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Review Article

The Color Stability of Rhodium-Coated Archwire: A Review

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ABSTRACT: This study intended to analyze the attributes of rhodium-coated arch wires, advancements in wire composition, wire coating techniques, and elements affecting the color stability of aesthetic archwires. **Materials and Methods:** Until May 2023, various sources, including reference books, PubMed search, the Cochrane Database of systematic reviews, Web of Science, Wiley Online Library, and hand searching, were used for rhodium-coated archwire and their applications and advantages. The information in these papers is summarized after similar articles have been removed, and it is presented in the form of advancements in wire composition, wire coating techniques, and elements affecting the color durability of aesthetic archwires. **Conclusion:** The application of rhodium coatings on basic archwires has several benefits since they enhance aesthetics, minimize nickel contact with mouth tissue and fluid, and reduce friction.

Keywords: Color stability; Esthetic archwire; Orthodontics; Rhodium-coated archwire.

INTRODUCTION

The esthetic look of orthodontic treatment has become very considerable in modern-day life, with numerous patients asking for orthodontic treatment [1, 2, and 3].

A biocompatible, aesthetically pleasing, low-friction substance that can be applied in thin layers and has low friction resistance should be used to coat archwires [4]. The bracket surface, SS, and nitinol (NiTi) wires can serve as a base where the coating is applied [5].

Types of esthetic Archwire [6]:

- Transparent nonmetallic archwires*:*
  - Fiber-reinforced composite archwires.
  - Optiflex archwires.
- Coated metallic archwire:
  - Polytetrafluoroethylene (PTFE).
  - Epoxy archwire.
  - Bioforce archwires.
  - Marsenol archwire.
  - Lee White archwire.
  - Gold-plated archwires.
  - Rhodium-coated aesthetic archwire

The advent of coated, tooth-colored archwires gives the patient a more aesthetically pleasing appearance. Aesthetic archwires should be the same color as the dentition and brackets [3]. Rhodium plating is used to enhance the aesthetic of these archwires [7]. Rhodium is a tough and unique metal of the platinum group (figure 1), a silvery-white, delicate, ductile, malleable metal; face-centered square meter structure [8].

Figure (1): Rhodium element [9].

Rhodium is a precious metal with a white reflecting look and good anti-corrosive capabilities, although it resists acids; sulfuric acid levels make it soluble. The metal rhodium has the atomic symbol Rh, atomic mass 102.905, and atomic number 45 [10]. It is observed that this sort of characteristic can be tolerated within oral conditions since it can resist rusting and deterioration [11].

Because Rhodium provides the wire with a high sheen and reduces its visibility, it is described as being highly aesthetic when coated on archwires. It aligns with the current trend toward using more stable, biocompatible materials from the noble materials group [12].

Properties

The ion leakage rises for nitrified and uncoated NiTi wires in preventive remineralizing solutions with high fluoride concentrations, but it reduces for rhodium-coated NiTi wires [13].

Relative to polymer-coated wires, rhodium-coated wires have a much lower yield strength and a greater elastic modulus, This might be due to coating effects or variations in the underlying core material, Unlike polymer-coated wires, which stripped off when they came into touch with testing equipment, rhodium plating does not peel off, so to protect against nickel allergy ions, metallic orthodontic components, including braces, hooks, bands, tubes, buttons, cleats, pins, springs, arch wires, arch bows, bumpers, expansion screws, and quad-helix are coated with Rhodium [14].
Compromised upper layers promote the escape of nickel ions from the NiTi wire and subsequently decrease the biocompatibility of the wire if the protective ceramic or metallic coatings are nonhomogeneous or contain microcracks, which increases the risk of localized corrosion within the underlying alloy. [11]

According to Yakima et al., the rhodium-coated archwires were found to be rougher than the sent alloy non-coated wires [15]. Orthodontic wires were examined under a microscope without and with an aesthetic coating by D'Anto et al., who discovered that the implantation of rhodium ions increased the roughness of aesthetic wires [16]. The fluoride ion in fluoridated mouthwash increases the surface roughness of rhodium-coated archwires [2].

Commercial archwire

Ilusio™ Aesthetic Archwires (figure 2) have a particular surface treatment that causes light to be refracted by the wire. This archwire matches the teeth for the best look. Because of the patent-pending technology, the wire's surface won't peel, break, or discolor, giving the patients an aesthetically pleasing experience. Unlike

conventional fully coated archwires, Ilusio Aesthetic Archwires maintain the original size of the wire. The surface treatment does not impact the material's force characteristics or usefulness [17].

Figure (2): illusion Rhodium-coated archwire [17].

Fantasia™ is the trademark of Rhodium archwire (Figure 3). Its active bases are lustrous NiTi and SS and have tooth-colored exterior surfaces. It is the only brand of aesthetic wires on the market to withstand aesthetic coating material peeling or cracking for up to 45 days [18]**.**

Figure (3): Fantasia Rhodium-coated archwire [18].

TOMY's Rhodium coating on stainless steel white wires (Figure 4), which is extremely reflective and disperses light to give them a white aesthetic look, makes them unlike any other type of aesthetic archwire. Its rhodium coating is incredibly resilient and won't fade, flake, or detach. Using Micro Mini Rhodium-coated, Clippy C, and Crystalline 7 ceramic brackets together is ideal [19].

Figure (4): TOMY's Rhodium coating on stainless steel white wires [19].

Improvement

In research by Osseinzadeh *et al.* (2019), it was reported that after being immersed in 0.05% NaF, Rhodium-coated stainless-steel wires exhibited reduced friction and smoother surfaces compared to non-coated stainless-steel wires. They related this to using a noble gold alloy combined with Rhodium for coating metal archwires. Compared to nickel and other components of Stainless steel archwires, the noble gold alloy responds with outside influences like NaF considerably less. [20]

Method of wire coating

The rhodium coating is applied with a plasma-immersion ion implantation process [21,22]. Ion implantation (figure 5) is the process by which electrified atoms improve a substrate by attaching to the highly energetic ionized radicals of the protective coating via negative loading. After piercing the substrate's surface, the radicals bond to it. The surface composition is permanently modified by introducing ionized atoms (it is not a coating) [23].

Iridium, platinum, palladium, Rhodium, rhenium, gold, and silver are useful for this function because they produce an exterior layer on the archwire that is hard, inert, and reduces friction [24]. The Rhodium Aesthetic Archwire's coating layer has a thickness of (0.3 to 0.5 mm). It is roughly 370 nm (0.37 m) long. [13]

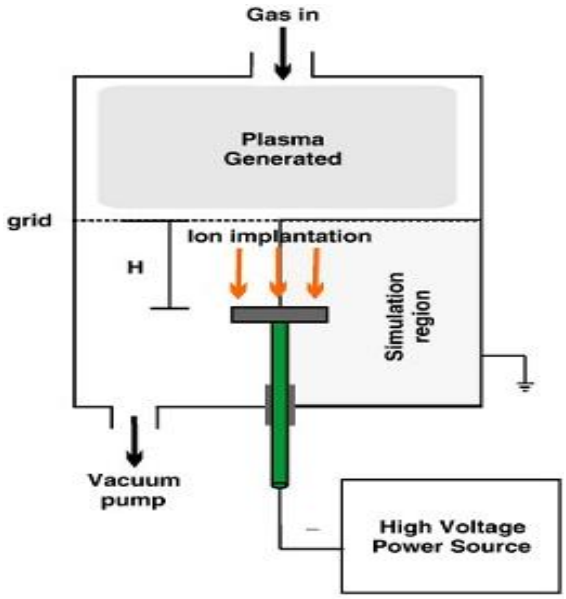

Figure (5): plasma immersion ion implantation technique [25].

Factors Influencing Aesthetic Arch Wires' Color Stability

A. Saliva: Moisture, proteins, electrolytes, and essential minerals make up saliva. Extrinsic discolorations may be caused by colored materials attaching to biofilm, developed pellicles, or chemical alterations to these organic coatings [26]. The selective

adsorption of salivary glycoproteins creates the acquired pellicle; this process starts immediately after washing and slows down after 60–90 minutes. It has been shown that when acrylic specimens are exposed to saliva, the staining increases due to pellicle production from salivary glycoproteins [27].

B. Diet: due to stains from natural food (concentrated tomato paste, grape juice, coffee-tea infusion, and orange juice), the Diet includes both hard and soft foods [28]. Concentrated orange juice solution causes the least discoloration, followed by concentrated coffee, tea, grape juice, and tomato paste solutions. Coffee is a staining beverage often consumed simultaneously with tea [29]. In addition, many in vitro investigations show that several food ingredients and drinks, such as fruit juices, coffee, cola drinks, tea, ketchup, and mustard, can significantly alter the color of resin materials [30, 31].

C. Smoking: Cigarette smoking is one factor contributing to the fading of acrylic resin [32]. A paper claims that cigarettes can permeate into resin materials and alter their composition physicochemically [33].

However, Wasilewski *et al*. (2010) found substantial color alterations in dental materials and explained these results as sedimentation brought on by the buildup of some cigarette elements [34].

D. Mouth Washes (Chlorhexidine): Chlorhexidine is the antibacterial that best controls periodontitis and dental buildup. Chlorhexidine is considered the highest quality standard by which healthcare providers assess other anti-plaque and anti-gingivitis medicines after 20 years of use [35]. The disadvantages of chlorhexidine include a bitter flavor, brown discoloration on the dentition, and an alteration in taste sensibility. This pigmentation may affect the mucous membrane of the tongue and is particularly challenging to remove [36, 37].

DISCUSSION

The color durability of the aesthetic arch wires—which is the capacity of the material to retain its color through time and in a specific environment—is regarded to have a substantial impact on the outcome of aesthetic orthodontic treatment, Natural tooth color varies with age, ethnicity, sex, and color assessment methods; thus, aesthetic arch wires must match the color of aesthetic brackets and natural teeth for the best aesthetic result [38, 39].

The color differences in aesthetic archwires could be caused by water absorption, dye adsorption from mouthwashes, or both. These findings support those of Al-Attar (2014). Who discovered that exposure to mouthwashes causes the molecules to diffuse and adhere to the brackets' ceramic and sapphire surfaces, discoloring them [40]. This

study is further supported by Lepri *et al*. (2014), who demonstrated that water absorption might contribute to discoloration [41].

Additionally, Razavi *et al. (*2016) clarified that mouthwash solutions contain various components, such as disinfectants, dispersants, organic acids, and colorants, which could impact the substance's color [42]**.** This may be explained by the colorant particles of the mouthwashes absorbing or adhering to the coating material, causing it to degrade over time, as well as the effect of water as a polymer softener, including continuous adsorption or absorption, superficial washing penetration, and surface coating degradation; the readings of color change values (**ΔE***) gradually increased as the immersion time frequency increases. According to Noori and Ghaib (2016), it was discovered that the longer the wires were immersed in staining solutions, the more color changes occurred [27]. Moreover, Al-Attar (2014) and Albo Hassan and Ghaib (2015) reported that the degree of aesthetic bracket discoloration increased with the duration of immersion in mouthwashes and staining solutions [43]. Moreover, Turgut et al. (2013). Findings that using mouthwash for three weeks led to clinically unsatisfactory staining of natural teeth are analogous to this [44].

A paper claims that aesthetic arch wires can change color after 21 days in staining solutions due to the effects of chewing pressures and the oral cavity's metabolism [45]. According to Sham *et al*. (2004), intrinsic factors that contribute to the discoloration of dental materials include water uptake, partial polymerization of adhesives or polymers, matrix composition, composition and size of reinforcing particles, brand, and intensity [46].

Extrinsic factors include the consumption of food dyes containing caffeine (coffee, tea, and colas), mouthwash use, moisture, tobacco, lip glosses, temperature, duration, and polymerization severity [47].

Manufacturers have created several aesthetic materials, like rhodium-coated aesthetic arch wires, in response to patients' requests for better aesthetics in orthodontics. Clinically speaking, aesthetic archwire color stability is crucial since any staining or discoloration will reduce patient acceptability and contentment. Rhodium coating adds a thin coating of Rhodium and gold (0.5mm) to the wire's surface to enhance its looks, but it has no appreciable impact on how the wire reacts to corrosion. As a result, the coating's porous portions are where the rusting process occurs locally [48].

CONCLUSIONS

With the growing demand for esthetic orthodontic appliances, the need for tooth-colored archwires with better appearance, physical properties, and durability is a

challenge to manufacturers; more in vivo studies of these archwires are needed. Until now, no evidence of any single esthetic archwire being clinically superior to conventional archwires has been available. However, applying rhodium coatings on basic archwires has several benefits since they enhance aesthetics, minimize nickel contact with mouth tissue and fluid, and ultimately reduce friction. However, these wires can be changed before month to maintain their color and aesthetic value throughout an orthodontic treatment regimen.

Authors' Contribution

Al-Ameri, MS. and Al-Joubori SK. contributed to conceptualization, validation, and writing the original draft. Al-Ameri MS. and Al-Joubori SK. are responsible for formal analysis, methodology, and project administration. Al-Ameri MS. and Al-Joubori SK. reviewed & and edited the manuscript. Al-Ameri MS. and Al-Joubori SK. contributed to the investigation, software development, validation, and visualization. Al-Ameri MS. and Al-Joubori SK. are involved in data curation, resources, and review & editing. All authors have read and approved the final manuscript.

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Conflict of interest

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Declaration of Generative AI and AI-assisted technologies

No artificial intelligence tools were used. The authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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ثبات اللون للسلك المقوس المطلي بالروديوم: مراجعة مقال

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الملخص

الأهداف: تهدف الدراسة الحالية إلى هدفت هذه الدراسة إلى تحليل سمات الأسلاك المقوسة المغطاة بالروديوم، والتطورات في تكوين الأسلاك، وتقنيات طلاء الأسلاك، والعناصر التي تؤثر على ثبات لون أسلاك القوس الجمالي. **المواد وطرائق العمل**: حتى مايو 2023، تم استخدام مصادر مختلفة، بما في ذلك الكتب المرجعية، موسوعة البحث المنشور، وقاعدة بيانات كوكرين للمراجعات المنهجية، وشبكة المعلومات للعلوم، ومكتبة ولي الطبية على شبكة الانترنت والبحث اليدوي، للبحث عن سلك القوس المطلي بالروديوم وتطبيقاتها ومزاياها. يتم تلخيص المعلومات الواردة في هذه الأوراق بعد إزالة المقالات المماثلة، ويتم تقديمها في شكل تطورات في تكوين الأسلاك وتقنيات طلاء الأسلاك والعناصر التي تؤثر على متانة اللون لأسلاك القوس الجمالية. **الاستنتاجات**: إن تطبيق طلاء الروديوم على الأسلاك المقوسة الأساسية له فوائد عديدة حيث أنها تهدف إلى تعزيز الجماليات وتقليل ملامسة النيكل لأنسجة الفم والسوائل وتقليل الاحتكاك في النهاية.

الكلمات المفتاحية: تقويم الأسنان، السلك المقوس التجميلي، سلك القوس المطلي بالروديوم، ثبات اللون.