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Meta-Analysis
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Bad splits in bilateral sagittal split osteotomy: systematic review and meta-analysis of reported risk factors

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Abstract. An unfavourable and unanticipated pattern of the bilateral sagittal split osteotomy (BSSO) is generally referred to as a 'bad split'. Patient factors predictive of a bad split reported in the literature are controversial. Suggested risk factors are reviewed in this article. A systematic review was undertaken, yielding a total of 30 studies published between 1971 and 2015 reporting the incidence of bad split and patient age, and/or surgical technique employed, and/or the presence of third molars. These included 22 retrospective cohort studies, six prospective cohort studies, one matched-pair analysis, and one case series. Spearman's rank correlation showed a statistically significant but weak correlation between increasing average age and increasing occurrence of bad splits in 18 studies ($\rho = 0.229$; $P < 0.01$). No comparative studies were found that assessed the incidence of bad split among the different splitting techniques. A meta-analysis pooling the effect sizes of seven cohort studies showed no significant difference in the incidence of bad split between cohorts of patients with third molars present and concomitantly removed during surgery, and patients in whom third molars were removed at least 6 months preoperatively (odds ratio 1.16, 95% confidence interval 0.73–1.85, $Z = 0.64$, $P = 0.52$). In summary, there is no robust evidence to date to show that any risk factor influences the incidence of bad split.

Key words: bad split; intraoperative complications; mandibular fracture; bilateral sagittal split osteotomy; sagittal ramus osteotomy; orthognathic surgery; risk factors; age; third molar; surgical technique.

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The bilateral sagittal split osteotomy (BSSO) is one of the most common procedures in orthognathic surgery. Since the first report of this technique by Trauner and Obwegeser (1955),[1–3] several modifications have been reported in order to reduce complications.[4–6] Despite these improvements, intraoperative complications still occur and include nerve injury, bleeding, and mechanical problems such as irregular split patterns.[7]

An unfavourable and unanticipated split pattern of the BSSO is generally referred to as a 'bad split'. The average reported incidence is 2.3% per split site,[8] and incidences of 0.2% up to 11.4% per split site have been reported.[9,10] Despite advances in technology, the incidence may not have changed significantly over recent decades.[11] Patient factors predictive of a bad split reported in the literature are the subject of controversy; it remains unclear whether and how the age of the patient, the presence of impacted third molars during surgery, the surgical technique, an incomplete inferior border osteotomy, larger osteotomes, surgical experience, or the mandibular anatomy may influence the risk of a bad split.[9–22] In order to reduce the risk of these complications occurring, risk factors for bad splits need to be identified.

The aim of this article was to review the most commonly suggested risk factors for bad splits reported in the literature: patient age, the intraoperative presence or absence of third molars, and the splitting technique employed. In addition, it was aimed to perform meta-analyses of pooled summary statistics where possible.

Materials and methods

Systematic review

A systematic review was undertaken, which is reported in accordance with the PRISMA statement.[23]

Eligibility criteria

All retrospective and prospective studies of unwanted splits in BSSO procedures, with or without control groups, with data on patient age, and/or the splitting technique employed, and/or comparative cohorts of patients with third molars present versus absent intraoperatively, 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).

Meta-analysis

Meta-analyses of pooled summary statistics were undertaken only if it was possible to combine studies; i.e. if these included cohorts with the same characteristics.

Data analysis and synthesis

For dichotomous treatment outcomes of interest, odds ratios (ORs) with 95% confidence intervals (95% CIs) were used as the summary statistic. These data were pooled across studies using invariance weighting. Results were combined using the random-effects model, in order to prevent substantially overstated precision of final estimates of effects even when statistical heterogeneity was low ($I^2 < 60\%$ and $P > 0.10$).[24]

To explore the degree to which the findings of the meta-analysis could be affected by bias, sensitivity analyses were performed, when considered appropriate.

The data analysis and synthesis were performed by two authors (SAS, AJvW).

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. After secondary review, three studies were excluded because they did not report data on patient age, the surgical splitting technique, or the presence of third molars. The eligibility criteria were met by a total of 30 reports; these included 22 retrospective cohort studies,[9–14,17,19,20,25–37] six prospective cohort studies,[15,16,38–41] one matched-pair analysis,[21] and one case series[42] (Table 2).

Study characteristics

Characteristics of the studies included are summarized in Table 2.

Risk factors

Age

Eighteen studies determining the incidence of bad split also reported overall patient mean or average age. A scatter-plot showed the distribution of the data not to be normal. Spearman's rank correlation (weighted by number of splits per study) showed a statistically significant but weak correlation between increasing average age (range 17–41 years old) and increasing occurrence of bad splits (range 0.5–11.4%) in these 18 studies (total $N = 8959$ splits; $\rho = 0.229$; $P < 0.01$). Two studies statistically compared mean ages of bad split cases with regular split cases,[19,33] and found significantly higher mean ages for bad split cases (35 vs. 25 years old ($P = 0.01$) and 26.6 vs. 21.8 years old ($P < 0.001$), respectively).

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 1975 to present (v.5.13.1)	#1: TS = (sagittal AND osteotomy) #2: WC = (Dentistry, Oral Surgery & Medicine) #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]

WHO, World Health Organization.