



Intra-operative and early post-operative implant stability changes at tissue-level zirconia and titanium implants. A comparative study in the miniature pig mandible using resonance frequency analysis.

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Introduction

Implant stability is subjected to change in the early healing phase and a dip in stability is expected until secondary stability, osseointegration, is established. This study was conducted to evaluate intra-operative and early post-operative stability changes for transmucosal implants placed in a miniature pig model using repeated resonance frequency analysis (*RFA*).

Aim

The objective was to evaluate possible differences in implant stability between test and control implants intra-operatively during the first 6 hours following implant placement, and subsequently during the early post-operative phase up to 21 days.

Methods

As test implants, 27 commercially available, two-piece zirconia tissue-level implants (*Patent™ Zirconia Implant* $\varnothing 4.1 \times 11\text{mm}$) with a modified rough surface (*Patent™ BBS*) were inserted in mandibular healed premolar sites of 7 adult miniature pigs. Additionally, 13 commercially available titanium tissue-level implants (*Straumann® Standard RN* $\varnothing 4.1 \times 10\text{mm}$) with a moderately rough surface (*SLActive® Roxolid®*) were placed as controls. Test and control implants were placed using a flapless procedure according to manufacturer's surgical protocol including the use of a screw-tap.



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Methods

At defined time points a calibrated titanium peg was attached to the test and control implants. A peg is basically a titanium rod, with a magnet attached to its top. When a magnetic pulse excites the peg through the magnet, it starts to vibrate with its resonance frequencies. These frequencies reflect the stiffness of the implant-bone interface.

For the control implants, the peg was attached to the implant by its internal screw connection (*Fig. 1*). For the test implants, where prosthetic components typically are cemented to the internal connection, an expandable holding insert had been constructed (*Fig. 2*). The peg can be screwed down into the insert, thereby expanding and rigidly connect to the implant. In this study, all used pegs were calibrated so the instrument output was presented as a genuine resonance frequency with a resolution of 100 Hz. Moreover, all pegs were designed to give calibrated values irrespective of implant material.

Intra-operative RFA measurements were performed immediately after implant insertion (*Fig. 3*), and thereafter every 10 minutes up to 1 hour. Further follow-up measurements were conducted at days 1, 3, 5, 7, 14 and 21 following implant insertion. Measurements were expressed in kilohertz (kHz). To analyze changes, the mean kHz value for all time points during the first hour was calculated (*Fig. 4*). Additionally, the mean kHz value calculated for the first hour for each animal was compared to the mean kHz value at the end of the follow-up (*Fig. 5*).

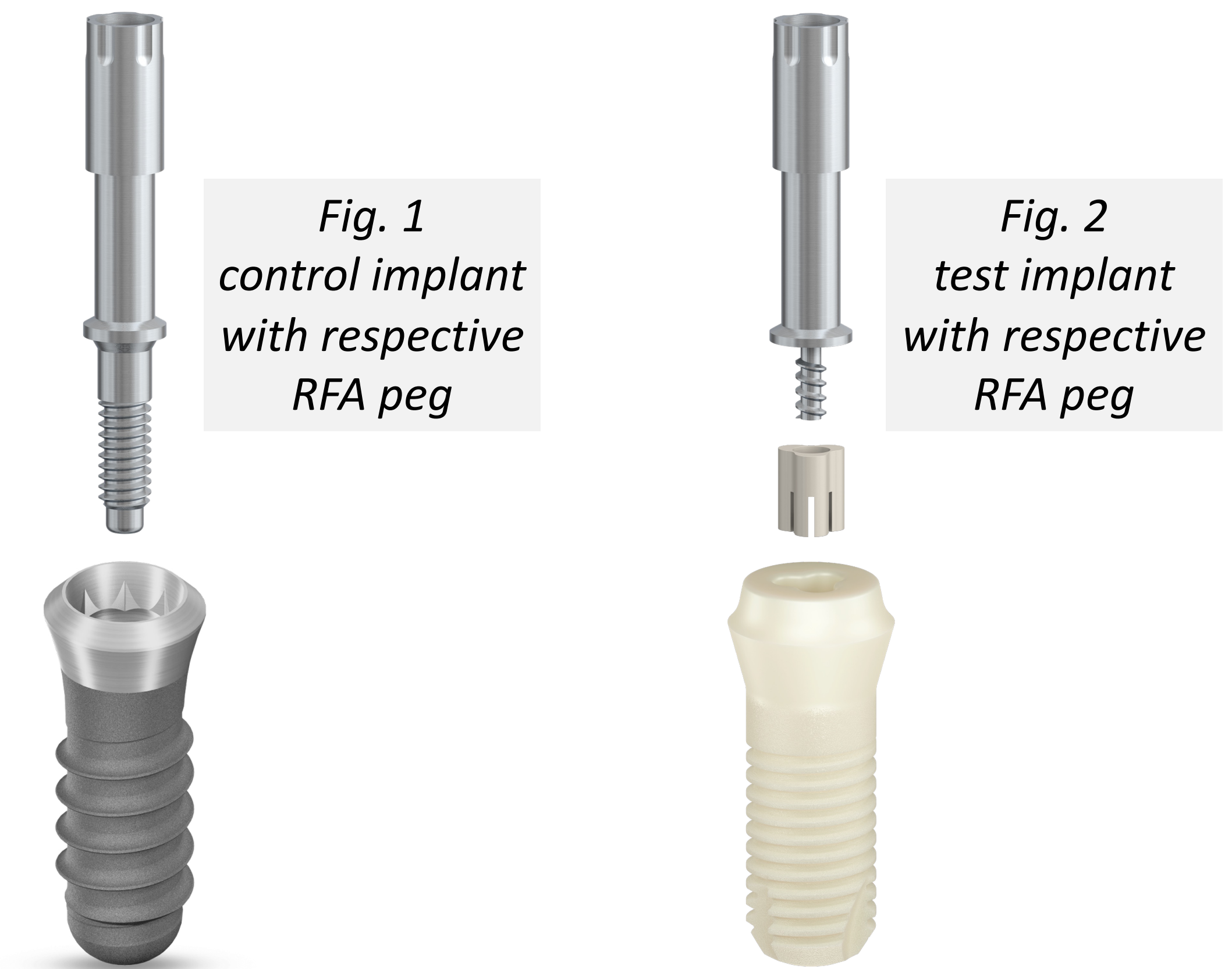


Fig. 3 intra-operative RFA measurement with mounted pegs on test and control implants



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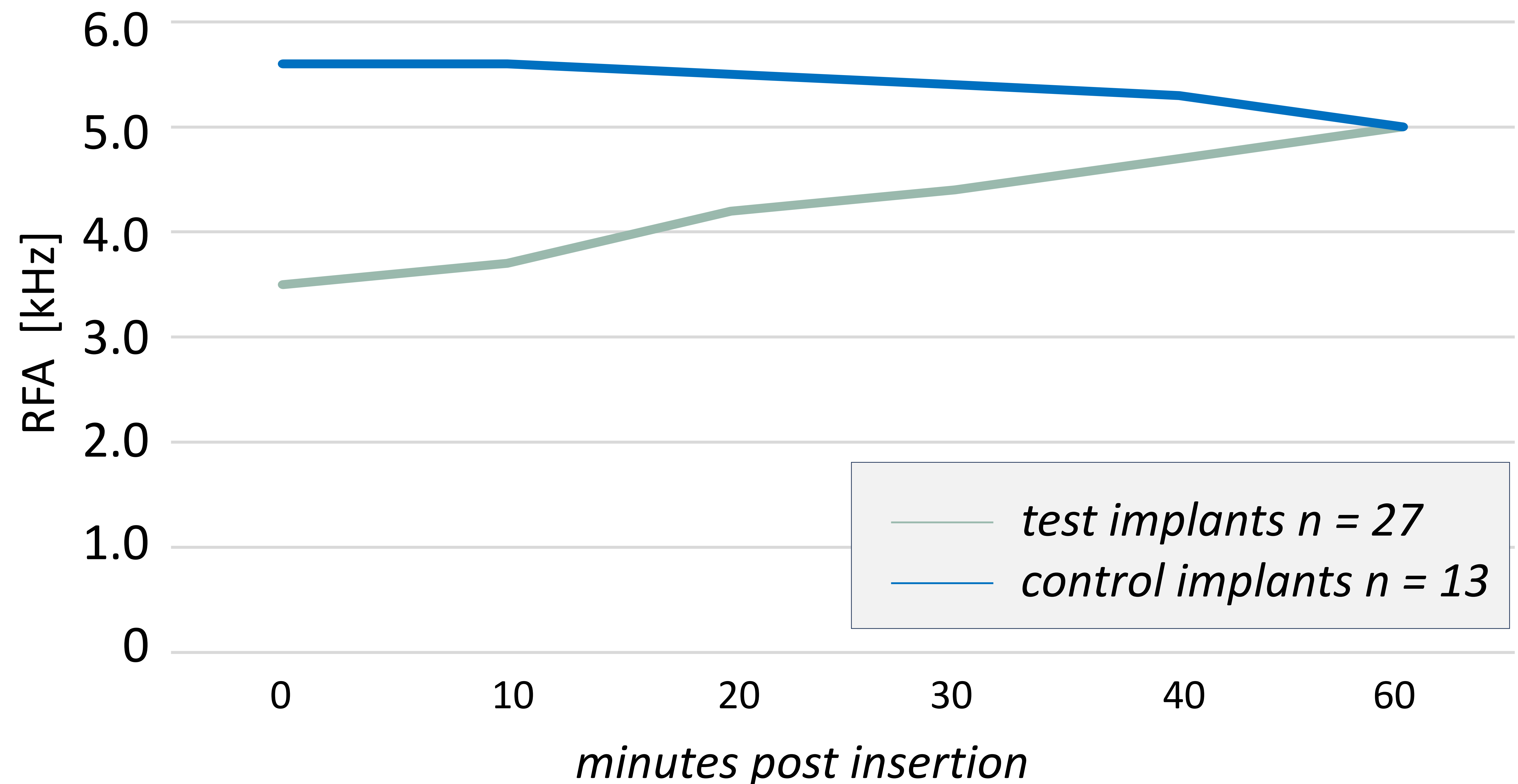
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Results

At insertion, mean RFA values for test implants was in the range of 3.0 kHz, whereas control implants revealed RFA values in the range of 5.0 kHz. Within the first hour following implant insertion, mean RFA indicated a steady increase in stability (kHz) for the group of test implants, whereas the group of control implants presented a slight decrease in stability (kHz) (*Fig. 4*).

Fig. 4 implant stability changes within the first hour





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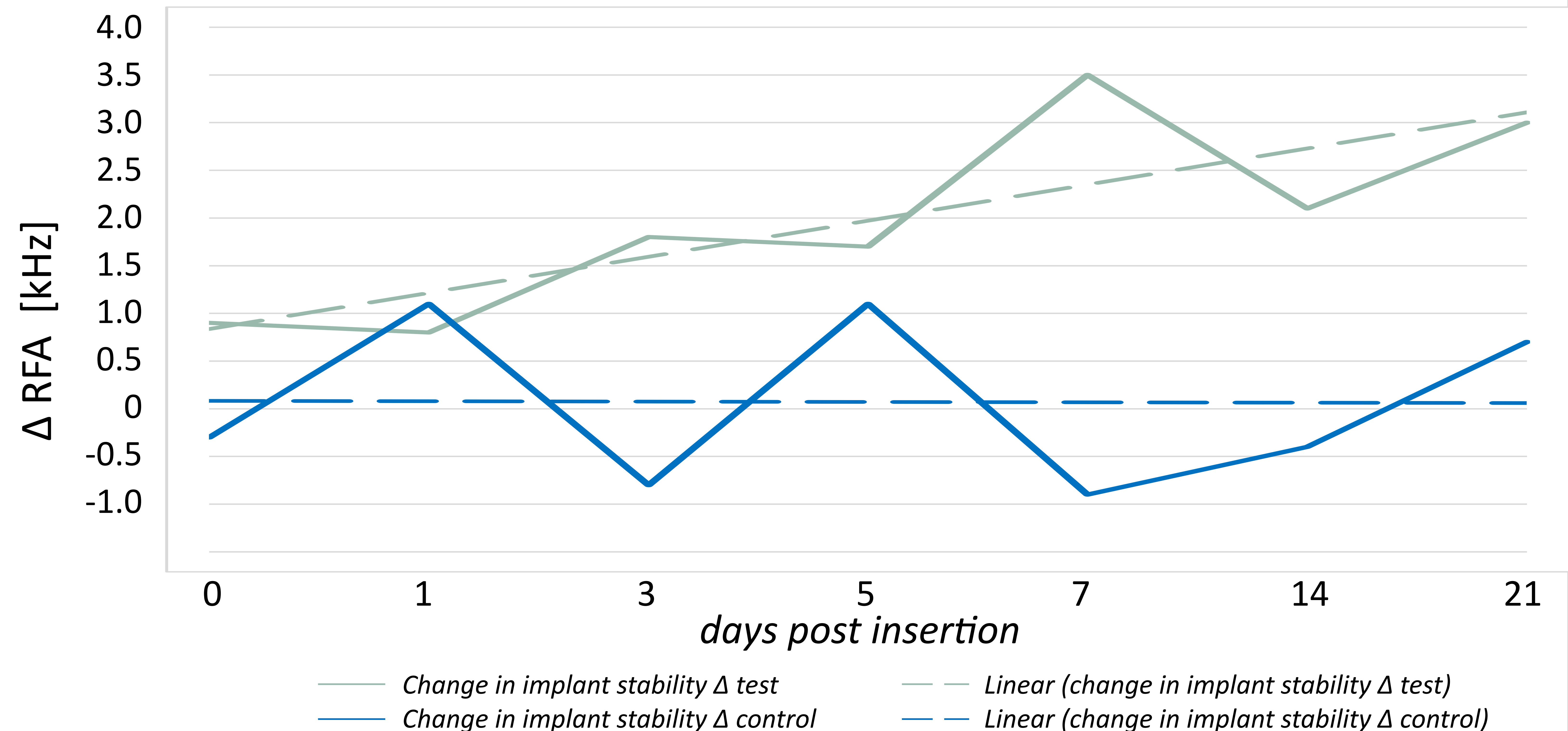
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Results

From day 0 to day 21, test implants revealed a continuous increase in stability (kHz) with a mean increase of 3.0 kHz at day 21. In contrast, control implants presented unaltered stability (kHz) values from day 0 to day 21 of healing (*Fig. 5*).

Fig. 5 implant stability changes from first hour to 3 weeks





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Conclusions

Within the limitations of this study, it is concluded that the test implants exhibited an increase in stability measurements already within the first hour after implant placement and subsequently for the next 21 days. In contrast, control implants maintained or slightly reduced stability levels over time compared to what was established at implant insertion when assessed with the RFA technique. The present evaluation indicates that alterations in the early post-operative phase at the bone-implant interface of this particular zirconia implant are different to that documented for surface-modified titanium control implants.

References

Glauser & Meredith 2001, Glauser et al. 2004, Abrahamsson et al. 2004, Jayaprakash et al. 2020, Glauser & Schüpbach 2022