

## Systematic Review Orthognathic Surgery

# Bad splits in bilateral sagittal split osteotomy: systematic review of fracture patterns

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**Abstract.** An unfavourable and unanticipated pattern of the mandibular sagittal split osteotomy is generally referred to as a ‘bad split’. Few restorative techniques to manage the situation have been described. In this article, a classification of reported bad split pattern types is proposed and appropriate salvage procedures to manage the different types of undesired fracture are presented. A systematic review was undertaken, yielding a total of 33 studies published between 1971 and 2015. These reported a total of 458 cases of bad splits among 19,527 sagittal ramus osteotomies in 10,271 patients. The total reported incidence of bad split was 2.3% of sagittal splits. The most frequently encountered were buccal plate fractures of the proximal segment (types 1A–F) and lingual fractures of the distal segment (types 2A and 2B). Coronoid fractures (type 3) and condylar neck fractures (type 4) have seldom been reported. The various types of bad split may require different salvage approaches.

**Key words:** bad split; intraoperative complications; mandibular fracture; bilateral sagittal split osteotomy; sagittal ramus osteotomy; orthognathic surgery; classification; management.

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Segmenting the mandible in an orthognathic procedure to reposition the tooth-bearing part is generally known as a bilateral sagittal split osteotomy (BSSO). Historically, different ways of splitting the mandible have been advocated. The Trauner and Obwegeser technique (1955),<sup>1–3</sup> the Dal Pont modification (1961),<sup>4</sup> and the Hunsuck modification (1968)<sup>5</sup> are the best documented. Various approaches, splitting techniques, and instruments have been advocated to reduce complications over the years since Hugo Obwegeser reported the operation in 1955.<sup>1,6</sup> Despite these improvements, the procedure remains technically challenging in some

cases. Intraoperative complications include nerve injury, bleeding, and mechanical problems, such as irregular split patterns. An unfavourable and unanticipated pattern of the mandibular osteotomy fracture is generally referred to as a ‘bad split’. Incidences of 0.2% up to 14.6% per split site have been reported.<sup>7,8</sup>

Bad splits may cause mechanical instability, a disturbance in bony union, and lead to bone sequestration with subsequent infection.<sup>9</sup> In addition, it has been proposed that temporomandibular joint (TMJ) dysfunction and inferior alveolar nerve damage may arise due to

excessive intraoperative manipulation in an attempt to reposition the fractured segments, and that subsequent difficulty in positioning the condyle in the glenoid fossa may increase the risk of relapse.<sup>10–14</sup> In order to reduce the risk of postoperative functional deficits, fractured split segments are best fixated and reconsolidated. However, few restorative techniques to manage the situation have been described.<sup>15–18</sup>

The aim of this article is to review unfavourable split pattern types reported in the literature, and to present appropriate salvage procedures to manage the different types of undesired fracture.

## Materials and methods

### Systematic review

A systematic review was undertaken, which is reported in accordance with the PRISMA Statement.<sup>19</sup>

### Eligibility criteria

All retrospective and prospective studies of unwanted splits in BSSO procedures, with or without control groups, were included. There were no restrictions.

### Information sources and search

An electronic search without date or language restrictions was undertaken on 12 August 2015, in the online databases PubMed (all indexed years), Web of Science (Science Citation Index Expanded; 1975 to present (v. 5.13.1)), the Cochrane Central Register of Controlled Trials, and the World Health Organization International Clinical Trials Registry Platform, using the strategy outlined in Table 1.

### Trial selection

After assessing the eligibility of the articles in a standardized manner by reading the titles and abstracts, selected articles were retrieved and the full-texts read to screen for eligibility.

### Data extraction and collection

A data extraction sheet was developed. For each of the articles identified and included in this study, the following data were extracted: (1) author and year of publication, (2) study design, (3) surgical technique, (4) number of patients who underwent BSSO, (5) number of patients who underwent concomitant third molar removal, (6) number of patients who had no third molars present at surgery, (7) patient age statistics, (8) number of split sites, number of bad splits, and the unwanted split pattern types per patient and per split site. Summary outcome data were

entered into Review Manager software (RevMan version 5.2; Cochrane Collaboration, 2012).

The development of the search strategy, study selection, and data collection were performed by one author (SAS).

## Results

The initial search yielded a total of 2062 citations (Fig. 1). After the primary screening process, 33 full-text reports were read for detailed examination. No articles needed to be excluded after secondary review. The eligibility criteria were met by a total of 33 reports; these included 15 retrospective chart reviews,<sup>7,9,16–18,20–29</sup> nine retrospective cohort studies,<sup>8,12,30–36</sup> six prospective cohort studies,<sup>37–42</sup> one cross-sectional study,<sup>43</sup> one matched-pair analysis,<sup>10</sup> and one case report<sup>15</sup> (Table 2).

The first study by Guernsey and DeChamplain (1971) reported two unanticipated proximal segment and three distal segment fractures among 22 patients who were operated on using the classical Obwegeser technique for BSSO.<sup>20</sup> Since then, several reports of bad splits occurring while using the different surgical techniques<sup>4,5,44–47</sup> have followed, up until the present time. A literature review for the period 1971–2015 revealed a total of 458 cases of bad splits among 19,527 sagittal ramus osteotomies performed in 10,271 patients (i.e., 2.3% of sagittal splits reported). The characteristics and results of these studies are summarized in Table 2. The most frequently reported bad splits were various unfavourable fracture patterns of the buccal plate of the proximal segment (52.7%) and lingual fractures of the posterior aspect of the distal segment (42.9%; Table 2). Four cases of condyle fracture and four cases of coronoid fracture were also reported (Table 2).

## Discussion

This is the first systematic review of unfavourable and irregular split patterns in

BSSO. The results are limited by incomplete or missing specifications for the bad split types in some studies. Normal variations of the lingual split line have been classified previously,<sup>48–50</sup> however unfavourable split pattern types have not. Therefore, based on the splits described in the reports reviewed, a classification is proposed (Table 2; Figs. 2–4). In addition, to provide some structure in clinical practice, guidelines are given for salvage surgical procedures to manage these different fracture types.

### Salvage surgical approaches

In general, if a bad split occurs, emphasis should first be placed on a careful inspection and if necessary dissection, in order to visualize the splitting pattern, followed by minimal stripping of the periosteum to assure vascularization of the fractured segment. Second, a salvage surgical procedure needs to be designed to produce the desired functional and aesthetic results. Lastly, and equally important, great care must be taken not to increase the morbidity further, such as impairment of the neurovascular bundle. The various types of bad split may require different salvage approaches.

### Type 1: Proximal segment (buccal) fractures

The buccal cortical plate of the mandible in some patients is rather thin and susceptible to fractures posterior to the second molar,<sup>8</sup> which may explain the frequently reported 1A, 1B, and 1C fracture types (Table 2; Fig. 2). The difficulty of proximal segment fracture reduction depends on the fractured segment size and anatomical location.<sup>12</sup> Small segments that have been stripped from the periosteum (e.g., type 1A fractures) may be removed to prevent sequestration.<sup>9</sup> Larger fractured fragments (e.g., types 1B, 1C, 1E, and 1F) with an intact periosteum are best secured immediately, and simply and quickly reduced with plate osteosynthesis,

Table 1. Search terms.

| Database                                                                      | Search terms                                                                                                                      |
|-------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| PubMed (all indexed years)                                                    | (orthogn* OR (sagittal AND (ramus OR split))) AND (bad OR unfavo* OR undesired OR unwanted OR unexpect* OR complic* OR irregular) |
| Web of Science, Science Citation Index Expanded<br>1975 to present (v.5.13.1) | #1: TS = (sagittal AND osteotomy)<br>#2: WC = (Dentistry, Oral Surgery & Medicine)<br>#3: #1 AND #2                               |
| Cochrane Central Register of Controlled Trials                                | Sagittal osteotomy                                                                                                                |
| WHO International Clinical Trials Registry Platform                           | Split osteotomy OR ramus osteotomy [Recruitment status: ALL]                                                                      |

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