

Effect of rotation bump on removal torque of orthodontic mini-implants

Odontuya Gansukh¹, Jong-Wha Jeong¹, Jong-Wan Kim², Young-Kyun Kim³, Jong-Ho Lee⁴, Tae-Woo Kim¹

¹Department of Orthodontics and Dental Research Institute, School of Dentistry, Seoul National University, Seoul,

²Department of Orthodontics, Section of Dentistry, Seoul National University Bundang Hospital, Seongnam,

³Department of Oral and Maxillofacial Surgery, Section of Dentistry, Seoul National University Bundang Hospital, Seongnam,

⁴Department of Oral and Maxillofacial Surgery and Dental Research Institute, School of Dentistry, Seoul National University, Seoul, Korea

Abstract (J Korean Assoc Oral Maxillofac Surg 2013;39:269-273)

Objectives: This study is designed to evaluate the mechanical stability of orthodontic mini-implants with vertical grooves in rabbits.

Materials and Methods: This study was done from March 2011 to February 2012 in Dental Research Institute of Seoul National University. Thirty-two mini-implants in the control group and 32 in the rotation bump (RB) group were inserted in the tibias of 16 rabbits and were removed after two weeks and four weeks, respectively. The maximum insertion torque (MIT), maximum removal torque (MRT), torque ratio (TR) of MRT to MIT and removal angular momentum (RAM) were all measured at the time of removal.

Results: There were no significant differences between the two groups in MIT and MRT at two weeks or four weeks. However, TR and RAM at four weeks in the RB group were significantly higher than in the control group ($P<0.05$). TR of the RB group was significantly increased at four weeks ($P<0.05$). In both groups, RAM at four weeks was significantly higher than at two weeks ($P<0.05$).

Conclusion: These results suggest that RB of the mini-implant could provide resistance to the removal rotation, although it did not increase the MRT.

Key words: Mini-implant, Rotation bump, Torque, Torque ratio, Angular momentum

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I. Introduction

An implant with a small diameter and a short length may be useful in orthodontic treatment¹. However, the stability of a mini-implant is uncertain because mini-implants with a small diameter can be easily loosened by low removal torque^{2,3}. A previous study reported that the failure rate of orthodontic mini-implants ranges from 10% to 30%⁴. Therefore, further efforts to improve the clinical survival rate of mini-implants are needed. A number of studies on the shape^{2,5}, soft tissue contact surface⁶, and insertion method⁷ of mini-implants have been conducted to enhance success rates. Various methods,

such as the modification of the shape of mini-implants, have been suggested to increase mechanical stability. Sullivan et al.⁸ showed that the removal torque of a screw-shaped implant with a 3.74 mm diameter T-chamber was greater than 10 Ncm, despite a lack of osseointegration. A vertical bump on a mini-implant provides vertical space for bone growth and could improve stability when rotational movement is applied⁹. The stability of implants with an anti-rotational vertical bump may be increased through bone remodeling and bone proliferation.

Stability in the form of resistance to rotational movement can be analyzed by measuring the removal torque. The mobility test, resonance frequency analysis and torque analysis are techniques to evaluate the stability of implants¹⁰. Although insertion torque analysis was developed as a method to measure the stability and supportive capacity of implants¹¹, insertion torque may have a weak relationship with stability, and removal torque may be more useful to test the mechanical stability of implants⁵. Torque ratio (TR) can show the increase in stability from the insertion stage to the final stage². Angular momentum, which is defined as the torque in-

Jong-Wan Kim

Department of Orthodontics, Section of Dentistry, Seoul National University Bundang Hospital, 82, Gumi-ro 173 beon-gil, Bundang-gu, Seongnam 463-707, Korea
TEL: +82-31-787-7549 FAX: +82-31-787-4068
E-mail: kimjongwan@hotmail.com

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tegrated during a certain period, represents the stability of the implant¹², and removal angular momentum (RAM) describes the resistance to removal rotational movement¹³.

This study was performed to evaluate the stability of orthodontic mini-implants with an anti-rotational vertical bump in rabbits through the mechanical analysis of maximum insertion torque (MIT), maximum removal torque (MRT), TR and RAM at two and four weeks after insertion.

II. Materials and Methods

1. Implants and subjects

A total of 64 titanium orthodontic mini-implants (length 6.0

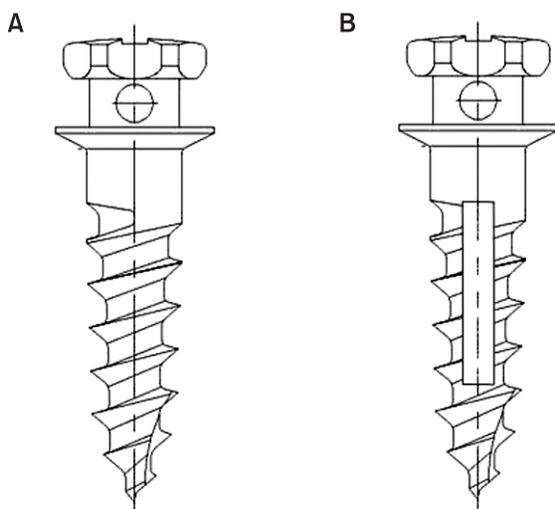


Fig. 1. Tested groups of orthodontic mini-implants. A. Control group. B. Rotation bump group.
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mm, diameter 1.6 mm, Dual-Top; Jeil Medical Corporation, Seoul, Korea) were included in the present study: 32 in the control group and 32 in the rotation bump (RB) group.(Fig. 1) This study was approved by the Ethics Committee for Research on Animals (Seoul National University Ethical Board, SNU 120308-2). Sixteen three-month-old New Zealand white rabbits (mean weight was 3.5 to 4.0 kg, Dooyeol Biotech, Seoul, Korea) were used in this study. This study was done from March 2011 to February 2012 in Dental Research Institute of Seoul National University (Seoul, Korea).

2. Surgical procedures

The rabbits were anesthetized with an intravenous injection of Zoletil 50 (7.5 mg/kg; Virbac Korea, Seoul, Korea) and Rompun 2% (0.15 mL/kg; Bayer Korea, Seoul, Korea). The internal surface of the tibia was further blocked with 0.5 mL of 2% lidocaine. The metaphyses of both end sides of the tibia were surgically exposed by scalpel incision to the periosteum and blunt dissection. The mini-implant was inserted into the metaphysis of the tibia with a surgical implant engine (Elcomed SA200C; W&H Dentalwerk, Bürmoos, Austria) after pre-drilling (\varnothing 1.0 mm) under saline irrigation.(Fig. 2. A)

3. Mechanical analysis

The mini-implants were removed at two weeks and four weeks after implantation, with the torque recorded by the surgical engine (Fig. 2. B), which had a rotational speed of 20 rpm. Impdat software (Kea Software GmbH, Poeking, Germany) was used for the readout of the removal torque value. The torque was recorded eight times per second. MIT, MRT



Fig. 2. Insertion procedure of orthodontic mini-implant and equipment. A. Pre-drilling with saline irrigation. B. Surgical engine which can measure and record the torque.
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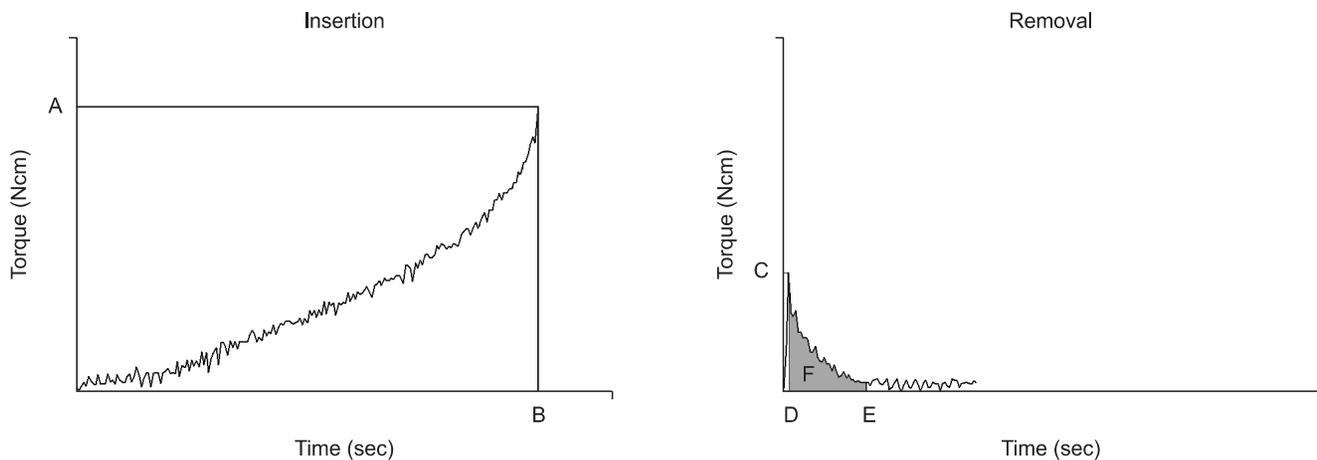


Fig. 3. Schematic graph to explain the mechanical characteristics of mini-implants. (A: maximum insertion torque [MIT], B: time of MIT, C: maximum removal torque [MRT], D: time of MRT, E: 1.5 seconds after MRT, which is a time needed for a half turn, F: removal angular momentum which is the torque integrated from the time of MRT to 1.5 seconds after MRT)

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Table 1. Maximum insertion torque at two and four weeks after insertion of a mini-implant

Removal time (wk)	Maximum insertion torque (Ncm)		P-value ¹
	Control group	Rotation bump group	
2	10.28±1.61	10.25±1.84	0.968
4	10.57±2.37	10.06±2.37	0.868
P-value ²	0.805	0.932	

¹P-value was calculated by independent t-test between control group and rotation bump group. ²P-value was calculated by independent t-test between two and four weeks in each group.

Values are presented as mean±standard deviation.

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and TR of MRT to MIT were measured to analyze mechanical stability.(Fig. 3) To analyze the energy exerted to remove the mini-implant from the bone, the RAM (Ncms) was calculated by integrating the torque during a half turn, which took 1.5 seconds under 20 rpm after MRT.

4. Statistical methods

All measurements were statistically evaluated using the independent t-test to determine any differences in MIT, MRT, TR and RAM between the control and RB groups and at two and four weeks in each group. A $P<0.05$ was considered to be statistically significant.

III. Results

No failures of mini-implants occurred at two weeks. However, two mini-implants in each group failed at four weeks, resulting in identical failure rates.

Table 2. Maximum removal torque at two and four weeks after insertion of a mini-implant

Removal time (wk)	Maximum removal torque (Ncm)		P-value ¹
	Control group	Rotation bump group	
2	6.61±1.88	5.90±1.59	0.261
4	6.07±2.99	7.07±2.44	0.230
P-value ²	0.584	0.077	

¹P-value was calculated by independent t-test between control group and rotation bump group. ²P-value was calculated by independent t-test between two and four weeks in each group.

Values are presented as mean±standard deviation.

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There were no significant differences between the two groups with regard to MIT and MRT at two or four weeks. (Tables 1, 2) However, the TR of the RB group (79.80%) was significantly higher than that of the control group (56.42%) at four weeks ($P<0.05$). (Table 3) The RAM of the RB group (14.94 Ncms) was significantly higher ($P<0.05$) than that of the control group (11.20 Ncms). (Table 4)

TR and RAM at four weeks in the RB group were significantly higher than in the control group ($P<0.05$). The TR of the RB group significantly increased from 58.99% at two weeks to 79.80% at four weeks ($P<0.05$). In both groups, RAM at four weeks was significantly higher than at two weeks ($P<0.05$). RAM increased from 7.57 to 11.20 in the control group and from 6.78 to 14.94 in the RB group.

IV. Discussion

Mini-implants have low stability in bone because their surface area is small. The removal torque of an implant is

Table 3. Torque ratio at two and four weeks after insertion of a mini-implant

Removal time (wk)	Torque ratio (%)		P-value ¹
	Control group	Rotation bump group	
2	65.06±18.69	58.99±17.48	0.350
4	56.42±22.79	79.80±24.71	0.023*
P-value ²	0.358	0.017*	

¹P-value was calculated by independent t-test between control group and rotation bump group. ²P-value was calculated by independent t-test between two and four weeks in each group.

*P<0.05.

Values are presented as mean±standard deviation.

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Table 4. Removal angular momentum (integrated torque during a half turn after maximum removal torque) at two and four weeks after insertion of a mini-implant

Removal time (wk)	Removal angular momentum (Ncms)		P-value ¹
	Control group	Rotation bump group	
2	7.57±2.02	6.78±1.72	0.246
4	11.20±4.21	14.94±3.12	0.013*
P-value ²	0.005**	0.000***	

¹P-value was calculated by independent t-test between control group and rotation bump group. ²P-value was calculated by independent t-test between two and four weeks in each group.

*P<0.05, **P<0.01, ***P<0.001.

Values are presented as mean±standard deviation.

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proportional to its surface area, and the osseointegrated area is proportional to the square of the implant radius⁷ under the same osseointegration ratio condition. This indicates that mini-implants with a small radius have low removal torque requirements and can be easily removed without an additional operation. A previous study reported that mini-implants could be loosened with application of orthodontic loading, which can induce a rotational moment¹⁴.

A vertical rotation bump can provide vertical space for bone proliferation. The bone growth into the rotation bump space can resist the rotational movement of mini-implants. In the present study, there were no significant differences between the control group and RB group at two or four weeks. (Tables 1, 2) However, RAM at four weeks in the RB group was significantly higher than that of the control group.(Table 4) These results imply that the mini-implants in the RB group are more resistant to removal rotation. Because RAM was defined as the integrated torque value during a half turn, high RAM might indicate high resistance to removal rotation. The removal torque suddenly decreased after MRT. High RAM might indicate that a high torque value was maintained after

MRT¹⁵. When rotational moments were applied to the mini-implant, high RAM might have made the mini-implant more resistant to the loosening moment. In both groups, RAM at four weeks was significantly higher than at two weeks. This might indicate that the osseointegration at four weeks was better than at two weeks. The higher RAM of the RB group at four weeks compared to the control group might mean that the bone growth and the osseointegration in the vertical rotation bump space improve resistance to removal torque¹⁶.

TR was significantly increased at four weeks in the RB group and was significantly higher than that of the control group.(Table 3) Increased TR may indicate an increase in final stability compared to initial stability². The MRT of the RB group was increased at four weeks, although it did not show a statistically significant difference.

Although the stabilities of both groups did not differ, there was an increase in the resistance to the removal rotational movement in the RB group. This might suggest that the vertical rotation bump did not enhance the stability of the mini-implant at the initial stage. If the mini-implant remains stable during initial bone remodeling, the vertical rotation bump could improve the resistance of a small mini-implant to rotational movement, which could occur under clinical orthodontic loading. Although conventional orthodontic force is not a rotational movement, food irritation and practices in the orthodontic environment could cause rotation force around the mini-implants during a long treatment period. A rotation bump could support resistance to some unexpected rotational movements.

A previous study suggested that immediate or early orthodontic loading did not affect mini-implant stability because similar histomorphometric results were observed for immediate loading, early loading and delayed loading groups¹⁷. However, the histological results did not analyze the intensity or change in stability over time. The results of the present study suggest that RAM changes with time, and that a vertical rotation bump can reinforce the stability of mini-implants.

When orthodontic loading is applied to the mini-implant immediately after insertion, a vertical rotation bump does not enhance mini-implant stability. However, a mini-implant with a rotation bump may have greater stability than a mini-implant without such a bump, as long as the implant is kept stable at the initial stage.

Further studies of histological changes and clinical observations are needed to improve stability and to decrease tissue stress.

V. Conclusion

The rotation bump group did not show significant differences compared to the control group in MIT and MRT at two or four weeks after insertion of mini-implants. However, the TR and RAM of the rotation bump group were significantly higher than the control group at four weeks. RAM was significantly increased at four weeks in both groups. This suggests that the mini-implants were securely osseointegrated at four weeks, and bone growth at the rotation bump space may increase resistance to removal rotation movements.

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