Predisposing Conditions for Condylar Luxation After Intraoral Vertical Ramus Osteotomy

Satoshi Rokutanda (jj20170075@ms.nagasaki-u.ac.jp)
Department of Oral and Maxillofacial Surgery, Juko Memorial Nagasaki Hospital, 6-17 Maruo Town, Nagasaki city, Nagasaki 852-8004, Japan

Shin-Ichi Yamada
Shinshu University

Souichi Yanamoto
Nagasaki University

Hiroshi Sakamoto
Nagasaki University

Keisuke Omori
Nagasaki University

Hiromi Rokutanda
Nagasaki University

Tomoko Yoshimi
Nagasaki University

Ayumi Fujishita
Nagasaki University

Yukiko Morita
Nagasaki University

Noriaki Yoshida
Nagasaki University

Masahiro Umeda
Nagasaki University

Research Article

Keywords: Intraoral vertical ramus osteotomy (IVRO), temporomandibular joint (TMJ) symptoms, Univariate analysis

DOI: https://doi.org/10.21203/rs.3.rs-132750/v1

Abstract

Intraoral vertical ramus osteotomy (IVRO) is a surgical procedure for the treatment of mandibular prognathism and temporomandibular disorders. However, the improvement of temporomandibular disorders after surgery is considered to be due to the anterior and downward movement of the mandibular condyle, which may lead to condylar sag, and in the worst case, condylar luxation. In this retrospective cohort study, we examined factors potentially associated with condylar luxation. Univariate analysis indicated that condylar luxation was significantly associated with the following factors: magnitude of setback ($P = 0.001$); presence of temporomandibular joint (TMJ) symptoms ($P = 0.002$); occlusal cant correction ≥ 2 mm ($P = 0.018$); and mandibular condyle deformation ($P < 0.001$). The magnitude of setback ($P = 0.035$) and the presence of TMJ symptoms ($P = 0.008$) remained significant in the multivariate analysis. In the receiver operating characteristic curve, the cut-off value of the magnitude of setback for condylar sag and condylar luxation after IVRO was 3.25 mm. Thus, the risk of condylar luxation after IVRO is increased with a smaller magnitude of setback (≤ 3.25 mm) and the presence of TMJ symptoms. These factors should be carefully evaluated by surgeons during treatment planning for IVRO.

Introduction

Intraoral vertical ramus osteotomy (IVRO) and sagittal split ramus osteotomy (SSRO) has been used extensively to correct mandibular prognathism, and IVRO is one of the treatment modalities for certain types of temporomandibular joint disorder (TMD) [1–3]. IVRO is effective in alleviating TMD symptoms [4], and is also advantageous in that it is technically simple [5]; facilitates the repositioning of the condyle [5, 6, 7]; and is associated with a lower incidence of inferior alveolar nerve injury [8]. On the other hand, IVRO has some disadvantages compared to the SSRO. First, the principle disadvantage of the IVRO is the need for maxillomandibular fixation (MMF) [5]. Second, depending on the magnitude of setback, posterior drift may occur after IVRO, which adversely affects the corrective treatment [9]. The most pertinent issue for the surgeon is the difficulty in predicting the magnitude of condylar sag that may occur after IVRO. Indeed, severe cases of condylar luxation have been reported to occur unexpectedly after IVRO [10].

While patients with TMD are more prone to temporomandibular luxation after IVRO compared to patients with jaw deformities [10], methods for preventing this complication have been proposed. Kawase-Koga *et al.* [11] reported that condylar luxation can be prevented by adjusting the osteotomy line shape. Rotskoff *et al.* [12], on the other hand, described the use of an overcorrected occlusal splint to avoid condylar displacement. Nevertheless, the optimal method for managing condylar luxation after it has occurred remains unclear.

Condylar sag improves temporomandibular joint symptoms, and this will decrease over time [4]. The appropriate treatment for condylar luxation is controversial, with some studies advocating the use of conservative management [10], and other studies reporting the need for surgical treatment [13]. As condylar luxation is thought to occur continuously during condylar sag [2], we investigated the conditions

under which condylar sag was likely to occur, and the factors specifically associated with condylar luxation.

Results

No patients were excluded by the exclusion criteria. The total number of patients was 57, and 114 temporomandibular joints were investigated. The mean age of the cohort (21 male and 36 female patients) at the time of surgery was 27.2 ± 10.4 (range: 17 to 54) years. The mean setback achieved with IVRO was 5.9 ± 3.4 mm (range: 0 to 15 mm). Condylar sag was diagnosed in 42 of 114 temporomandibular joints (37%), while condylar luxation was only diagnosed in one temporomandibular joint (0.01%). Approximately a third (39 of 114) of the temporomandibular joints exhibited symptoms. Maxillary surgery was performed in 26 of 57 cases (46%); concurrent occlusal cant correction was carried out in 14 of 26 cases (54%), with the majority involving corrections of 2 mm or more (12 of 26 cases). Mandibular condyle deformation was observed in 12 of 144 (11%) temporomandibular joints. Condylar sag was observed in 20 of the 75 (27%) joints that did not exhibit symptoms. Condylar sag was observed in 22 of the 39 (56%) joints that exhibited symptoms (Table 1).

Univariate analyses of potential explanatory factors for condylar sag and condylar luxation after IVRO did not find significant associations for age, sex, classification of the main and sub-functional side of the temporomandibular joint, maxillary surgery, occlusal cant modification, or osteotomy line shape. On the other hand, significant associations were found for the magnitude of setback ($P = 0.001$), presence of temporomandibular joint symptoms ($P = 0.002$), occlusal cant correction ≥ 2 mm ($P = 0.018$), and mandibular condyle deformation ($P < 0.001$) (Table 2). These variables were subsequently included in a multivariate analysis. Only the magnitude of setback ($P = 0.035$; odds ratio, 0.87; 95% confidence interval, 0.764–0.99) and the presence of temporomandibular joint symptoms ($P = 0.008$; odds ratio, 3.23; 95% confidence interval, 1.362–7.65) remained significant in the multivariate model (Table 3).

To quantify the relationship between the magnitude of setback and condylar sag and luxation after IVRO, a cut-off value was obtained from the receiver operating characteristic (ROC) curve using the Youden index as an indicator. Both condylar sag and condylar luxation after IVRO were significantly more likely in cases where the magnitude of setback was 3.25 mm or less.

Discussion

The results of this study suggest that condylar sag and luxation after IVRO are associated with the magnitude of setback and temporomandibular joint symptoms. Therefore, it is important that these factors be evaluated during treatment planning for IVRO.

In this study, a decrease in the magnitude of setback was associated with a higher risk of condylar sag and luxation. The association with temporomandibular joint symptoms is supported by the results of a prior study that reported a higher likelihood of condylar luxation in patients with TMD who experienced

symptoms (such as clicking sounds and temporomandibular joint pain), compared to patients with simple jaw deformities [10]. These results may be attributed to an increased fragility and loss of elasticity in the joint capsule due to inflammation, which subsequently leads to condylar sag and luxation. The association between condylar sag, luxation and an occlusal cant correction of 2 mm or more may be explained by the development of TMD due to the perturbation of normal mandibular movement by the non-physiological inclination of the maxillary occlusal plane. This was significantly different in univariate analysis, but not in multivariate analysis. Since occlusal cant correction of 2 mm or more may be associated with temporomandibular joint symptoms, it is necessary to increase the number of cases and confirm the association.

While osteotomy line shape was not significantly associated with condylar sag or luxation, a significant relationship was reported in a previous study [11]. This may have been due to the small sample size employed in our study. Although mandibular condylar deformation was a significant explanatory variable in the univariate analysis, it was not retained in the multivariate model. This may be attributed to the finding that the exacerbation of symptoms in patients with TMD often results in mandibular condyle deformity. As a result, mandibular condyle deformation would not be evident prior to the appearance of temporomandibular joint symptoms. Since the multivariate analysis had a strong association and affected other analysis results, the mandibular condyle deformity was excluded. From this, it is necessary to collect and examine a sufficient number of cases for events that may cause temporomandibular joint symptoms and events that may occur continuously for temporomandibular joint symptoms. In the ROC curve, the cut-off value of the magnitude of setback for condylar sag and condylar luxation after IVRO was 3.25 mm; therefore, surgeons should be vigilant for these complications if the magnitude of setback is less than 3.25 mm.

In this study, the medial pterygoid muscle was almost detached from the proximal segment. This facilitated the setback procedure and reduced the potential for possible relapse after IVRO. The complete detachment of the medial pterygoid muscle is typically avoided, as it may result in the complete displacement of the condyle from the glenoid fossa. Retaining some medial pterygoid muscle attachment also lowers the risk of condylar luxation and ischemic necrosis of the tip of the proximal segment [3, 5, 14]. Nevertheless, some studies have reported the absence of complications in cases where the entire medial pterygoid muscle was detached from the proximal segment [13, 15]. In the present study, condylar sag was observed in just over a third (37%) of the cases, and only one case (0.01%) of condylar luxation was documented; the incidence of both complications are lower than those reported by previous studies [5, 10, 11]. Therefore, even if the medial pterygoid muscle is completely detached, the stability of the temporomandibular joint is relatively unaffected. In addition, avascular necrosis of the proximal segment was not observed in the postoperative 1-year follow-up period. This is notable, as the proximal segment was only connected to the mandibular condyle at the joint capsule. This implies that the blood supply and minimal amount of attachment provided by the joint capsule was sufficient to avoid avascular necrosis following IVRO. The adequacy of the blood supply from the joint capsule has been previously reported [15].

Some limitations are acknowledged in the present study. Firstly, it was a preliminary study involving a small number of patients. Secondly, we investigated the conditions under which condylar sag, and then we estimated the conditions under which condylar luxation occurs. However, by planning and performing the surgery paying attention to the magnitude of setback, the presence of temporomandibular joint symptoms, and mandibular condyle deformation derived from this study, it is possible to prevent condylar luxation, which is difficult to deal with if it occurs. In the future studies, it will be necessary to collect cases from other facilities and clarify the results.

Methods

Subjects

The study protocol was approved by the Institutional Review Board of the Nagasaki University Graduate School of Biomedical Sciences (approval number 16020826), and all participants provided written informed consent. All experiments were performed in accordance with relevant guidelines and regulations. The retrospective cohort study included patients diagnosed with skeletal mandibular prognathism who underwent IVRO between November 2012 and February 2017 at the Unit of Translational Medicine in the Department of Clinical Oral Oncology at the Nagasaki University Graduate School of Biomedical Sciences. Inclusion criteria comprised patients who (1) underwent mandibular setback via IVRO performed by the same surgeon, and (2) did not have previous orthodontic treatment. Patients were excluded if they did not agree to participate. We evaluated both the left and right temporomandibular joints in 57 patients (36 women and 21 men) using computed tomography (CT) (Aquilion 64™, Canon Medical Systems Corporation, Tochigi, Japan) before and after IVRO. This study was investigated by using the cases and methods that we previously published [9].

Three-dimensional (3D) CT images were used to diagnosis condylar sag and condylar luxation prior to surgery, and check for complications after surgery. The CT images were acquired with the mouth closed to ensure reproducibility of the distal segment position during diagnosis.

Surgical procedure and MMF

IVRO was performed under general anesthesia. An intraoral incision was made at the anterior border of ramus. A pair of Bauer retractors was placed in the sigmoid and antegonial notches to visualize the antelingular prominence and to prevent bleeding from the internal maxillary artery. A subcondylar osteotomy was performed using an oscillating saw. The distal segment was slid distally and placed medially to the proximal segments. After IVRO, the medial pterygoid muscle was almost detached from the proximal segment in all cases. The distal fragment of the mandible was placed in the planned postsurgical position and stabilized using rigid MMF and a splint in the maxillary dental arch [9].

Assessment methods

Condylar sag and luxation after IVRO was diagnosed based on 3D-CT imaging of the left and right temporomandibular joints. A diagnosis of condylar sag was made if the highest point of the mandibular

condyle was observed from the glenoid fossa. Condylar luxation was diagnosed when the mandibular condyle deviated from the glenoid fossa beyond the articular eminence (Fig. 1). All diagnoses were performed twice by three oral surgeons. Two or more oral surgeons were present during each diagnosis in order to ensure accuracy.

Statistical analysis

Univariate and multivariate analyses were performed to determine the potential association of clinical factors with condylar sag and condylar luxation after IVRO. Condylar sag (or condylar luxation) after IVRO was the dependent variable, and the potential explanatory (independent) variables included the following: sex; age; magnitude of setback; classification of the main and sub-functional side of the temporomandibular joint (main functional side: ×, sub functional side: ⬤); presence of temporomandibular joint symptoms (such as temporomandibular joint clicking, temporomandibular joint pain and trismus at the opening and closing mouth, habitual temporomandibular joint luxation); provision of concurrent maxillary surgery; occlusal cant modification; magnitude of occlusal cant modification (≥ 2 mm or < 2 mm); presence of mandibular condyle deformation; and an osteotomy line shape. For factors found to be significantly associated with condylar sag or condylar luxation during multivariate analysis, cut-off values were determined from the ROC curve. All statistical analyses were performed with SPSS software (version 24.0; Japan IBM Co., Tokyo, Japan). A P-value less than 0.05 was considered statistically significant.

Declarations

Data availability: All data generated or analysed during this study are included in this published article.

Acknowledgements

None.

Author contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by SR, HS, KO, HR, TY, AF, and YM. The first draft of the manuscript was written by SR and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Competing interests: The authors declare no competing interests.

References

1. Broadbent, T. R. & Woolf, R.M. Vertical ramisection for prognathism. *Plast. Reconstr. Surg.***60**, 735-743 (1977).

2. Hall, H. D., Chase, D. C. & Payor, L. G. Evaluation and refinement of the intraoral vertical subcondylar osteotomy. *J. Oral Surg.***33**, 333-341 (1975).
3. Hall, H. D. & Mckenna, S.J. Further refinement and evaluation of intraoral vertical ramus osteotomy. *J. Oral Maxillofac. Surg.***45**, 684-688 (1987).
4. Rokutanda, S. *et al.* Effects of the changes in the condylar long axis angle and condylar position on temporomandibular symptoms after intraoral vertical ramus osteotomy: a preliminary study. *Oral Surg. Oral Med. Oral Pathol. Oral Radiol.***128**, 597-605 (2019).
5. Ghali, G. E. & Sikes, J. W. Jr. Intraoral vertical ramus osteotomy as the preferred treatment for mandibular prognathism. *J. Oral Maxillofac. Surg.***58**, 313-315 (2000).
6. Peterssen, A. & Willmar-Hogeman, K. Radiographic changes of the temporomandibular joint after oblique sliding osteotomy of the mandibular rami. *Int. J. Oral Maxillofac. Surg.***18**, 27-31 (1989).
7. Eckerdal, O., Sund, G. & Astrand, P. Skeletal remodeling in the temporomandibular joint after oblique sliding osteotomy of the mandibular rami. *Int. J. Oral Maxillofac. Surg.***15**, 233-239 (1986).
8. Bell, W. H. Mandibular prognathism in *Modern Practice in Orthognathic and Reconstructive Surgery* 61, 2111-2137 (Saunders, 1992).
9. Rokutanda, S. *et al.* Anterior relapse or posterior drift after intraoral vertical ramus osteotomy. *Sci. Rep.* **10**, 3828; 10.1038/s41598-020-60838-1 (2020).
10. Yamauchi, K., Takenobu, T. & Takahashi, T. Condylar luxation following bilateral intraoral vertical ramus osteotomy. *Oral Surg. Oral Med. Oral Pathol. Oral Radiol. Endod.***104**, 747-751 (2007).
11. Kawase-Koga, Y. *et al.* Complications after intraoral vertical ramus osteotomy: relationship to the shape of the osteotomy line. *Int. J. Oral Maxillofac. Surg.***45**, 200-204 (2016).
12. Rotskoff, K. S., Herbosa, E. G. & Nickels, B. Correction of condylar displacement following intraoral vertical ramus osteotomy. *J. Oral Maxillofac. Surg.***49**, 366-372 (1991).
13. Ritto, F., Parente, E., da Silveira, H. M., Medeiros, P. J. & de Moraes, M. Avoiding condylar displacement after intraoral vertical ramus osteotomy. *J. Craniofac. Surg.***21**, 826-829 (2010).
14. Werther, J. R., Hall, H. D. & Gibbs, S. J. Disk position before and after modified condylotomy in 80 symptomatic temporomandibular joints. *Oral Surg. Oral Med. Oral Pathol. Oral Radiol. Endod.***79**, 668-679 (1995).
15. Lai, S. S. *et al.* Skeletal changes after modified intraoral vertical ramus osteotomy for correction of mandibular prognathism. *J. Plast. Reconstr. Aesthet. Surg.***60**, 139-145 (2007).

Tables

Due to technical limitations, table 1-3 is only available as a download in the Supplemental Files section.

Figures

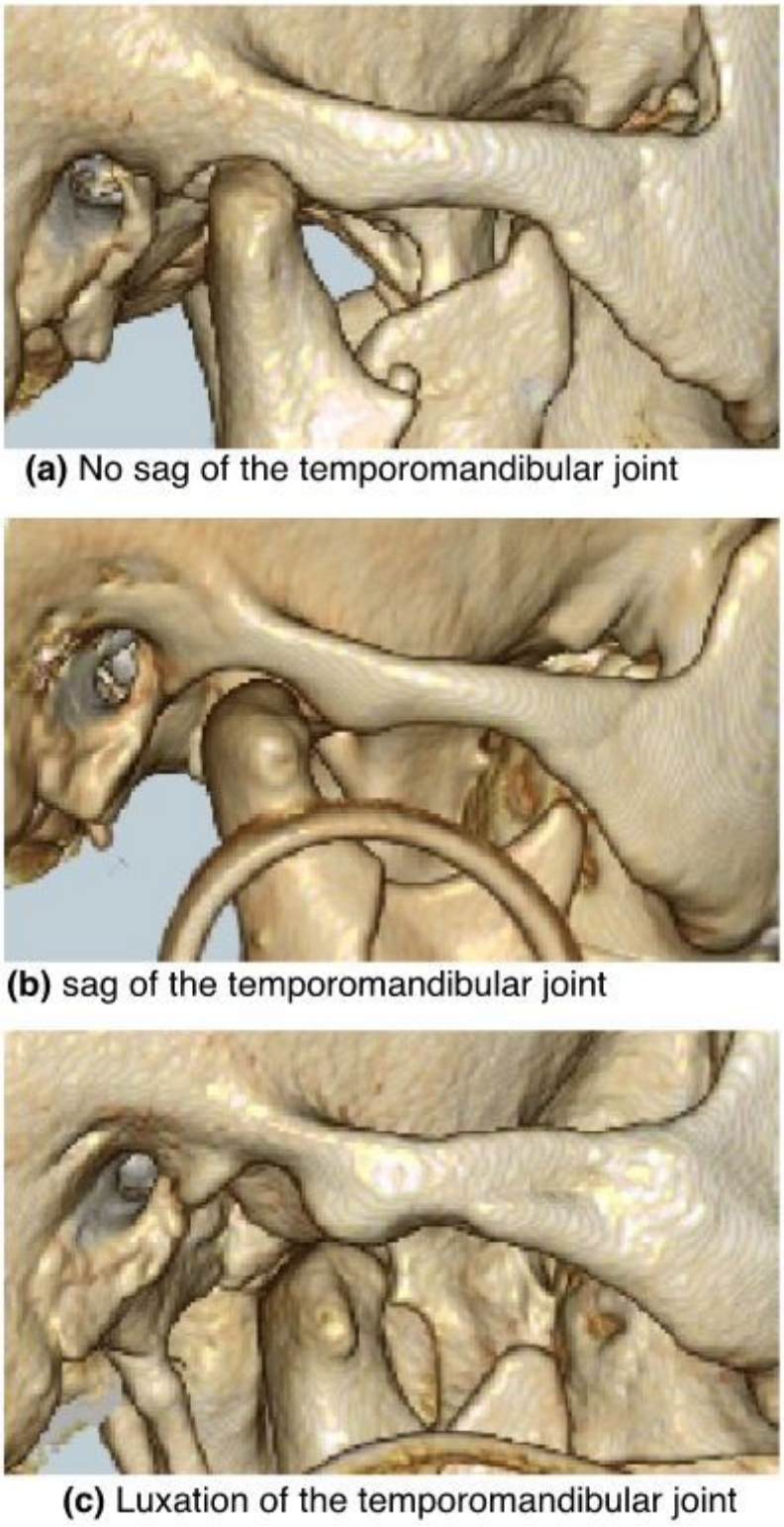

Figure 1

Diagnosis of temporomandibular joint sag and luxation

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- table1.xlsx
- Table2.xlsx
- Table3.xlsx