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Historical Evolution of Dentin Bonding Agents: A Clinician's Perspective

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ABSTRACT: The development of dentin bonding agents has revolutionized the field of esthetic and restorative dentistry. Buonocore's discovery on enamel acid-etching followed by description of hybrid layer by Nakabayashi et al are some of the major breakthroughs which are responsible for changing paradigms in adhesive dentistry.On the basis of mode of use,dental adhesives can be divided in generations. Currently, challenges lie in front of the researchers to develop products that not only bind to the tooth but also contain antibacterial, remineralizing and enzymatic-inhibitory properties that can increase the longevity of the adhesive procedures.This paper provides an insight into the historical evolution of dentin bonding agents.

KEYWORDS: adhesion, bonding, bonding agents, dentin, generations

INTRODUCTION

Outlook towards cavity preparation has changed drastically with the advent of adhesive materials since it is no longer necessary to prepare the cavity in order to provide mechanical retention through features such as dovetails, grooves, undercuts to retain the restorative material. Adhesive dentistry has also resulted in the conservation of large quantities of sound tooth structure.

BONDING AGENTS AND ADHESIVE DENTISTRY

In the early 1950s,research into agents that could attach resins to tooth structure was initiated.The first attempt to develop an adhesive system for bonding acrylic resins to tooth structure was made by Dr. Hagger who was a Swiss chemist and worked for DeTrey/Amalgamated Dental Company [1].He patented the first dental adhesive product called "Sevriton Cavity Seal" in 1951. This bonding agent contained adhesive glycerolphosphoric acid dimethacrylate (GPDM) [2]. In the year 1952,a study published by Mclean and Kramer suggested that, "Sevriton Cavity Seal" material containing glycerolphosphoric acid dimethacrylate (GPDM) improved adhesion to dentin by "penetrating the surface and forming an intermediate layer" [3].Later in the year 1955,it was Dr. Michael Buonocore,regarded as the pioneer of 'Adhesive Dentistry',who gave the concept of acid-etched enhanced adhesion after observing that some automobile industries used phosphoric acid to treat metal surfaces in order to obtain better adhesion of the primer to the metal [4].He subsequently applied this idea to enhance the adhesion of resin to enamel surfaces [5] and in his groundbreaking research used 85% phosphoric acid [6]. A timeline of major breakthroughs in the history of bonding agents has been illustrated in Figure 1.

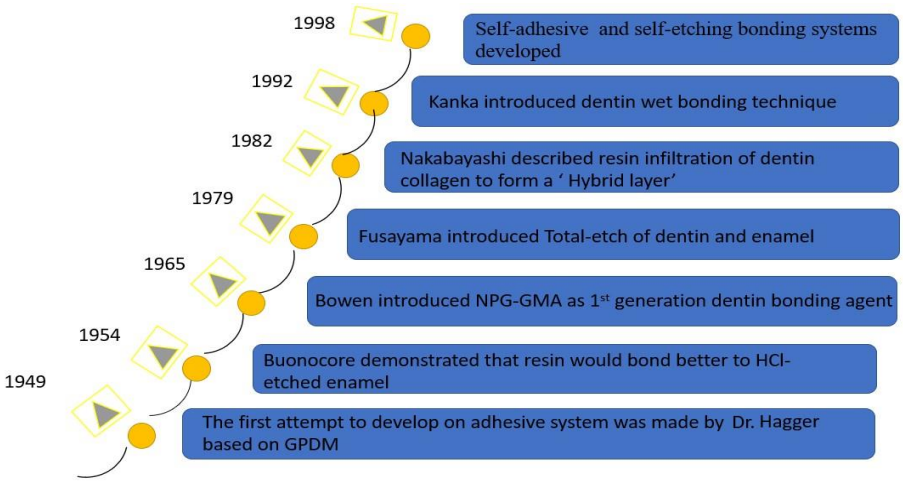

Fig.1. A timeline of major breakthroughs in the history of bonding agents

Bowen in his ground-breaking research developed the BisGMA (bisphenol glycidyl methacrylate),a monomer which is used in most modern composite resin materials [7].In his efforts to effectively bond this compound to the tooth,in the year 1965**,**he also developed a surface active comonomer named NPG-GMA(N-phenylglycine-glycidyl methacrylate). He concluded that the mechanism by which the NPG-GMA coupling agent improves bonding between a methacrylate resin and hard tooth tissues may be primarily by interaction with the mineral phase rather than with the organic phase of the tooth structures [8]. This formed the basis of development of NPGGMA origin dentin bonding agents,also known as the **first generation adhesives**. The first commercially available product was Cervident (SS White).

In the 1970s, identification of smear layer was made possible using the scanning electron microscope (SEM) and was first reported by Eick et al [9]. The **second generation adhesives** evolved around this time.The first and second generation adhesives were applied over the smear layer which resulted in low bond strengths [10].Commercial products from secondgeneration bonding agents include Clearfil and Prisma Universal Bond.

The researchers soon realized that the smear layer had to be removed or modified/ in order to let the adhesives bond with dentin [11] which led to the advent to the **third-generation adhesives**. Scotchbond 2 (3M Dental) was one of the first bonding agents in this generation.

Developed in the 1980s-1990s, the **fourth generation bonding agents** were the first ones aiming to completely eliminate the smear layer. They make use of the "Total-Etch" technique, which was based on a Japanese research originally conducted by Fusayama et al [12].

During the early 1990s, the complexity of use of the preceding generation led the manufactures to develop the **fifth generation.** It is 2-step etch and rinse adhesives that combined the primer and bonding agent in "one-bottle". The commercial products of this generation bonding systems include One-Coat Bond (Coltene) and Prime and bond (Dentsply) [13].

In the late 1990s, **sixth generation systems** were developed.They are 2-step self-etch adhesives that provide a self-etch primer, combining the etchant with a primer, followed by the application of an adhesive resin.Commercial systems available are Adper Prompt L – Pop (3M ESPE) and Xeno III (Dentsply) [13].

During the years 1999-2005, **seventh generation adhesives** or 1-step self-etch adhesives or "all-in-one" adhesives were developed.They combined all three etching, priming and bonding functions in just one bottle.Commercial materials available are ibond (Heraeuskulzer), Xeno IV (Dentsply) and One coat 7 universal (Coltene) [13].

CONCLUSION

In the hindsight,the state and simplification of adhesive bonding technology that has been achieved today,can be attributed to the persistent efforts made by various researchers in the past.After extensive experiments and research, a paradigm shift has been seen in adhesive dentistry. The future perspectives include adhesive systems that not only bond effectively to enamel and/or dentin but also present additional features such as remineralizing properties,antibacterial effects and enzymatic inhibition.Though research has been going on in this arena but further research is needed to develop products that deliver better results in clinical conditions.

The historical perspective of evolution of bonding agents as per their development has been illustrated in Figure 2 –

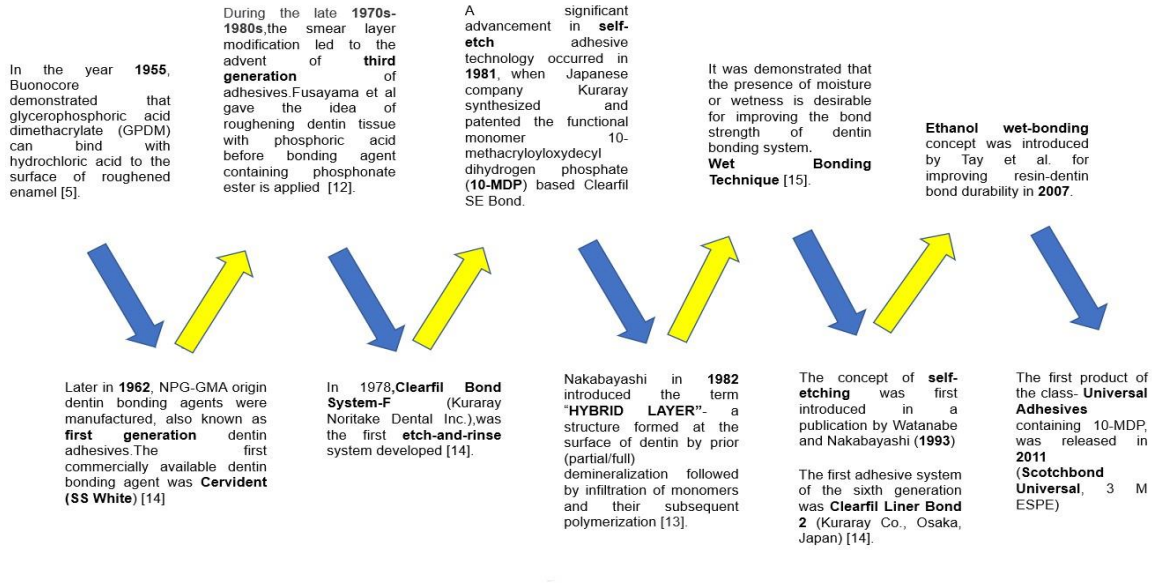

Fig. 2. Historical perspective of evolution of bonding agents

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