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Lower incisor intrusion with intraoral transosseous stainless steel wire anchorage in rabbits

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SUMMARY The purpose of this research was to investigate the potential use of intraoral transosseous stainless steel wires as anchorage for intrusion of the lower incisors using a rabbit model. Placement of intraoral transosseous stainless steel wires around incisors is similar to that of intraoral transosseous wiring of edentulous mandibular fractures. Ten male New Zealand rabbits, 9 ± 1.5 months of age, average weight 1.8 ± 0.3 kg, were used in this study. One lower incisor was intruded with a 50 g bilateral force using a coil spring for 10 weeks, while the other incisor served as the control. Clinical measurements of the distances between the occlusal edges of the incisors (EE) were performed weekly with a calliper. In addition to standard descriptive statistical calculations, a paired Student's *t*-test was used for comparison of the two groups.

All surgical sites healed uneventfully after insertion of the wires. Significant differences were found in the change of EE between the experimental and control sides from 4 weeks onwards. Intrusion of the incisor, 4 ± 0.58 mm, was seen on the test side, while EE on the control side remained unchanged. Within the limits of this animal study, it is concluded that the intraoral transosseous stainless steel wire anchorage system is a cost-effective method for intrusion of lower incisors when the use of other anchorage system is not possible.

Introduction

Problems caused by over-erupted molars and incisors are often encountered during orthodontic treatment. Intrusion of over-erupted teeth is a challenge with traditional methods such as intrusion archwire systems and subapical alveolar osteotomy in adult patients (Poulton, 1989; Simmons *et al.*, 1992; Pangrazio *et al.*, 2001; Huang *et al.*, 2006). The use of mini-implants for orthodontic anchorage has increased in popularity over the past decade. These temporary anchorage devices offer absolute anchorage for orthodontic retraction of incisors, mesialization of posterior segments, as well as intrusion (Kanomi,1997; Melsen and Costa, 2000; Kyung *et al.*, 2003a,b; Maino *et al.*, 2003; Kuroda *et al.*, 2004; Wu *et al.*, 2006).

Intrusion of the teeth applying only apically directed force to the buccal tooth attachment will tip the teeth buccally. The most preferable biomechanics for tooth movement is balanced bilateral loading. In order to achieve an optimal bilateral intrusive force system, two miniscrews or miniplates, one placed buccally and the other lingually, has been reported in both animal and human studies (Daimaruya *et al.*, 2001; Ohmae *et al.*, 2001; Park *et al.*, 2003; Erverdi *et al.*, 2004). However, when human mandibular teeth are intruded, it is difficult to place the miniscrews from the lingual aspect due to the limitations of the oral cavity.

Therefore, the purpose of this study was to investigate a new method, the intraoral transosseous stainless steel wire anchorage system, for obtaining a bilateral force system for absolute intrusion of mandibular teeth when other anchorage system such as miniscrew anchorage is not possible.

Materials and methods

The research protocol was approved by the Experimental Animal Committee of Zhejiang University.

Ten New Zealand male rabbits, average age 9 ± 1.5 months, average weight 1.8 ± 0.3 kg, were used in this study. The rabbits were kept in cages at a temperature of approximately 20°C and fed with a diet of Chinese cabbage and clear water. One lower incisor was intruded using intraoral transosseous stainless steel wire anchorage, while the other served as control. A special needle, modified from those used in lumbar anaesthesia, was used to guide the stainless steel wire. It consisted of a hollow tube with sharp tip and a removable core (Figure1), which prevented the soft tissues from blocking the tube at the beginning of the procedure (Figure 2).

All experimental procedures, including the surgical procedures and clinical intraoral examinations, were performed under general anaesthesia by intramuscular application of a combination of ketamine, meperidine hydrochloride, and dihydroetorphine at 0.5 ml/kg.

Surgical procedure

Placement of the transosseous stainless steel wire around the incisor was similar to that for intraoral transosseous wiring of edentulous mandibular fractures (Freihofer and Sailer, 1973). The puncture point, opposite to the lower incisor to be intruded, was located on the inferior border of the mandible. Under local anaesthesia at the puncture point,

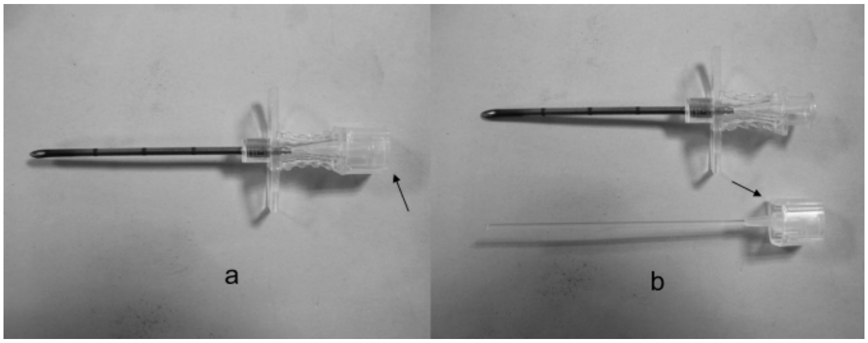

Figure 1 The needle used to guide the stainless steel wire (a and b) consists of a hollow tube with a sharp tip and a removable core (arrow).

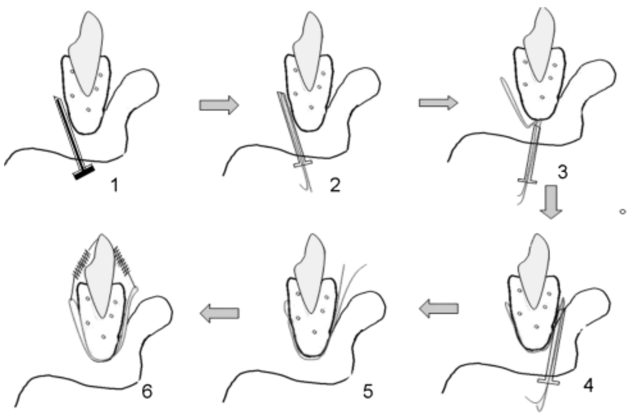

Figure 2 Schematic drawing showing the insertion of the transosseous stainless steel wire. Step 1: the needle with the removable core was inserted from the lingual aspect. Note, the inside core which prevents the soft tissues from blocking the tube. Step 2: after withdrawl of the core, a double-strand of 0.20 mm stainless steel wire was inserted through the needle. Step 3: the needle with the wire inside was then drawn back to the inferior border of the mandible. Step 4: the needle was reinserted from the buccal aspect. Step 5: the needle was withdrawn and the wire was left in the oral cavity. Step 6: the Ni–Ti spring was connected.

the needle was inserted along the lingual bone surface to the lingual side of the incisor until it reached the oral cavity. A double-strand of 0.20 mm stainless steel wire was inserted through the needle after the core was withdrawn (Figure 2). The needle, with steel wire inside, was then drawn back to the inferior border of the mandible and reinserted along the buccal jaw bone surface to the buccal side of the incisor until it reached the oral cavity. After withdrawal of the needle, the transosseous wire was left in the oral cavity. The free ends of the wire on both sides were twisted to produce hooks which connected the Ni–Ti spring (Westlake, Hangzhou, China). The coil spring, delivering a force of 50 g on both sides, was placed across the edge of the incisor to be intruded. The coil spring was bonded to the incisor at the incisor edge to ensure that the spring remained stable during orthodontic intrusion. Figure 2 shows the surgical procedures schematically. The springs were carefully calibrated biweekly for 10 weeks. The rabbits were given a soft diet to prevent breakage of the appliance as a result of the biting force. The appliances and teeth were brushed and cleaned with 2 per cent chlorhexidine digluconate weekly.

Measurement of intrusion

Measurements of lower incisor intrusion were based on the assumption that the upper incisors remained stable during the experiment. Clinical measurements were performed weekly with a digital callipers (KT5-230-62, Kenta Technologies, Singapore) in each rabbit under general anaesthesia. The distances between the occlusal edges of the antagonistic incisors, edge to edge (EE), were measured. At the end of experimental period, the rabbits were killed by intravenous injection of an overdose of ketamine. One mandible was dissected for radiographic examination of the transosseous stainless steel wire.

Statistical analysis

The data were normally distributed. The mean and standard deviation were calculated for the data. Time changes in EE were evaluated using analysis of variance and the difference between the test and control side for each period was determined by paired Student's *t*-test. $P < 0.05$ was considered to be statistically significant.

Reproducibility of the measurements was assessed by statistically analysing the difference between 10 double measurements made at 30 minutes interval by one author (JCW). The method error was calculated using the formula: $Sx = \sqrt{(\sum D^2 / 2n)}$, where Sx is the error of the measurement, D is the difference between duplicate measurements, and n is the number of double measurements. The errors for EE were 0.18 mm.

Results

All puncture sites healed uneventfully after surgery. The rabbits did not eat anything until 12 hours after surgery or spring adjustment. At the end of the experiment, no loss of weight was found.

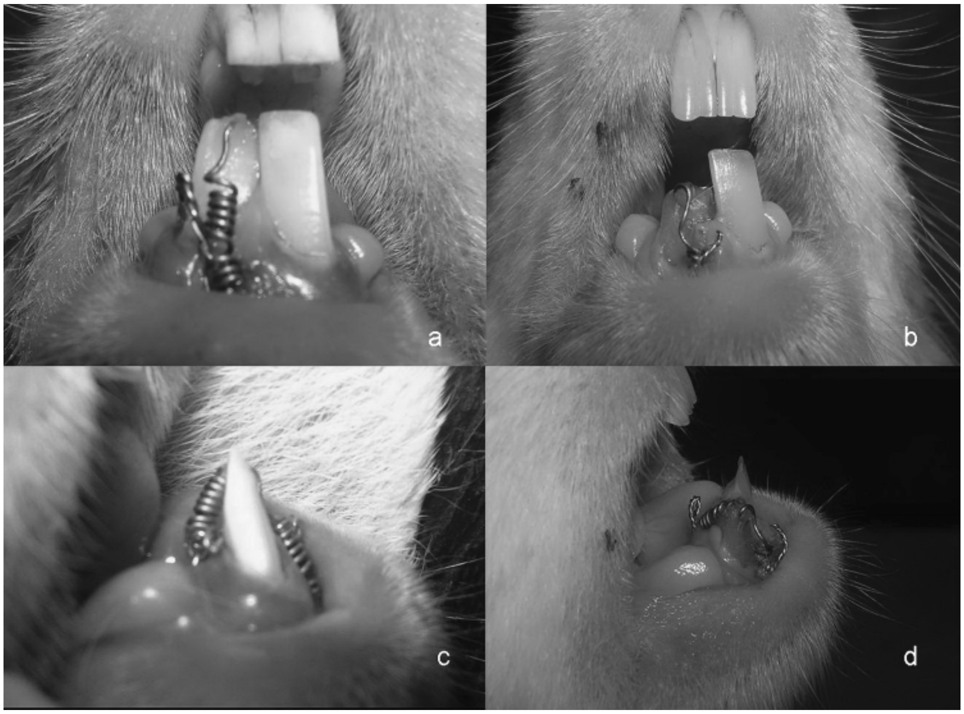

Figure 3 Intrusion of the lower incisor with the transosseous stainless steel wire anchorage system. Before intrusion (a and c) and after intrusion using a 50 g bilateral intruded force for 10 weeks (b and d). The coil spring was connecting to the bilateral hooks made of the twisted free ends of the double stranded transosseous stainless steel wire.

Figure 4 Radiograph of the transosseous stainless steel wire anchorage system, showing the relationship between the mandible and the wire. The radiograph is of a dissected free mandible including the intruded incisor after 10 weeks of orthodontic intrusion with a bilateral intrusive force of 50 g.

Intrusion of the experimental lower incisors was observed while no displacement was found for the control incisors at the end of treatment. The intruded incisors showed no buccal or lingual tipping (Figure 3). Deepening of gingival sulcus of the intruded teeth and bleeding on probing were frequently observed. Slight mucositis was found around the wire at both the buccal and lingual sides. There was no traumatic ulceration of the tongue or buccal mucosa. At the end of the experiment, the wire was easily removed by pulling one end, after 1 per cent iodine sterilization. Figure 4 shows a radiographic view of the transosseous stainless steel wire and the intruded lower incisor.

The values of EE in both groups at the different time points are shown in Table 1. Significant differences were found in the change of EE between the experimental and control sides from 4 weeks onwards. Intrusion of the incisor, 4 ± 0.58 mm, was seen on the experimental side, while the control side remained unchanged. Figure 5 shows root apex resorption of the intruded incisor.

Discussion

Simultaneous application of intrusive forces from the buccal and lingual aspects guarantees good control of the tooth (van Steenbergen *et al.*, 2005). Due to their advantages, miniscrews or miniplates have recently been introduced in orthodontics (Kanomi, 1997; Melsen and Costa, 2000; Kyung *et al.*, 2003 a,b; Maino *et al.*, 2003; Kuroda *et al.*, 2004; Wu *et al.*, 2006; Leung *et al.*, 2008). Intrusion of teeth using two miniscrews or miniplates, one buccally and the other lingually, has been reported in both animal and human studies (Daimaruya *et al.*, 2001; Ohmae *et al.*, 2001; Park *et al.*, 2003; Erverdi *et al.*, 2004). Although miniscrew anchorage has many advantages, there are still some limitations when intruding lower

Table 1 Time-course changes in the distance between the upper and antagonistic lower incisor edge in each rabbit.

	Week 0		Week 4		Week 8		Week 10	
Rabbit	Test	Control	Test	Control	Test	Control	Test	Control
1	−1	−1	0.2	−1.2	2.2	−1	2.9	−1
2	−1.3	−1.3	0.2	−1.1	2.2	−1.2	2.8	−1.2
3	−0.8	−0.7	0.5	−0.7	2	−0.8	3.5	−0.7
4	−0.8	−0.9	0.5	−0.8	2.1	−0.8	2.5	−1
5	−1	−0.8	0.3	−0.8	2.3	−1	2.9	−0.8
6	−0.9	−1	0.5	−1.1	1.8	−0.8	2.8	−1
7	−1.2	−1.2	0.2	−1.1	1.7	−1.2	2.7	−1.1
8	−1.2	−1	0.3	−1	1.8	−1.1	3	−1
9	−0.8	−0.7	0.8	−0.8	2.8	−0.8	3.6	−0.7
10	−0.8	−0.8	0.7	−0.7	2.5	−0.8	3.5	−0.8
Mean	−0.98	−0.94	0.42*$^{\Delta}$	−0.93	2.14*$^{\Delta}$	−0.95	3.02*$^{\Delta}$	−0.93
Standard deviation	0.19	0.2	0.21	0.19	0.34	0.17	0.37	0.17

*Significant difference between each experimental time point and week 0 in the test group $P < 0.05$.
$^{\Delta}$Significant difference between the test and control groups at each experimental time point $P < 0.05$.

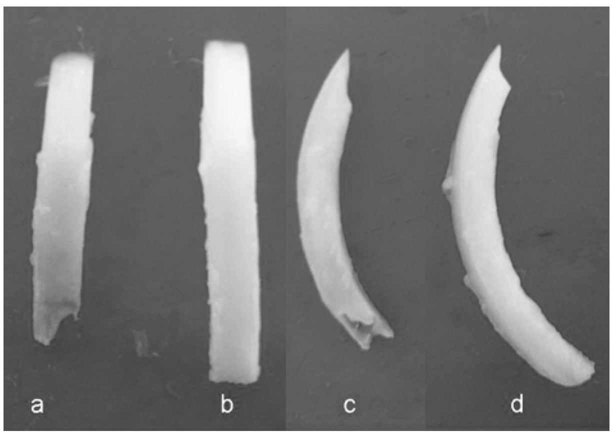

Figure 5 Extracted incisors after 10 weeks of intrusion. Intruded incisor (**a** and **c**) and control incisor (**b** and **d**). Frontal (a and b) and lateral (c and d) views. Root resorption was found at the apex of the intruded incisor.

human teeth. If lower teeth are to be intruded, it is difficult to place miniscrews from the lingual aspect. Furthermore, the discomfort, potential injury to the roots, and looseness of microimplants inserted in the interradicular region are a concern. Thus, the objective of this study was to investigate a new anchorage system, intraoral transosseous stainless steel wire, to obtain bilateral intrusive force for intrusion of lower teeth when bilateral miniscrew anchorage is not possible.

Before intraoral transosseous wire anchorage can be used in humans, it must be proven safe and efficient in an animal model. To investigate the potential anchorage of intraoral transosseous wires for intrusion of lower teeth, a rabbit model was used because it is difficult to intrude the lower incisors of rabbit with traditional anchorage systems, even with the recently advocated miniscrew anchorage. As the lower incisors of the rabbits are intruded, the upper incisors would over-erupt due to the lack of occlusal contact. As overeruption of the upper incisors is not obvious during short experimental periods, to simplify the measurement method, the distances between the upper and lower incisors (EE) were measured to calculate intrusion.

Zygomatic ligatures made of stainless steel wire have been proven to be an effective anchorage device for intrusion and retraction of the maxillary incisors in partially edentulous patients (Melsen *et al.*, 1998). The method of placing transosseous stainless steel wire around incisors is similar to that of intraoral transosseous wiring of the endentulous mandible for mandibular fractures. Generally, it does not result in infections at the interface of the stainless steel wires. In the present study based on a rabbit model, no infection was seen.

With bilateral miniscrew anchorage, Daimaruya *et al* (2001) intruded the lower molars 3.4 mm using an intrusive force from a buccal miniplate and lingual bone screw in dogs. Ohmae *et al* (2001) reported, in their beagle dog intrusion model, that the lower third premolars were intruded 4.5 mm, on average, after 12–18 weeks of bilateral orthodontic force application. In this rabbit model, the lower incisors were intruded approximately 4 mm after 10 weeks of intrusion using intraoral transosseous stainless steel wire anchorage. Two hooks, made from the ends of the inserted transosseous stainless steel wire, successfully served as bilateral anchors.

Previous studies suggest that external apical root resorption (EARR) occurs during treatment when forces at the apex exceed the resistance and reparative ability of the periapical tissue (Parker and Harris, 1998) and heavy forces increase the risk of EARR (Ohmae *et al.*, 2001). In this study, shortening of the intruded roots caused by severe root resorption after orthodontic treatment was observed. Severe root resorption indicates ‘high stress’ at the apex of the incisor. In this study, a bilateral force of less than 50 g (20 g) might have been appropriate. The correct amount of force for intrusion of the lower incisors needs to be investigated.

With intraoral transosseous stainless steel wire anchorage, the incisors could be easily and rapidly intruded. However, insertion of the transosseous stainless steel wire is difficult. Good command of the topical anatomy and surgical skill are necessary. The discomfort and the consistent slight mucositis around the wire are of concern. Moreover, there are still questions that need to be answered such as the influence of the wire on the mandible. Further research should focus on these issues.

Conclusion

Easy and rapid intrusion of the lower incisors was achieved with the intraoral transosseous stainless steel wire anchorage system in rabbits. Within the limitations of this animal study, it is concluded that the intraoral transosseous stainless steel wire anchorage system is cost-effective for intruding the lower incisors when the use of other types of anchorage system such as miniscrews is not possible.

Further studies are necessary to determine the influence of the intraoral transosseous stainless steel wire anchorage system on the mandible.

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