Determination of Microelements from Orthodontic Implants by the Flame Atomic Absorption Spectroscopy Method

CAMELIA SZUHANEK*, ADELINA GRIGORE
University of Medicine and Pharmacy ''Victor Babes'' Timisoara, 2 EftimieMurgu Sq., 300041, Timisoara, Romania

Orthodontic miniscrews gained popularity in the last decade due to the possibility of reduced treatment time, low cost, small dimensions and low morbidity rate. Absolute anchorage with no dental side effects make orthodontic mini implants an attractive choice for orthodontists. Although these advantages provide optimal clinical solutions, some characteristics must be taken into account when choosing the type of the mini implants. The chemical composition is one of the most important factors that can lead to either success or failure of the orthodontic treatment. In order to prevent fracture, corrosion and toxicity, certain metal alloys must be used in the manufacturing process of the miniscrews. The microelements from Leone orthodontic implants were investigated in this study by the flame atomic absorption spectroscopy method. The sample was immersed in aqua regia (3 parts HCl and one part HNO_3). After sample dissolution 50 mL were taken for analysis. The microelements were determined by AAS (Varian 220 FAA equipment). Mix standard solutions (ICP Multielement Standard solution IV CertiPUR) were purchased from Merck. All tests were run in triplicates.

Keywords: orthodontic mini implants, chemical microelements, spectroscopy analysis

The introduction of orthodontic implants has opened new horizons in daily dental practice. Orthodontic implants provide good skeletal anchorage that allows the orthodontist to obtain tooth movements without secondary effects. Stationary anchorage is possible with orthodontic implants, also known as TADs (temporary anchorage devices) (fig. 1). A large variety of TADs are available in the orthodontic field to provide bone anchorage: onplants, retromolar implants, palatal implants, mini-plates, cobalt-chromium screws, vitreos carbon screws, bioglass coated implants etc. [7].

Several orthodontic movements are harder to obtain without anchorage loss (dental tipping, improper space closure). TADs are used to achieve mass retraction of anterior teeth, rapid palatal expansion, molar intrusion etc. The insertion procedure has a low morbidity rate and requires, sometimes, only topical anesthetic.

The risk of failure correlated with mini implants depends on several factors such as bone density, root proximity, gingival mucosa, age, force levels, dental hygiene, implant morphology and chemical composition.

The chemical composition of orthodontic implants is among one of the most important factors. These devices are designed to be temporarily inserted in the alveolar bone and to provide anchorage for teeth movement[9].

As stated above, mini implants facilitate orthodontic mechanics but the chemical composition of the TADs must not be ignored. Some experimental studies sustain the process described above regarding metal ion release. Elevated concentrations of Ti, Al and V were found in the lungs and kidneys of rabbits. Although human physiology is a bit different, this process cannot be excluded [6].

Another important factor regarding the chemical composition of the TADs is the risk of fracture. Mini implants come in different sizes, lengths, thickness and design. Failure and fracture of a temporary anchorage device is correlated with structural defects, material bubbles (inclusions) and material composition. Ferreira's study on *Metallographic analysis of the internal microstructure of orthodontic mini-implants* emphasizes the importance of chemical constituents in implant failure [5]. After sectioning several mini implants with no structural manufacturing errors, he concluded that the mini implants must contain certain amounts of Ti, Al and V in order to provide stability, low toxicity and resistance. The alpha and beta phase in Ti seems to have an important contribution regarding the success of an orthodontic TAD. The alpha phase is weldable and provides higher resistance and lower corrosion [10,12].

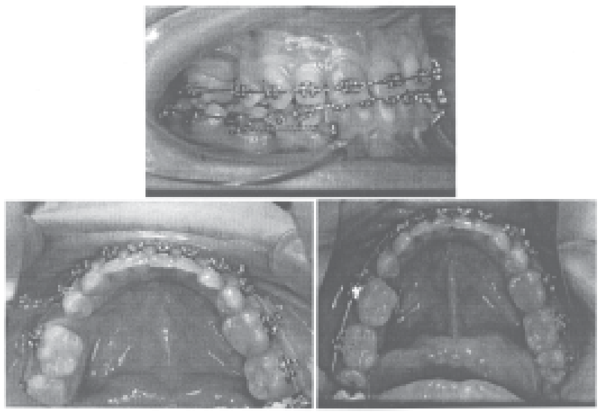

Fig. 1.Orthodontic implant used in space closure without secondary movements

Experimental part

Material and methods

In order to evaluate the efficiency of the mini implants from our daily practice, a special analysis was performed. Its importance is of great use because it provides information regarding patient selection, mini implant placement, force levels, fracture risk and bone reactivity. All this factors are related to the chemical composition of the mini implant.

The experiment took part at Banat's University of Agricultural Sciences and Veterinary Medicine ''King Michael I of Romania'' from Timisoara. Orthodontic implants were produceby *Leone* S.p.A. Ortodonzia,

* email: camellia_fleser@yahoo.com; cameliaszuhanek@umft.ro

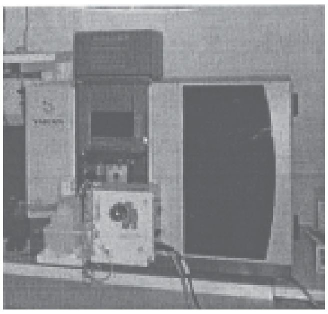

Fig. 2.The AAS device with all its components

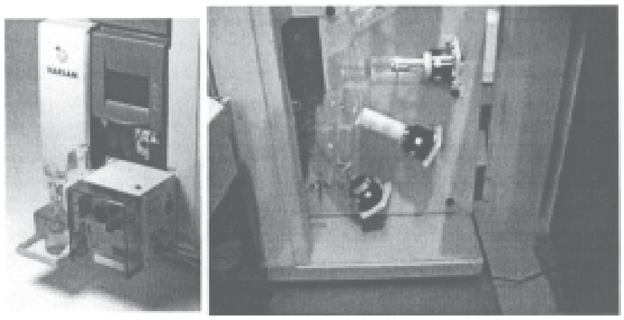

Fig. 3. Different lamps; each lamp is correlated with a chemical element (Ca, Mg, Pb, Ti etc.) and each element has a specific wavelength

Table 1
MICROSTRUCTURE OF THE MINI IMPLANT

Typical performance	Element Wavelength (nm)	Slit Width (nm)	Characteristic Mass (pg)	Detection Limit (3 sigma) Peak Height (μg/L)	Peak Area (μg/L)
AI	396.2	0.5	5.0	0.2	0.2
Ti	364.3	0.5R	R50	0.75	0.85
Cd	228.8	0.5	0.2	0.01	0.01
Cr	357.9	0.2 R	1.5	0.075	0.075
Ni	232.0	0.5	4.8	0.5	0.5
Pb*	283.3	0.5	3.0	0.2	0.25

Firenze, Italy. The determination of microelements was made by the flame atomic absorption spectroscopy method (AAS) [7]. The sample was immersed in aqua regia (3 parts HCl and one part HNO_3). After sample dissolution 50 ml were taken for analysis. The microelements were determined by AAS (Varian 220 FAA equipment). Mix standard solutions (ICP Multielement Standard solution IV CertiPUR) were purchased from Merck. All tests were run in triplicates. Each value is the mean of three (n = 3) independent determinations.

The AAS equipment (fig. 2) consists in a detector, a flame, different lamps (fig. 3) in order to produce the correct wavelength, a special system that aspirates the solution into the flame and a computer to guide the experiment, collect and analyse the data [4].

The solution that we used had a known absorbance value. The specific absorbance has a corresponding concentration. After the solution was absorbby the flame, the microstructure of the mini implant was measured and calculated due to the specific wavelength of each chemical element. The computer generated different colour intensities corresponding to the concentration of each element (Al, Ti, Cd, Cr, Ni, Pb). The algorithm must be previously inserted.

Results and discussions

The computer generated the exact amount of each element found in the mini implant (Leone S.p.A., Ortodonzia, Firenze, Italy). The values that we obtained revealed high amounts of Ti and Al. These two elements are found in all orthodontic mini implants in order to provide resistance, biocompatibility and low toxicity. The lowest levels were represent by Ni, Pb (table 1).

These findings emphasize that this type of mini implants are suitable for orthodontic purposes and fit the standard norms regarding resistance, corrosion, toxicity and cellular response. Care must be taken regarding Ni percentage due to some allergy reports found in the literature [11].

This study was aimed to provide more information regarding the selection of the mini implants. Several factors are taken into account such as type of dental movement, the patient's age and bone morphology, biomechanical force levels, etc. The typical composition of orthodontic mini implants is titanium alloy but certain amounts of aluminum and vanadium are added. The titanium alloy is known as grade 5 Ti. This type of alloy is also used in regular dental implants due to its great capacity to resist corrosion, fracture and to provide low toxicity levels when exposed to oral fluids [5]. Cell adhesion may be compromised if corrosion occurs. Than metallic ion contamination takes place, affecting the osteoblasts and the surrounding bone physiology. As a reparatory response, a layer of en-capsulated tissue forms around the mini implant, affecting the orthodontic treatment and preventing the doctor from loading the mini implant. If the orthodontists disregard this cellular response, implants may be lost. A certain period of time must pass in order to insert a new mini implant in the same location [3, 5].

The mini implant's design is correlated with multiple fracture possibilities but most of them occur at the neck of the TAD. Alpha phase titanium provides a better option regarding the chemical composition of the orthodontic devices. Using this type of alloy minimalizes the risk of fractures, providing resistance and biocompatibility [8].

The spectroscopy method is valuable in analyzing the microstructural compositions of metals by the help of several solutions: aguaregia solutions, Kroll's reactive solutions, etc. This type of analysis is important in the osseointegration process, cellular response, periimplantitis frequency and biomechanical considerations regarding the orthodontic treatment. Smooth titanium surfaces provide a better response and allow orthodontist to use low forces in the same day that the TAD was inserted. Calcium phosphate coat seemed to have a positive effect on mini implants integration [13].

X-ray photoelectron spectroscopy can also reveal information about biofilm deposits. Although mini implants are exposed to autoclave sterilization, their surface contains carbon contamination and other inorganic elements such as Zn, Pb, Ca and Cr. Biofilm formation after intraoral insertion is strictly correlated with the chemical composition of the mini implant and with surface roughness [2,4].

Conclusions

Many orthodontists disregard the chemical composition of the miniscrews and often find themselves in the situation of mini implant failure, without an obvious reason. Further investigations are required in order to evaluate the microstructure of different orthodontic implants and to help the clinician in choosing the right product and in achieving clinical success.

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Manuscript received: 22.01.2015