Cytotoxicity of SK surgical implants used for anchorage in orthodontics: In vitro study

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ABSTRACT

**Background:** The material used for mini implants (temporary anchorage devices [TADs]) must be nontoxic and biocompatible, possess excellent mechanical properties, and provide resistance to stress, strain, and corrosion. Commonly used materials can be divided into three categories: Biotolerant (stainless steel and chromium-cobalt alloy), bioinert (titanium and carbon), and bioactive (hydroxyapatite and ceramic oxidized aluminum). Due to titanium’s characteristics (no allergic and immunologic reactions and no neoplasm formation), it is considered an ideal material and is widely used. Bone grows along the titanium oxide surface, which is formed after contact with air or tissue fluid. However, pure titanium has less fatigue strength than titanium alloys. Titanium alloy is used to overcome this disadvantage. This study was done to determine the cytotoxicity of the SK surgical mini implants, which is one of the most commonly used TADs in India due to its economic feasibility. **Aim:** The aim of this study is to evaluate the cytotoxicity of SK surgical implants used in orthodontics. **Materials and Methods:** An in vitro cytotoxicity test using indirect contact method was performed using test sample as per the ISO 10993:5. The culture medium from the L929 cell monolayer was replaced with a fresh agar medium. Test sample, control in triplicates was placed on the cells after incubation at 37 ± 1°C for 24–26 h. Monolayer was examined microscopically to determine the cytotoxic effect before and after removing the test sample from the agar medium. The reactivity was graded as 0, 1, 2, 3, and 4 based on the zone of lysis, vacuolization, detachment, and membrane disintegration. **Results:** This method showed that the SK surgical implants have Grade 1 cytotoxic reactivity. The viability of the cells was found to be >90%. **Conclusion:** From the results obtained in this study, it can be concluded that the SK surgical implant is biocompatible with Grade 1 or slightly reactive cytotoxic effects.

**KEYWORDS:** Anchorage, Biocompatibility, Cytotoxicity, Mini-implants, SK Surgical implants

INTRODUCTION

The control of orthodontic anchorage has been a concern to orthodontists since the beginning of this specialty. A successful orthodontic treatment, in the great majority of cases, requires judicious planning for anchorage, and it would not be an exaggeration to state that this is one of the determinant factors for success or failure in many orthodontic treatments.

Mini-implants are currently being used for improving those situations in which orthodontic anchorage is difficult.[1-4] Their use is motivated by their proper positioning, easy removal, and cost factor.[4-6] Most mini implants are made up of titanium alloy, differing in aspects such as shape, design, measurements, and trademark.[7] The commercially pure titanium (CPT) is largely utilized in the manufacture of dental and orthopedic implants since it is chemically inert, in addition to mechanical properties and excellent biocompatibility.[8] Despite these favorable characteristics, CPT has not been preferred for manufacturing orthodontic mini-implants because of its low resistance to fracture and possibility of osseointegration.[9]

Fracture resistance is one of the most necessary characteristics required for insertion and removal of orthodontic mini-implants in spite of their reduced size and inter-radicular placement.[10] To overcome this problem, the material chosen for manufacturing orthodontic mini implants is the Ti-6Al-4V alloy due to its high resistance to fracture.[11]

However, the metallic alloys that are used in orthodontics are subject to corrosion and release
of metal ion into the oral cavity, which may lead to adverse physiological effects such as cytotoxicity, genotoxicity, carcinogenicity, and allergenic effects. The choice of certain alloy depends largely on its indications. Ti-6Al-4V alloys are composed of aluminum (Al) and vanadium (V), both found to be cytotoxic elements when released in the form of ions during erosion of physiological medium.\cite{12}

Ti-6Al-4V alloy is less resistant to corrosion when compared to CP it,\cite{11,13} resulting in metal ions release. As these ions can accumulate in tissues surrounding the mini implant\cite{14} and even in distant sites,\cite{15} undesirable effects can occur such as osteolysis, allergic reactions, renal lesions, cytotoxicity, hypersensibility, and carcinogenesis.\cite{16} In addition, metal ions are often accounted for implant failure. Since all commercially available orthodontic mini implants are made of Ti-6Al-4Vanloy, the author aims to investigate the hypothesis that there is no cytotoxicity in the mini implant used in the Department of Orthodontics, Saveetha Dental College and Hospitals.

**MATERIALS AND METHODS**

**Cell Culture**

An *in vitro* cytotoxicity test using indirect contact method was performed using test sample as per the ISO 10993:5. The culture medium from the L929 cell monolayer was replaced with a fresh agar medium. Test sample, control in triplicates was placed on the cells after incubation at 37 ± 1C for 24–26 h.\cite{17} Monolayer was examined microscopically to determine the cytotoxic effect before and after removing the test sample from the agar medium. The reactivity was graded as 0, 1, 2, 3, and 4 based on the zone of lysis, vacuolization, detachment, and membrane disintegration.

**RESULTS**

This method showed that the SK surgical implants have Grade 1 cytotoxic reactivity. The viability of the cells was found to be >90%.

**DISCUSSION**

The use of cell culture has been employed as a part of the series of recommend tests for evaluation of the biological behavior of materials being in contact with human tissues. In the present study, cytotoxicity tests were conducted to evaluate the biocompatibility of mini implants for the orthodontic purpose.

The commercially available orthodontic mini implants are usually made up of the Ti-6A-4V alloy. The biocompatibility of Ti ions is very well described in the literature, but the biocompatibility of aluminum (Al) and vanadium (V) have not been so studied. Al ions usually affect proliferation, metabolic activity, and differentiation of osteoblasts.\cite{18} Some of the toxic effects that are described in the literature are encephalopathy and Alzheimer-type senile dementia,\cite{19} and aluminum may also be associated with osteocalcin and pulmonary granulomatosis as well.\cite{20}

Vanadium, whose main source is food, is an essential microelement that is present in the majority of the mammalian cells.\cite{21,22} However, this chemical element is considered toxic when compared to other nutritionally essential microelements because there is only a small difference between the necessary and toxic doses.\cite{23} On the other hand, V has important pharmacological and physiological effects, playing an important role in the auxiliary treatment of diabetic patients.\cite{22}

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The effects of acute and chronic V intoxication are being well documented. Vanadium is also cytotoxic...
for macrophages and fibroblasts,[24] binds to certain proteins (e.g., Ferritin and transferrin), affecting their distribution and accumulation throughout the body,[22] stimulates local and systemic allergic reactions, inhibits cell proliferation and may also cause renal lesions. Urinary excretion is the main exit for the elimination of injected vanadium in human beings.[23]

This difference in cell viability may be related not only to aluminum and vanadium but also to other components such as carbon (C), titanium (Ti), iron (Fe), copper (Cu), oxygen (O), and nitrogen (N).

A drawback of this study was the lack of evaluation of ion content in the supernatant placed on the cells. Only ions present in mini implants were evaluated. Further studies are needed to evaluate this point, which can allow us to assess any relationship between ions released by mini implants and their real cytotoxicity.

CONCLUSION

Small change in the viability of cells (i.e., 90% of cells were only viable) was observed, possibly due to the concentration of chemical elements.

REFERENCES


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