Figure 31: Monocrystalline (A) & Polycrystalline (B) Ceramic Brackets