Are large movements a risk factor for subsequent plate removal in bilateral sagittal split osteotomy?

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Abstract: BACKGROUND: Metal plate removal is a common complication of mandibular osteotomy with up to 27.5% of patients requiring removal of some or all of their hardware. However, little is known about the risk factors for removal. We hypothesised that large advances and setbacks may result in stretching of overlying soft tissues which could increase risk of dehiscence and infection, and hence plate removal. METHODS: Retrospective case review of all orthognathic surgery carried out at Aberdeen Royal Infirmary between May 2011 and May 2017. RESULTS: One hundred and ninety nine mandibular osteotomies were carried out, and full surgical records were available for 166 of these. 85 advances and 81 setbacks were identified, with mean advance 6.77mm (1 to 15mm SD 3.00mm) and mean setback of 4.66mm (1 to 10mm, SD 2.00mm). 25 patients underwent subsequent plate removal, 11 who had undergone BSSO advance and 7 setback. There was no significant correlation between size of advance and plate removal. DISCUSSION: Previous risk factors identified for subsequent plate removal include smoking, age, female sex, stainless steel plating systems, mandibular plates, increased number of plates and plates placed close to the upper border of the mandible. We showed that there is no correlation between increased magnitude of mandibular advancement or setback and subsequent plate removal.

BACKGROUND

Rigid fixation of the mandible has been carried out using metals since the 19th century (Gilardino 2009), initially with wires, and more recently with metal plates. Early plates were removed routinely due to corrosion, absorption and tissue reaction. Since the introduction of titanium plates in the late 20th century, plate removal is no longer necessary due to improved biocompatibility, strength and corrosion resistance. Therefore, most patients who undergo orthognathic surgery do not undergo subsequent plate removal (Mathew 1999).

However, metal plate removal remains relatively common following BSSO, with between 6.5% and 27.5% of patients requiring removal of some or all of their hardware (see table three). Indications for plate removal include pain, infection, swelling, dehiscence of soft tissues, palpable plate, aesthetics, intermittent pain with cold temperatures, broken plates, and removal to allow normal bone growth in young patients. Potential risk factors include gender, age, smoking, type of plate, position of plate, and length of procedure (see table three).

During bilateral sagittal split osteotomy (BSSO), the mandible may be advanced or setback up to around 15mm, however certain movements, such as mandibular setback and advances over 10mm may relapse, predominantly due to the effects of soft tissues. Mandibular advances up to 10mm are thought to be very stable over five years (10% chance of 2mm relapse) and maxillary advances are stable (20% chance of relapse) (Bailey 2004). Larger advances result in a longer lever arm and greater forces across the fracture site. Large advances also result in stretching of soft tissues overlying the fracture site, and potential thinning of the soft tissue envelope. Instability of the fracture might allow movement across the fracture line and ingress of oral fluids and potentially contamination of the site. A thinner soft tissue envelope might exacerbate this effect, with a poorer blood supply and less of a physical barrri between the oral environment and the fracture site. These factors might predispose to infection, dehiscence and pain, and eventually plate removal.

We hypothesised that larger advances may be a risk factor for subsequent plate removal, as large advancements result in stretching and thinning of overlying soft tissues and a longer lever arm over the fracture site. Our aim was to determine whether there are correlations between size and direction of mandibular movement and subsequent removal of mandibular plates.

METHODS AND MATERIALS

Ethics approval was granted by the NHS Grampian/University of Aberdeen local Research Governance manager in May 2017.

Initially, a literature review was carried out. The pubmed and embase databases were searched using the term ‘orthognathic AND plate removal’. Titles were screened, abstracts were reviewed and full text retrieved for relevant studies.

All cases of orthognathic surgery were identified between May 2011 and May 2017 using the OPERA surgical recording system (Centricity, GE Healthcare). This time scale was chosen because the procedure for storing clinical records changed at this time, with clinic letters before this not being stored electronically. Cases of removed metal work were also gathered in the same way, and through hand searching of the local anaesthetic case records maintained by the department.

Clinic letters were retrieved for all cases identified, and cases of removed metalwork not resulting from orthognathic surgery and those whose plates were inserted before May 2011, were excluded. Smoking status was not recorded for patients operated on before 2014, as their anaesthetic record was not uploaded as standard, and was recorded incompletely on more recent anaesthetic records, therefore the decision was taken not to include smoking status in the final analysis.

Measurements were made of model surgeries in combination with wax bites and intraoperative wafers for each of the patients identified. Measurements were usually recorded on the prescription sheet accompanying the models, or noted on the plaster of the models, though when these were unclear or not present, models were articulated and new measurements were made using calipers and a ruler. Data recorded from these models included size of maxillary impaction or disimpaction (at first molar position and incisor position), size of maxillary advance or setback and size of mandibular advance or setback. Where the movement was rotational, an average of the measure on each side was taken.

Data recorded included age, sex and hospital number, size and direction of ostoetomy movements, whether plate was subsequently removed, and indication for plate removal (from clinic letter). Data was anonymised and compiled in Microsoft Excel and analysed using SPSS (IBM. SPSS statistics for Mac. Version 24.0. Armonk, NY: IBM; 2016) and Tableau (Tableau version 10.3 for Mac, Tableau software, 2017). Significance level was set at p<0.05.

RESULTS

Two hundred and sixteen patients underwent orthognathic surgery between May 2011 and May 2017. One hundred and ninety nine saggital split osteotomies were carried out, 174 le fort one osteotomies and 23 genioplasties. Sixty four percent (138 cases) of these procedures were carried out on females and average age was 27 years (median 24, range 16-59, SD 8.9).

Surgical planning models were available for 202 of the 216 patients (94%). Models were available for 85 mandibular advancements and 81 mandibular setbacks. The mandibular advances ranged from +1 to +15mm (mean +6.77mm, SD 3.00mm), and setbacks from -1 to -10mm (mean -4.6mm, SD 2.01mm).

Metal plates were subsequently removed from 25 patients (11.6%), including 11 mandibular advancements, and 7 mandibular setbacks. Indications included pain, dehiscence, infection, young patient, to allow subsequent implants or denture, or a combination of these.

ANALYSIS

Students t-test showed no correlation between size of mandibular advance and subsequent removal of plates (p=0.12, mean difference 1.46, 95% CI -0.45 to 3.37, n=85). Mandibular advances were divided into those >10mm and those less than 10mm, and cross tabulation carried out to determine whether plate removal was more likely with large advances. Pearsons Chi square test showed non-significance with p=0.24 (OR 2.4, CI 0.54- 10.60, n=85).

Mandibular setbacks were also tested in the same way, with students t test showing no significant correlation between size of setback and subsequent removal of plates (p=0.56, mean difference 0.52, 95% CI -1.05 to 2.11, n=81) and when values were categorised into large and small setbacks (binned at 5mm), a chi square test showed non significance (p=0.48, OR 1.40, CI 0.294 to 6.73, n=81).

Analysis was also carried out of age, sex, and duration of plate remaining in situ using the entire cohort. An independent samples t-test showed that there was a significant correlation between increased age at time of surgery and plate removal (p=0.07, mean difference 5.84 95% CI 1.7 to 9.9, n=216), and a Chi square test showed no significant difference in the gender of groups (p=0.58, OR 1.00 CI 0.42 to 2.39 n=216).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variable | n | Plate removed? |  | p value |
|  |  | Yes | No |  |
| Sex (female/male) | 216 | 16/9 | 69/122 | 0.58(a) |
| Age (years) (mean, SD) | 216 | 32.92 (+/- 9.58) | 27.08 (+/- 8.62) | 0.07(b) |
| Size of mandibular advancement (mm)(mean, SD) | 85 | 8.1 (+/- 2.73) | 6.6 (+/- 3) | 0.12(b) |
| Mandibular advancement categorised (<10mm/>10mm) | 85 | 8/3 | 64/10 | 0.24(a) |
| Size of mandibular setback (mm)(mean, SD) | 81 | 5.1 (+/- 2.19) | 4.6 (+/- 2.0) | 0.56(b) |
| Mandibular setback categorised (<5mm/>5mm) | 81 | 3/4 | 38/36 | 0.48(a) |
| Duration of plate in situ at end of study (days, SD) | 216 | 454 (+/- 384) | 1026 (+/-599) | 0.00(b) |

Table 1. Characteristics of patients undergoing orthognathic surgery. Where (a) is Chi square test and (b) is independent samples t-test.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sex | Age at time of surgery (years) | Indication for plate removal | Position of removed mandibular plate | Duration of plate in situ (days) | Size of mandibular advancement (mm) |
| Female | 49.1 | Pain | n/a | 211 | 5 |
| Female | 21.5 | During subsequent extraction of tooth | Left | 181 | 6 |
| Female | 46.7 | Infected plate | Left | 106 | 7 |
| Female | 25.8 | Wound dehiscence | Right | 128 | 7 |
| Female | 31.4 | Pain | Left | 420 | 7 |
| Female | 31.4 | Pain | Right | 574 | 7 |
| Male | 25.7 | Pain | Left | 174 | 8 |
| Female | 19.0 | Exposed plate | Left | 854 | 10 |
| Female | 32.5 | Infection | Right | 547 | 13 |
| Female | 32.6 | Infection | n/a | 527 | 13 |

Table 2. Characteristics of patients who had plates removed.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Authors | Year of publication/ country | Study design | Number of patients studied | Type of orthognathic surgery (maxillary, mandibular or both) | Rate of metal plate removal | Risk factors identified | Was size or direction of movement studied? |
| Widar F | Sweden/2017 | Retrospective questionnaire | 404 | Both | 15% | Smoking, mandibular plates, number of plates | no |
| Little M | UK/2015 | Retrospective case review | 202 | Both | 10.40% | Mandibular plates | no |
| Falter B | Belgium/2011 | Retrospective case review | 570 | Both | 27.50% | Female sex | no |
| Kuhlefelt M | Finland/2010 | Retrospective case review | 153 | Mandibular | 18.60% | Smoking  | Direction showed no correlation, size not studied |
| Haraji A | Iran/2009 | Retrospective case review | 142 | Maxillary | 10.60% |  | no |
| Chow LK | Hong Kong/2007 | Retrospective case review | 1294 | Both | 3.50% |  | no |
| Theodossy T  | UK/2006 | Retrospective case review | 80 | Mandibular | 15.60% | Increased age, duration of procedure | Direction showed no correlation, size not studied |
| Alpha C | USA/2006 | Retrospective case review | 533 | Mandibular  | 6.50% | Hardware close to superior border | Direction showed no correlation, size not studied |
| Bhatt V | UK/2005 | Retrospective case review | 153 | Both | 10.40% | Increased age of patient | no |
| Paulina K | Finland/2001 | Retrospective case review | 655 | Both | 8% |  | no |
| Manor Y | Israel/1999 | Retrospective case review | 70 | Both | 12% | Increasing age, female sex, stainless steel material | no |
| Schmidt | USA/1998 | Retrospective case review | 190 | Maxillary  | 11.10% | Titanium plates removed more than vitallium plates | no |

Table 3. Results of systematic review of previous studies of plate removal in orthognathic surgery.

DISCUSSION

Removal of metalwork following maxillofacial surgery is a common complication of maxillofacial surgery, and is carried out for a diverse range of reasons. However, removal of plates requires a general anaesthetic (or occasionally local), an operating theatre time slot and all associated costs and risks. Therefore identification and modification of risk factors for plate removal could have a positive impact on patients.

We carried out a retrospective review of cases of mandibular advancements and setbacks, to determine whether increased size of advancement or setback was a risk factor for subsequent plate removal, and a systematic review of current literature. Analysis of our results showed that there was not a significant correlation between increasing size of advancement or setback and subsequent plate removal.

Plate removal following facial trauma has received more attention than that carried out after orthognathic surgery, but many of the same risk factors are likely to apply. Procedures carried out on the mandible are known to have a higher risk of complication than those carried out in the maxilla, specifically infection (Chow 2007). This is likely to be primarily an anatomical issues, with saliva pooling in the mandibular labial sulcus and floor of mouth, introducing oral flora to these wounds.

Smoking has been identified as a potential risk factor, though significance has not been shown in some studies (Widehar 2017, Kuhlefelt 2010). Cigarette smoking was studied as binary factor in all studies, partly due to patient’s poor recollection of number of cigarettes smoked, but also to establish statistical significance. In our study, smoking status was not recorded due to data availability issues.

Sex is a risk factor for subsequent plate removal in some studies, though this was not the case in our cohort (Bart 2011). Age at time of surgery was shown to be a significant risk factor in our cohort, and also in previous studies identified (Theodossy 2006, Manor 1999, Bhatt 2005). Possible reasons for this include difference in younger patients having improved tissue healing which allows incorporation of the plate more easily, with older tissues being more likely to break down and cause dehiscence. All risk factors and previous studies identified are summarised in table 3.

Three studies also addressed the direction of movement (advance or setback), though none showed that this was a risk factor for subsequent plate removal (Kuhlefelt 2010, Alpha 2006, Theodossy 2006). None of the studies addressed magnitude of advancement, which we have done.

Limitations of this study included the limited sample size, and also methodology of measuring model surgeries. The planned time period chosen for our study had to be altered because the clinic letters used to confirm type of surgery were unavailable before 2011. Therefore only six complete years of data were gathered, resulting in 216 orthognathic surgery patients. A centre dealing with higher volumes of orthognathic surgery might have access to a larger volume of cases.

Measurement of the model surgeries was challenging. Information contained with the plaster models was inconsistent, with some models having a prescription sheet, some models having movements noted on the models, and others having no information aside from the plastic splints used during surgery. This introduced potential measurement error when determining size of movements, though this was minimised by having only one rater. Use of surgical planning software and virtual model surgery should mean that in the future this process is no longer necessary, and auditing the size of movements could be done much more easily.

CONCLUSIONS

Our analysis suggested that size and direction of mandibular advancement is not a risk factor for subsequent plate removal. This result is reassuring for treatment of patients with very retrusive mandibles who require larger advancements.

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