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REVIEW ARTICLE **OPEN ACCESS**

Evolution of Clear Aligners

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ABSTRACT

In recent years, aligners have evolved greatly in their properties and manufacturing which increased their efficiency. The major properties of clear aligners (material, gingival margin design, attachments, divots, auxiliaries) have changed and improved in recent years, expanding their indications and efficiency. By examining the primary scientific sources, we examined the brands of aligners used in Italy and the literature on the development of transparent aligners based on the traits listed above. This article reviewed evolution of clear aligners trough years and major milestones is achieving today's clear aligners designing. All companies manufacturing clear aligners works on principle of Remensynder, Kesling and McNamara.so, purpose of this article is to know basic designing and principle so that we can design and manufacture clear aligners more efficiently with CAD-CAM.

Keywords: *Clear aligners, kesling tooth positioner, McNamara invisible retainer*

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INTRODUCTION

Clear aligners seem to be a new modality of orthodontic treatment but actually it dates back to early 20th century. First appliance was introduced by Remensnyder and named as "Flex-O-Tite" after which Kesling in 1945 introduced a created a rubber-based appliance which positioned the tooth slowly into correct positions. An evolutionary change came after the introduction of a thermoplastic based appliance by Nahoum in 1960 which was capable of applying slow and gradual forces to attain desired tooth movements. In 1993, Essix retainer is developed by Sheridan which was made of soft thermoplastic sheets. With increased use to digital technologies we are able to make different types of clear aligners which are capable of various types of tooth movements in a more efficient way [1-2].

Remensnyder's dental massage device:

In 1920, Remensnyder invented a device to massage and stimulate the gingiva for patients who were suffering from gingivitis or periodontitis. It was made up of a thin clear rubber sheet which vibrated and gently massaged gingiva.(Fig. 1) The clinical crown of teeth and marginal gingiva were covered with the rubber and hence it was also known as "Flex-O-Tite" gum massage device. He noticed that over a period of time there was some orthodontic tooth movement was occurring in patients who were wearing the appliance and from here the development and evolution of clear aligners started [3].

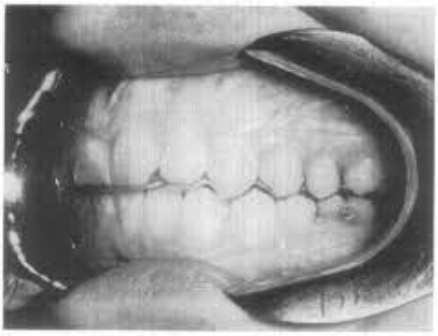

Fig. 1: Remensynder's dental massage device

Kesling's tooth positioning appliance:

Herald Dean kesling had a vision of orthodontic tooth movement which can be possible without interference of bands, brackets or wires. He aimed to design a simple appliance which can move teeth in a

more continuous and gradual way. This all lead to development of "Tooth Positioning device." This device was used for the finishing of teeth and to give more aesthetic outcomes. It took advantage in finishing stage that most of teeth were still mobile due to applied forces during orthodontic treatment and device moved more easily.(Fig 2)

Originally , the device was fabricated with a single pliable rubber sheets over a wax setup. Rubber sheet covered labial as well as lingual surfaces of teeth in the desired positions and he found that this appliance was only capable of minor tooth movements like spacing, mild crowding etc [4]. Kesling said that " right now doing whole orthodontic treatment with this appliance is nor possible but there is need of future advancement to accomplish proper orthodontic tooth movements with help of such an appliance."

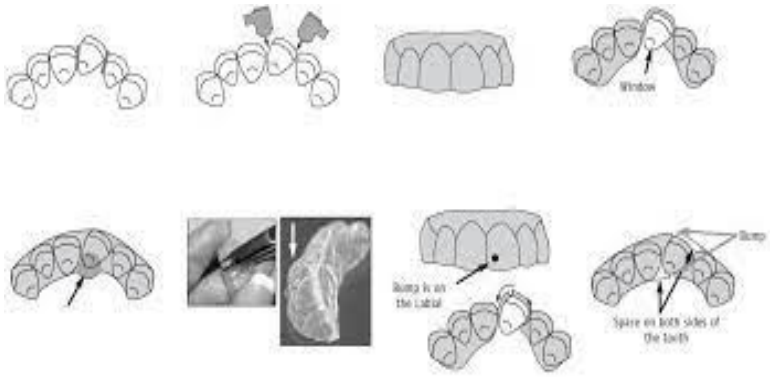

Fig. 2: Kesling's tooth positioning appliance.

Nahoum's Dental Contour Appliance:

The first ever documented thermoplastic clear appliance was given by Henry Isaac Nahoum in 1959 which was made by using industrial vacuum forming machine. It was given this name because it helped to correct and maintain contour of teeth. Various materials which were used are: butyrate, polyethylene, vinyl, and styrene. They were made using differently coloured sheet but mainly with transparent sheets. The resilient nature of these materials helped to move teeth in predetermined position (Fig. 3).

Nahoum found that some orthodontic problems were too complex to treat with a single appliance so, he used Kesling's setup to progressively move the teeth in correct position. A series of appliances were given to achieve a well-balanced occlusion. Attachments in modern clear aligners are also invention of Nahoum's work. He gave acrylic buttons on appliance after the orthodontic movements were completed to attach class II elastics. His appliance was capable to do more complex tooth movements like rotations, space closure etc[5].

Pontiz's Invisible Retainers:

Robert john Pontiz in 1971 used cellulose acetate butyrate, polyurethane, polyvinylacetate-polyethylene polymer, polycarbonate-cycolac, and latex to form clear retainer which were given to do finishing and also used as retainer after active treatment. To mould the sheet on dental cast, it was preheated in oven to make it soft and formable (Fig. 4). Main advantage of these appliance were that the can be repaired easily with help of heat guns, chair side time was reduced, fabrication was easy and less adjustments were made. In cases with edentulous spaces, prothesis replacements were easy to attach on appliance with same method in which appliance was manufactured. Over the time they were also used as splint for bruxism or splint for periodontal therapy [6].

5. McNamara's Invisible Retainer: McNamara in 1985 did changes in Pontiz's invisible retainer to achieve better results and stability.(Fig.5) Rather than making it with vacuum former, he used high air pressure to mould 1 mm thick sheet of Biocryl onto cast with Biostar forming machine. He concluded that invisible retainers have their own advantages but acrylic retainers have long term durability [7].

Fig. 3: Nahoum's dental contour appliance **Fig. 4:** Pontiz's invisible retainer.

Fig. 5: McNamara's invisible retainer**.**

Comprehensive Clear Aligners:

Currently used clear aligners are all based on principles of kesling, Remensnyder, McNamara and Pontiz. Back then it was very difficult and tedious to manufacture the appliance with wax setup. With advancement in technology, it is easy to predetermine the final tooth position which was not possible in manual setup. Computer Aided Designing- Computer Aided Manufacturing (CAD-CAM) bought revolution in designing and infinite possibilities to give better occlusion. First of all a 3 Dimensional scan of patient's teeth and surrounding tissues is done as reconstructed in software. Then various computer algorithms are used to separate coronal portion from rest of scan. They are then moved and placed in desired tooth movement achieved from that step. Manufacturing of appliance from that setup is done by rapid prototyping [8].

Fig. 6: comprehensive clear aligners.

Categories of contemporary aligners:

Based on method of fabrication and their applicability there are four major categories of clear aligners:

1. Direct to consumer aligners: Direct to consumer aligners are manufactured and marketed in such a way that patients can treat themselves at home. They can take intraoral scans and oral impressions at home and upload to system themselves. The aligners are fabricated and they are delivered directly to patient bypassing orthodontics. They are famously known as "Do it Yourself" and they are raising a concern about patient using them as they are wearing the aligners unsupervised [9-10].
2. Minor tooth movement: This type of aligners is used to correct minor correction only. Mostly they are single arch or confined only in anterior only segments
3. In house fabricated aligner system: This group of aligners provide a in house full system to orthodontist's clinical so that orthodontist can take the scans and he can manufacture set of aligners by himself and deliver to patient.
4. Comprehensive aligner system: This type of aligners is made with different attachments, acrylic spots, slits for elastic attachment. They also more complex tooth movements with these aligners [11-12].

CONCLUSION

Clear aligners and materials used in manufacturing them have immensely evolved in past century. Over period of time the basic principle given by Kesling, McNamara, Remensynder remained same. With advancement in technology, manufacturing become very easy and precise. Rapid rise in clear aligner demand have made their mainstay in contemporary orthodontics.

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