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ORIGINAL RESEARCH

IN VITRO STUDY OF BIO DEGRADATION OF VARIOUS ORTHODONTIC ARCH WIRES

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Abstract
Objective: *The purpose of this study is to evaluate whether the biodegradation products produced by four distinct orthodontic wires—copper NiTi, nickel titanium (NiTi), titanium molybdenum alloy (TMA), and stainless steel—fall within acceptable limits by comparing their biodegradation properties.*
Materials and Methods: *In this investigation, four different wires were incubated in artificial saliva for 28 days while the amount of metal liberated from them was measured. Nickel, chromium, copper, cobalt, manganese, iron, molybdenum, and titanium were among the metals evaluated. To stop the artificial saliva from being saturated with metals, it was changed on days 7, 14, and 21. After 28 days, these four artificial saliva samples from each wire were combined and subjected to an inductively coupled plasma spectroscope analysis to determine the presence of the eight metals.*
Results: *Only nickel, chromium, and iron were released from stainless steel wire, nickel from NiTi wire, nickel and chromium from copper NiTi, and none from TMA wire, according to the data.*
Conclusion: *The metals emitted from arch wires are in too small a quantity to pose a threat to human health. Metal release levels are well within accepted biocompatible ranges. Even though different orthodontic wires' biodegradation was examined in this study, mechanotherapy never uses orthodontic wires by themselves. More metals may be released by orthodontic wires in combination with the multiband appliance system, which is always employed, and with accessories like face bows.*
Key Words: *Arch wires, corrosion, inductively coupled plasma spectroscope*

Introduction

The cornerstones upon which the science and art of orthodontics are built are orthodontic wires. For a protracted period of 18 to 24 months, these wires are left in the mouth. It is reasonable to anticipate that these wires will experience some degree of biodegradation in the dynamic oral environment. Due to their exceptional mix of mechanical qualities, bioinertness, and corrosion resistance in the oral environment, stainless steel wires have long been the standard in clinical orthodontics. An iron-chromium-nickel alloy having a chromium concentration of 18% and a nickel content of 8%, stainless steel. 1 Nickel titanium (NiTi) possesses a high degree of elasticity and form memory, which have led to its widespread use in medical applications. These wire alloys typically contain about 53.5% nickel, 44.9% titanium, and 1.6% cobalt. [1]

A beta titanium alloy titanium molybdenum alloy (TMA) is another commonly used alloy. TMA is made up of 77.8% titanium, 11.3% molybdenum, 6.6% zirconium, and 4.3% tin in nominal amounts. The fact that beta titanium is the only alloy with true weldability and formability is a significant feature of these wires. A new quaternary alloy called copper NiTi has certain clear advantages over earlier NiTi alloys. Nickel, titanium, copper, and chromium are all components of this thermally activated alloy wire. If metal levels in orthodontic wires exceed the maximum advised daily intake levels, hazardous responses may result. Nickel should not be consumed in excess of 300 g per day, along with chromium, manganese, copper, molybdenum, iron, and trace amounts of cobalt. The recommended daily intake for titanium is between 300 and 2000 g. [2]

Hence, this study was conducted to compare in-vitro biodegradation characteristics of four different orthodontic wires stainless steel, NiTi, TMA, copper NiTi alloy and to assess whether the corrosion products were within acceptable biocompatible limits.

Materials and Methods

Four orthodontic archwires measuring 17 mil x 25 mil and 100mm in length made up the sample. Stainless steel was utilised for the archwires: Preform arch wires are available from Ortho-Organizers, Inc. in San Marcos, California. NiTi is available from 3M Unitek in Monrovia, California. TMA is available from Ormco Corporation in Glendora, California. Copper NiTi is available from the same company.

Each orthodontic wire sample was fully submerged in 100 ml of synthetic saliva, which was precisely measured by the measuring cylinders, and was kept in an airtight, transparent polyethylene container. All measuring cups used in the experiment were completely cleaned with tap water after spending the night submerged in soapy water, and they were then dried by keeping them in an incubator at 37°C. Finally, they were cleaned with distilled, de-ionized water from the distillation machine (provided by Millipore Corporation, Bedford), and dried the following day in an incubator at 37°C. All of the measurement cylinders utilised in the experiment had this routinely done to them.

0.4 g NaCl, 1.21 g KCl, 0.78 g NaH2 PO4 2H2 0, 0.005 g Na2 s, and 1 g urea [Co(HH2)] were the ingredients in the stimulated saliva. 1000 ml of distilled water with 2 (Gjerdet and Hero, 1987). Bovine serum albumin, 100 mg/L, was added to synthetic saliva. Biochemical balance was used to weigh the components, and a pH metre was used to alter the pH.

Care was taken to keep the 100 ml of synthetic saliva and the clear plastic vials always containing the wire sample airtight. These were maintained in an incubator at 37°C, a temperature that mimics the oral cavity. A 100ml wire sample without any wire was retained in addition to these four wire samples and served as a control sample.

Every flask's whole 100 ml of artificial saliva solution was drained on days 7, 14, 21, and 28 and replenished with brand-new solution, with the exception of day 28. To prevent saturating the artificial saliva medium with corrosion products, the solution has to be changed. Using an inductively coupled plasma (ICP) atomic emission spectrometer, nickel, chromium, copper, cobalt, iron, manganese, molybdenum, and titanium were analysed at the end of the 28-day experimental sample period using four samples of 100 ml each for each wire sample. A highly effective method for doing multi-element atomic emission spectroscopy analysis is the ICP atomic emission spectrometer. The electrode-less argon plasma used as the ICP excitation source operates in an electromagnetic field with an ambient frequency. ICP plasma scan 8410, produced by Labtam Ltd. in Australia, was used for this work. The Kruskal-Wallis test was used in statistical analysis to determine whether there was any correlation between the eight metals themselves and the discharge of metals from the four distinct wires.

Results

Three of the three metals that were tested from the study's four separate wires exhibited signs of leaching, according to the study. Nickel, chromium, and iron make up the three metals. Throughout the entire four-week research period, there was no release of copper, manganese, cobalt, molybdenum, or titanium from any of the wires.

Table 1: Total metal released

Type of metal	Metal release (ppm)
Nickel	0.006
Chromium	0.011
Copper	0.009
Cobalt	0.010
Manganese	0.010
Iron	0.289
Molybdenum	0.291
Titanium	0.011

Over the course of the 28-day investigation, the stainless-steel arch wire released 0.006 ppm of nickel, 0.011 ppm of chromium, and 0.289 ppm of iron. None of the five metals under study showed even the slightest hint of leaching. Only 0.002 ppm of nickel were released over the course of the entire study, according to the NiTi archwire. None of the metals for which the analysis was done were detected in the TMA wire. Over the course of the 28-day experimental period, the copper NiTi wire revealed nickel release of 0.004 ppm and chromium release of 0.003 ppm.

Discussion

Any system of orthodontic appliances would be incomplete without orthodontic wires. Regardless of the type of mechanotherapy used, orthodontic wires are a crucial component. The majority of research have used an accelerated corrosion process, either by heating wires [3] or by using a highly corrosive medium as 0.1 mol/L lactic acid or 0.1 mol/L NaCl. [4] The majority of earlier studies have considered how orthodontic wires degrade in simulated oral environments and artificial saliva mediums.

The two metals nickel and chromium have been the principal subjects of the limited research that have been done. While it is true that chromium and nickel are the two metals that most frequently result in allergic reactions in people, [5] other metals, including copper, cobalt, iron, manganese, molybdenum, and titanium, which are some of the other constituent metals of orthodontic wires, have the potential to have negative effects on people if ingested in large enough doses. [6] The goal of the current study was to determine how much of the following metals leached from orthodontic wires over a four-week period and ended up in artificial saliva: nickel, chromium, copper, cobalt, manganese, iron, molybdenum, and titanium.

According to the research conducted by Barrett et al., the wires under study were all prefabricated and had uniform dimensions of 0.017 x 0.025 inches. [2] The cables are all the same 100 mm in length. the total amount of teeth in the upper arch, from the first molar's distal end on one side to the first molar's distal end on the other. According to Ashley and Howe, the upper limit of this range—85–98 mm—was chosen, and 1 mm was added on either side to accommodate synch back. Consequently, the wire's overall length was 100 mm.

The current analysis demonstrated that the trace amounts of metals emitted from the stainless steel, NiTi, TMA, and copper NiTi alloy wires as received were negligible. But according to a study by Gjerjet and Hero [3], heat-treated orthodontic wires release 15–60 times more metals than wires that are just received. The increased metal release from orthodontic wire alloys is due to faster corrosion caused by heating. In operations when heating orthodontic wires is involved, this element should be taken into account. Additionally, the silver soldered wire displayed higher corrosion than the other wires when compared to orthodontic wires in their as-received condition. This was proven in a study by Berge and colleagues. [8] This is evidently caused by the fact that "silver solders" are eutectic alloys that are extremely vulnerable to corrosion.

The release of these metals is in such minute amounts that there is no risk of them surpassing the levels of maximum daily intake as far as the toxicity reactions of the metals examined are concerned.

For a longer period of 18 to 24 months, orthodontic wires are left in the patient's mouth. This investigation was only conducted over a period of 28 days, despite showing how very small amounts of metal are actually liberated from the wires. Furthermore, in any form of mechanical therapy, orthodontic wires are never utilised alone. According to the study by Barrett et al., orthodontic wires, the multiband appliance system that they are always used with, and accessories like face bows are likely to cause the release of more metals. [2]

Although every effort was made to closely resemble the conditions found in the oral cavity, the continual cleaning action of saliva, abrupt changes in temperature, and variations in pH could not be replicated. [9] According to the study by Baswa and Surendrashetty, these elements may speed up orthodontic wire corrosion, especially over longer periods of time. [10]

It is advised to study orthodontic wires in conjunction with a multiband/bracket appliance system that more accurately and extensively simulates the oral circumstances over time.

Conclusion

The metals emitted from archwires are in too small a quantity to pose a threat to human health. Metal release levels are well within accepted biocompatible ranges. Even though different orthodontic wires' biodegradation was examined in this study, mechanotherapy never uses orthodontic wires by themselves. In addition to the multibanded appliance system that is constantly utilised, orthodontic wires in conjunction with face bows and other accessories may release more metals.

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