Impacted third molars in sagittal split osteotomies in mandibular prognathism and micrognathia

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ABSTRACT

Background: The timing of removal of mandibular third molars (M3) in Sagittal Split Osteotomy (SSO) has been an issue of contention. The aim of this retrospective study is to identify the incidence of unfavorable fractures during SSO with the presence of M3 and to identify the association between unfavorable fractures with the factors specifically related to the M3.

Materials and Methods: Retrospective analysis of consecutive bilateral sagittal split osteotomy (BSSO) patient's treatment records of 208 patients treated by a single surgeon was analyzed. The position of M3, fracture details, and demographics were collected. Descriptive statistics and Chi-square tests were employed in SPSS package. A $P \leq 0.05$ was taken as significant.

Results: There were altogether 416 SSO performed. M3 was completely impacted in 88.9% of all instances, and in 85.6% of the instances, the bulk of the M3 was identified to be above the external oblique ridge. In 59.4% of the cases, M3 was positioned in alignment with the arch as observed during surgery. There were about 27 (6.5%) instances of unfavorable splits. A statistically significant relationship was observed with M3 root morphology and axial position of M3.

Discussion: This study for the first time has confirmed the spatial positioning of M3 as one of the several causes of unfavorable splits during SSO. An impacted M3 that lies below the oblique ridge, distoangularly/vertically oriented, with divergent/supernumerary root would cause unfavorable splits when the spreader is not used properly. Potential causes and influencing factors of the unfavorable splits are discussed.

Keywords: Bad split, bilateral sagittal split osteotomy, favorable split, impacted third molar, impaction, jaw correction, mandibular impaction, mandibular prognathism, micrognathia, retrognathia, unfavorable split

INTRODUCTION

The ramus sagittal split osteotomy (SSO) is the most common type of osteotomy done owing to its suitability for both advancement and setback of the mandible. The technique was introduced by Schuchart, modified and popularized by Trauner and Obwegeser. SSO has been described in the literature as a technically sensitive procedure, with numerous possible intraoperative complications. This has led to further modifications of the SSO technique with an aim to try to decrease the frequency of intraoperative complications and to increase the stability and predictability of the post-surgical results. Notable modifications of SSO are those proposed by Dal Pont and Hunsuck.

The timing of removal of third molars (M3) in Bilateral Sagittal Split Osteotomy (BSSO) has been an issue of contention. There are several studies that support the removal of the M3 during the BSSO procedure itself. Simultaneous removal of the M3 during SSO is reported to limit the risk, is cost-effective, minimizes unwanted post-surgical consequences, and provides a reliable guidance to identify inferior alveolar nerve, a mean by which planned surgery can be accomplished. It has been suggested that timing of removal of M3 during SSOs should be decided based on the angulation, relative height, and root form of the third molar, and its morphological relation to the inferior alveolar nerve (IAN).

On the contrary, there are several studies that support prior removal of the M3 at least by 6 to 9 months. The presence of unerupted M3 in SSO is reported to increase the operating time with increased technical difficulty. Moreover, the incidence of unfavorable fracture is greater, with reduced favorable sites for rigid fixation when impacted M3 is present. When an unfavorable
fracture does occur, it is reported that operating time and technical
difficulty are increased in the operation theater while in the
postoperative period, local infection, nonunion, mal-union,
prolonged neurologic symptoms, and enhanced chance of relapse
occur more often after such an unfavorable fracture.\cite{7,8}

The overall incidence of the unfavorable splits is reported to be
0.21-22.72%.\cite{9} Anatomical variations in the posterior mandible
render the split of SSO procedure more difficult, predisposing such
patients to a higher risk of unfavorable fractures. The risk is higher
when the split involves at or above a point of fusion between the
external and internal cortical plates of the ramus, or when the ramus
is thinner mediolaterally. It has been reported that the thickness of
the mandibular buccal cortex decreases significantly from the
second molar to the ramus region. Similarly, prognathic patients have
been shown to have a generally thinner mandibular ramus, and a
mandibular canal located more buccally, when compared to patients
with retrognathia, making them more likely to have unfavorable
splits and perioperative impairment of the inferior alveolar nerve.\cite{10}

The aim of this retrospective study is to identify the incidence of
unfavorable fractures during SSO with the presence of M3 and to
identify the association between unfavorable fractures with the
factors specifically related to the M3.

**MATERIALS AND METHODS**

Retrospective analysis of consecutive BSSO patient’s treatment
records of 208 patients treated in a single, tertiary center in
the period of January 2006 to December 2010. Criteria for
inclusion in this study were: 1) BSSO performed for correction of
dentofacial deformity and malocclusion, 2) Presence of Impacted
M3 (Partial/Complete) in both sides, 3) Completion of 2nd Molar
root formation, 4) Impacted M3 removed after the split; and
exclusion criteria: 1) Complete eruption of one M3, 2) Patients
with diagnosed systemic illness or diseases that influence the
morphology of mandible or bone structure, 3) Patients with
syndromes, 4) Previously treated SSO or orthodontic treated
cases, 5) History of mandibular fractures.

From the records, the data related to age, gender, and the position
of M3 were recorded. The degree of impaction was categorized
into: 1) Partially erupted and 2) Completely Impacted. The degree
of development of M3 was subdivided into: 1) Incomplete crown
formation, 2) Complete crown formation, and 3) Complete root
formation. Based on angulation of M3, it was classified as 1) Mesioangular, 2) Distoangular, 3) Horizontal, and 4) Vertical. When the greater than 50% of bulk of M3 was placed below the shadow of the External Oblique Ridge (EOR), it was classified as below the ridge and otherwise above the ridge.

The M3 root morphology was classified as 1) Fused roots, 2)
Divergent roots, 3) Fused roots with supernumerary roots, 4)
Divergent roots with supernumerary roots, 5) Normal root.
The orientation of the M3 in axial section was noted as 1) In
line with arch (Straight) 2) Oblique. The type of BSSO was also
noted down as a setback or advancement. The occurrence of
an unfavorable fracture or a favorable split during SSO was
also recorded. The extent of the unfavorable fracture was
also subdivided into: 1) Complete proximal (buccal) segment
fracture, 2) Incomplete (green stick) proximal segment fracture, 3)
Complete distal (lingual) segment fracture, 4) Incomplete (green
stick) distal segment fracture, 5) No unfavorable split.

All the surgery were performed by the single surgeon (Author; with
20 years of surgical experience) in the same setup. All osteotomies
were performed using the same technique.\cite{11} M3 were removed
after the split. When situation warranted, tooth was bisected or full
M3 was removed as assessed by the surgeon on the operation table.

All data thus collected were entered in Statistical Package for Social
Service (SPSS, version 16.0, IBM, Chicago, IL, USA) Package.
Descriptive statistics are presented for all variables. Chi-square test
was employed to find the association of M3 with the normal and
unfavorable split BSSO’s. A group comparison of patients serving
as their own control was also performed to analyze the importance
of earlier findings. $P \leq 0.05$ was taken to be significant.

**RESULTS**

There were 208 cases fulfilling the exclusion and inclusion
criteria. There were 91 (43.8%) males and 117 (56.2%) females.
Eighty-six were aged 20 years and below. The demographics are
described in Table 1. Of these 208 BSSO cases, there

| Table 1: Demographics of the study group |
|----------------------------------------|
| Demographic parameter                  | $N$ (%)               |
| Age                                    | 21.53±3.06 years      |
|                                        | (17 to 27 years)      |
| 20 years and below                     | 86 (41.1)             |
| 21 years and above                     | 122 (58.9)            |
| Gender                                 |                       |
| Male                                   | 182 splits; 91 cases (43.8) |
| Female                                 | 234 splits; 117 cases (56.2) |
| Male: Female                           | 1:1.29                |
| Impaction of teeth                     |                       |
| Completely impacted                    | 370 (88.9)            |
| Partially impacted                     | 46 (11.1)             |
| Angulation of impacted teeth           |                       |
| Mesioangular                           | 278 (66.8)            |
| Distoangular                           | 90 (21.6)             |
| Vertical                               | 25 (6)                |
| Horizontal                             | 23 (5.5)              |
| Degree of development of impacted teeth|                       |
| Incomplete crown                       | 20 (4.8)              |
| Complete root                          | 236 (56.7)            |
| Complete root                          | 160 (38.5)            |
| Position of bulk of impacted tooth     |                       |
| Above ridge                            | 356 (85.6)            |
| Below ridge                            | 60 (14.4)             |
| Impacted tooth’s root morphology       |                       |
| Normal                                 | 78 (18.8)             |
| Fused                                  | 251 (60.3)            |
| Divergent                              | 74 (17.8)             |
| Divergent with supernumerary           | 11 (2.6)              |
| Fused with supernumerary               | 2 (0.5)               |
| Impacted tooth in axial section        |                       |
| Straight                               | 247 (59.4)            |
| Oblique                                | 189 (40.6)            |
| Outcome of SSO                         |                       |
| No unfavorable split                   | 389 (83.5)            |
| Green stick fracture-distal            | 25 (6)                |
| Fracture-distal complete               | 2 (0.5)               |
| BSSO treatment needs                   |                       |
| Setback BSSO                           | 350 (84.1)            |
| Advancement BSSO                       | 66 (15.9)             |

SSO = Sagittal split osteotomy, BSSO = Bilateral sagittal split osteotomy
were altogether 416 SSO performed. M3 was completely impacted in 88.9% of all instances. M3 was mesioangular in 66.8% of the instances. Most of the M3 had incomplete root formation (56.7%), and in 85.6% of the instance, the bulk of the M3 was identified to be above the EOR. Only in 78 (18.8) cases, the root morphology was diagnosed to be normal. In 59.4% of the cases, the M3 was positioned in alignment with the mandibular arch as observed during surgery. There were about 27 (6.5%) instances of unfavorable splits. This occurred in 26 cases as one case had bilateral unfavorable split. The mean age of unfavorable splits cases was 21.44 ± 3.7 years while for the favorable splits cases was 21.54 ± 3.01 years. The difference was not statistically significant.

Of all fractures, distal green stick fractures were observed in 25 (6%) instances while complete distal fracture was identified in 2 cases (0.5%). There was statistical correlation between predictor variables and the type of fractures.

Table 2 depicts and compares the relationship of the predictor variables (gender, impaction status, impaction type, degree of development of M3,Bulk of M3, M3 root morphology, axial position of M3, and age group). A statistically significant relationship was observed with M3 root morphology and axial position of M3.

Table 2: Association of “unfavorable splits” with respect to normal SSO

|                      | n (%) | P value |
|----------------------|-------|---------|
|                      | No fracture | Fracture |
| Mean age (in years)  | 21.54±3.01  | 21.44±3.7 | 0.876 |
| Gender               |           |         |
| Male                 | 168 (43.2) | 14 (51.9) | 0.25 |
| Female               | 221 (56.8) | 13 (48.1) |
| Impaction status     |           |         |
| Completely impacted  | 346 (88.9) | 24 (88.9) | 0.59 |
| Partially Impacted   | 43 (11.1)  | 3 (11.1)  |
| Impaction type       |           |         |
| Mesioangular         | 263 (67.6) | 15 (55.6) | 0.156 |
| Distoangular         | 81 (20.8)  | 9 (33.3)  |
| Vertical             | 22 (5.7)   | 3 (11.1)  |
| Horizontal           | 23 (5.9)   | 0         |
| Degree of development of impacted tooth | | |
| Incomplete crown     | 19 (4.9)   | 1 (3.7)   | 0.168 |
| Incomplete root      | 225 (57.8) | 11 (40.7) |
| Complete root        | 145 (37.3) | 15 (55.6) |
| Bulk of tooth        |           |         |
| Above ridge          | 343 (88.2) | 13 (48.1) | 0.000 |
| Below ridge          | 46 (11.8)  | 14 (51.9) |
| Root morphology      |           |         |
| Normal               | 78 (20.1)  | 0        | 0.000 |
| Fused                | 240 (61.7) | 11 (40.7) |
| Divergent roots      | 64 (16.5)  | 10 (37)   |
| Divergent-supernumerary root | 7 (1.8) | 4 (14.8) |
| Fused with supernumerary roots | 0 | 2 (7.4) |
| Axial position of impacted tooth | | |
| Straight             | 241 (62)   | 6 (22.2)  | 0.000 |
| Oblique              | 148 (38)   | 21 (77.8) |
| Age group            |           |         |
| 20 years and below   | 230 (59.1) | 12 (55.6) | 0.432 |
| 21 years and above   | 159 (40.9) | 13 (44.4) |

SSO = Sagittal split osteotomy

Internal comparison was performed for the unilateral unfavorable splits (n = 25 cases) with corresponding opposite side. A significant difference was observed with type of impaction, degree of M3 development, bulk of M3, axial position of M3 and marginally with M3 root morphology [Table 3].

Table 3: Comparison of unfavorable splits cases serving as controls (n=25)

|                      | n (%) | P value |
|----------------------|-------|---------|
|                      | Fracture | No fracture |
| Impaction            |           |           |
| Completely impacted  | 23 (92)   | 24 (96)  | 0.5 |
| Partially Impacted   | 2 (8)     | 1 (4)    |
| Impaction type       |           |           |
| Mesioangular         | 14 (56)   | 23 (92)  | 0.012 |
| Distoangular         | 8 (32)    | 2 (8)    |
| Vertical             | 3 (12)    | 0        |
| Degree of development |          |           |
| Incomplete crown     | 1 (4)     | 5 (20)   | 0.019 |
| Incomplete root      | 10 (40)   | 15 (60)  |
| Complete root        | 14 (56)   | 5 (20)   |
| Bulk of tooth        |           |           |
| Above ridge          | 13 (52)   | 22 (88)  | 0.006 |
| Below ridge          | 12 (48)   | 3 (12)   |
| Root morphology      |           |           |
| Normal               | 0         | 3 (12)   | 0.049 |
| Fused                | 10 (40)   | 15 (60)  |
| Divergent roots      | 10 (40)   | 7 (17)   |
| Divergent-Supernumerary root | 4 (16) | 0 |
| Fused with supernumerary roots | 1 (4) | 0 |
| Axial position       |           |           |
| Straight             | 6 (24)    | 20 (80)  | 0.000 |
| Oblique              | 19 (76)   | 5 (20)   |

**DISCUSSION**

The presence of M3 is reported to increase the chances of an unfavorable split in SSO. The data emanating from several studies are contradictory.[4,5] Several authors have reported no significant difference in the incidence of unfavorable splits with or without M3.[11,12,13] Others have found an increased incidence of unfavorable splits with impacted M3 molars in younger patients but not in patients over age of 20 years.[14] The pattern (extent and direction) of such unfavorable split appears not to be associated with presence of M3.[15] Age group did not appear to influence the outcome of unfavorable splits in present study that was in contrast to earlier reported literature.[14] However, the distribution of the age in that study was questioned.[9] In our study, there was no significant difference between the 2 split groups with regard to age.

The reported factors with regard to the splits in the presence of M3 during SSO includes the place of M3,[16] incomplete osteotomies, unfavorable bone thickness [Figure 1], unfavorable mandibular shape, incorrect direction of the osteotomies,[16] however, the role of angulation of M3, relative height, root form of the M3, and its morphological relation to the IAN has been previously suggested.[16] Till date, to the best of our knowledge, no study has considered the effect of M3-related parameters on the splits.

It has been proposed without a direct data that impacted M3 that lie just below the cortical bone result in a region of weakness,
which in turn increases the likelihood of unfavorable split in SSO. The present study supports the above view. In the present case series, when bulk of M3 lie below the dense region of the EOR, the incidence of the unfavorable splits increases. In 356 instances where bulk of M3 was above the ridge, only 13 cases (3.65%) had unfavorable splits while in 60 instances, when bulk of M3 was below the ridge, 14 cases (23.33%) of the cases had unfavorable splits [Figure 2a-h]. The differences between the incidences were statistically significant. The same was also highlighted when internal comparisons were employed.

The Finite Element Analysis model study has revealed that the functional stress is concentrated along the EOR. M3 often are at close relation with EOR. A high mechanical stress is often associated with normal loading on the EOR when bone in the region is manipulated. Several studies have underlined the importance of the EOR in the osteotomy cut [Figure 3a and b]. Moreover, Champy’s lines of osseointegration is a very critical factor in the osteotomy as well as while selecting the place for positioning the miniplates and screw. The number of Champy’s lines and the number of bone lamellae and grains being involved in the cut would determine the outcome. The more the grains and lamellae gets involved, more the chance of unfavorable splits.

In the presence of impacted M3, the lingual cortex becomes thinned out, and owing to the spatial placement of the M3, there is a higher chance of bad splits in the lingual cortex (distal split). This has been the experience in the present study group too. The strong EOR probably helps to withstand undesired stress and direct the stress in the opposite direction -lingually where the unfavorable splits commonly occur. It has been observed that in young-aged males, after the removal of the M3, a perfect split often occur. In few cases, the lower border fails to split. This probably arises due to the fact that this border is the thickest. Hence, while performing a SSO in young males, after the removal of M3, should one require a further splitting under direct vision, care should be exercised to control the force needed to cause discontinuity in the lower border of mandible. This is essential owing to close proximity to the inferior alveolar nerve [Figure 4].

The root morphology of M3 appears to play a vital role in determining the unfavorable split. Normal root morphology had no splits while 4.38% of all fused roots, 13.5% of all diverged roots, 36.36% of all supernumerary roots with divergence, and all cases of supernumerary fused roots had bad splits. The difference was statistically significant. With internal controls too, this trend was observed. A large surface area of M3 (altered root morphology) would increase the number of bone lamellae, grains, and osteons being involved [Figures 5 and 6].

Among all the M3 that were oriented along the mandibular arch, only 2.47% had bad splits while 12.43% of all M3 that were obliquely oriented underwent bad splits. The difference was statistically significant. Similarly, an obliquely placed M3, relative to the mandibular arch, would involve more osteointegration planes, bone grains, and the number of bone lamellae being involved [Figures 7-10]. This would lead to poor stress distribution during the separation of the split bone. Multi-directional as well as force directed in a wrong direction would lead to unfavorable splits.

The direction, force of the spreader, and its efficient use is critical; as such requiring experience and expertise. A properly used spreader would cause a good split. In such cases, that does not respond favorably, a bur cut may be essential, below the bend of the M3, adjacent to proximal surface. This bur cut could damage

![Figure 1](image1.png) Thin mandibular ramus more likely to have unfavorable split

![Figure 2](image2.png) (a) Mesioangular, (b) Vertical, (c) Horizontal, (d) Incomplete crown, (e) Incomplete root, (f) Below ridge, (g) Fused root, (h) Straight in line with the arch-axial section
Figure 3: (a) Impacted tooth below oblique ridge and not in line with the arch (linguoverted impaction), (b) Thin lingual cortex higher chance of bad split in the lingual cortex

Figure 4: Thick lower border (young adult) - split under direct vision

Figure 5: Buccoverted impaction - with thin buccal cortical plate

Figure 6: Altered root morphology - involving more surface area

Figure 7: Case 1: BSSO - Sagittal cut before removal of impacted tooth

Figure 8: Case 2: BSSO - Sagittal cut before removal of impacted tooth

Figure 9: Case 3: BSSO with removal of impacted tooth - Note the application of spreader after sagittal cut for separation
the underlying nerves, hence should be used with extreme caution. The adjoining area in the buccal part is the thickest part of the EOR. This imparts the much required resistance against stress. Presence of M3 in this region would be a natural weak line of resistance. An M3 whose bulk is situated above the EOR would be safe while that involves the EOR would weaken the natural lines of resistance. Similarly, an obliquely placed M3 will be a source of weakness.

An impacted M3 that lies below the EOR, distoangularly or vertically oriented, with divergent/supernumerary root would cause more unfavorable splits when the spreader is not used properly. Such impacted M3 can be planned in such a way that they alone can be removed earlier to the BSSO.

Previous studies have related the mandible and several other factors related to the third molar, and only select parameters of the spatial position of M3 have been studied. This study for the first time has confirmed the spatial positioning of M3 as one of the several causes of unfavorable splits during BSSO. Further Fine Element analysis studies would be useful to predict the outcomes of the effect of the osteotomy. Though there is no direct evidence to prove the role of the M3 in causing unfavorable splits during BSSO, this study provides enough circumstantial evidence with statistical significance that the morphology and spatial orientation of the M3 is one of the major factor in causation of unfavorable splits.

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Figure 10: Case 4: Micrognathia- BSSO- Mandibular advancement of about 1.5 cm and simultaneous removal of horizontally impacted tooth

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