

# RESORBABLE SCREWS FOR ORTHODONTIC ANCHORAGE

A. Korrodi Ritto DDS, PHD

## INTRODUCTION

The risks associated with metallic microfixation devices used in paediatric craniofacial surgery and the need of a subsequent removal operation has given a rise to the development of biodegradable mini-osteosynthesis devices.

Devices made of polylactic acid (PLA) and polyglycolic acid (PGA) and their copolymers have been used in the internal fixation of fractures and osteotomies in orthopaedic surgery since 1980's after extensive experimental studies<sup>1</sup>.

The obvious biocompatibility of certain resorbable materials and the urgent need of alternative methods to metallic fixation led to a rapid change-over to biodegradable fixation in non-loaded osteosyntheses in the child neurocranium after 1995.

## COMMON RELATED PROBLEMS ASSOCIATED WITH METAL FIXTURES

Some of the problems associated with rigid (metallic) fixation in the growing skull are restriction of growth and passive translocation of metallic Implants (device transposition).

Metallic fixation devices may also cause a distinct cosmetic deformity, palpability or wound dehiscence especially if placed under a scarred, tight scalp, allergic reactions and may interfere with radiological investigations or other methods like MRI.

Compared with other metals, titanium has been considered to be highly biocompatible and to have high corrosion resistance characteristics<sup>2,3</sup>.

Although titanium ions may stay bound to local tissue, there is increasing recognition that they may also bind to protein moieties that are transported in the bloodstream and lymphatics to remote organs<sup>4</sup>. In the literature, hypersensitivity reactions to titanium have been reported<sup>5</sup>. Corrosion and wear have also been suspected to induce chemical carcinogenesis<sup>6</sup>.

However very few reports on literature have been described, and titanium is actually the best material for implantation regarding cost / benefit.

Common reasons for metallic rigid fixation removal have been reported to include palpable or prominent fixtures (34.5% of the patients needing implant removal), loosening of plates and screws (25.5%), pain (25.5%), infection (23.6%), wound dehiscence/exposure of hardware (20%), and removal at the time of secondary procedures (9.1%)<sup>7</sup>.

## MATERIAL

*Polylactic acid (PLA)* and *polyglycolic acid (PGA)* are derivatives of cyclic diesters of glycolic and lactic acid from which they have been produced by ring opening polymerization, resulting in poly-alpha-hydroxy derivatives of the original acids<sup>8</sup>.

Polymers exhibit a glass transition temperature (T<sub>g</sub>), below which the polymer is solid and stiff and above which it is soft<sup>9</sup>.

Polyglycolic acid is a brownish, hard crystalline polymer melting at about 224-228°C, with a glass transition temperature of 36° C<sup>10</sup>. It lacks a methyl group, which makes it hydrophilic and thus more susceptible to hydrolysis and faster degradation than polylactide.

The oldest and best known commercial product made of PGA is Dexon®<sup>11</sup>.

Polylactic acid is a pale-coloured semicrystalline polymer with a glass transition temperature of 57° C and a melting point of 174-184° C<sup>10, 12, 13</sup>.

The asymmetric lactic acid molecule has two stereoisomeric forms, L and D lactide<sup>14</sup>. In the human body, the L-isomer exists in carbohydrate metabolism, and the D-isomer is found in acidic milk. If the polymer consists only of the L isomer, it is called poly-L-lactic acid, PLLA, which has most commonly been used in orthopaedic implants.

Weakness of the materials was the major limiting factor in the manufacture of mini implants in the 1980's. Bulky, highly crystalline PLLA implants caused foreign body reactions<sup>15</sup>, which cast a shadow on all biodegradable implants.

Remnants of pure polylactic acid (PLA) implants have been identified up to eight years after implantation<sup>16</sup>, raising the question as to whether PLA is too "biostable" to be used as a bioresorbable material<sup>17</sup>.

The *self-reinforcing technique*, invented by Rokkanen and Törmälä, enables the manufacture of extremely strong orthopaedic *implants* and also thin but strong *mini implants*<sup>1,18</sup>.

The histological demonstration of *complete device resorption* without adverse local tissue effects is important before clinical application, because incomplete polymer elimination may eventually be associated with chronic inflammatory tissue changes<sup>19</sup>.

## BIOCOMPATIBILITY

Bioabsorbable materials generally undergo a two-phase degradation process in the body. In the first, mainly physical phase, water molecules hydrolyse the chemical bonds of the polymer and cut long polymer chains to short chains. During this depolymerization process, the overall molecular weight and strength of the polymer become reduced and the polymer fragments. The second phase involves phagocytosis of the fragments by macrophages, and the polymer mass rapidly disappears<sup>9</sup>. PGA is converted hydrolytically into glycolic acid and PLA into lactic acid, which are further metabolized in the citric acid cycle to carbon dioxide and water, and the final products are excreted via respiration or urine

Hydrophilic *PGA*, although highly crystalline, becomes absorbed very quickly in the body, losing virtually all strength in 6 weeks<sup>20</sup> and all mass within about 3 to 12 months<sup>11</sup>.

Excellent biocompatibility and slow biodegradation of *PLA* have been documented in hundreds of publications, since the first experiments: no inflammatory cell infiltrations have been reported, and foreign-body reactions have been limited to around the implanted material<sup>21-23</sup>.

*Copolymers of PLA and PGA (PLGA)* offer the capability of altering the degradation rate and mechanical properties of implants by changing the PLA-PGA ratio, which offers the potential to develop site-specific bone fixation and soft tissue-anchoring devices<sup>14,24-26</sup>.

Complete absorption of *PLGA 75/25* has been reported in *220 days*, *PLGA 50/50* in *180 days*<sup>14</sup>, and *PLGA 82/ 18* in *180-450 days*<sup>25,27</sup>.

*With PLGA implants, no implant-related clinical foreign body reactions have been reported.*

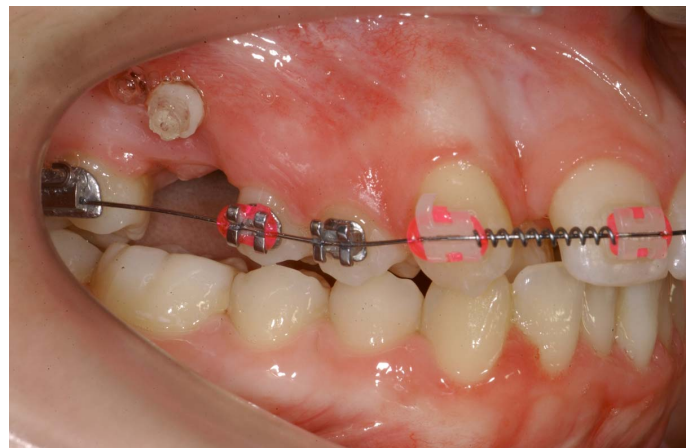
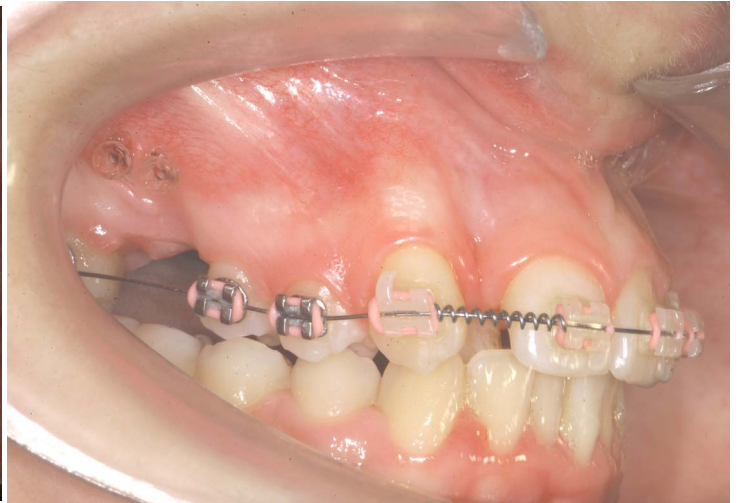
## CLINICAL EXAMPLE

Resorbable screws (1.6 mm diameter) composed of a polylactic acidpolyglycolic acid copolymer (*PLGA 75/25*) were placed in the area of tooth #16. Two screws were placed because the distal screw was not well fixed and it was decided to keep it in place and place another one mesially (Fig.1-3).

It was planned to apply 120 gm of force to distalize both premolars and canine until Class I was achieved. Because only 3 mm of distalization was needed, it was expected to get the teeth in place after 3 months of active force.

A plastic button was bonded with composite to the head of the screw (Fig.4, 5). The button was debonded 3 weeks later, and rebonded.

Three months after upper premolars distalized 3mm and some mobility of the screw was noticed. 80 days after applying the screws, the distal screw disappeared (Fig.6) and the same occurred for the other screw in 118 days (Fig.7).



## DISCUSSION

Absorbable screws are made of a resorbable copolymer, a polyester derivative of L-lactic and glycolic acids. Poly L-lactic/polyglycolic acid copolymer degrades and resorbs in vivo by hydrolysis into L-lactic and glycolic acids which are then metabolized by the body. The material is non-toxic, non-irritating and 100% amorphous, metabolizing to CO<sub>2</sub> and H<sub>2</sub>O.

The potential advantages of bioresorbable implants include less stress shielding of the bone that would be expected with metallic implants, less interference with modern imaging techniques, and elimination of the need for subsequent operations to remove the implant.

Recent improvements in the materials and design of bioresorbable plates and screws have addressed some of the problems with the first generation of resorbable implants.

Bioresorbable fixation has been suggested as a mean of overcoming some of the drawbacks of miniplate fixation in craniofacial complex while retaining the advantages.

## CONCLUSION

Micro absorbable screws can be applied with success for orthodontic purposes however, the correct PLA-PGA ratio should be selected to get the maximum performance during treatment.

Further studies should involve the appropriate shape for orthodontics as well as root effect when tooth is moved against the screw.

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