Journal of Orthodontics/Vol. 28/2001/105–114

## Clinical Section

# Mandibular Advancement Using an Intra-Oral Osteogenic Distraction Technique: a report of three clinical cases

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**Abstract.** *Osteogenic distraction has been used for decades to lengthen limbs and now attention is focused upon its use within the craniofacial skeleton. This paper addresses distraction of the mandible. It is proposed that mandibular osteogenic distraction could be a possible adjunct to the orthodontic treatment of those adult patients with skeletal anomalies, who would benefit from combined orthodontic/orthognathic treatment. Three consecutive cases from one unit are presented, where adult patients with severe Class II division 1 malocclusions have undergone orthodontic treatment combined with mandibular osteogenic distraction, instead of conventional bilateral sagital split osteotomies.*

*Index Words:* Class II division 1, Distraction osteogenesis, Mandibular osteogenic distraction, Orthognathic surgery, Osteogenic distraction.

### Introduction

Osteogenic distraction (OD) is a technique for gradually lengthening bone by the application of a gradual external force over a coritcotomized site. The concept was first published by Codivilla in 1905, but was pioneered by Ilizarov (1988), and has been used for many years by orthopaedic surgeons to lengthen 'long bones'. Recently, it has been developed for correction of craniofacial anomalies. Its use in the canine mandible was initially described by Snyder *et al*. (1973) and was later described in 106 human patients by Molina and Oritz-Monasterio (1995). Mandibular OD has been used to treat mandibular hypoplasia (congenital and acquired), hemifacial microsomia, Treacher Collin's syndrome (Klein and Howaldt, 1995; Diner *et al*., 1996), Pierre Robin and Nager's syndromes (McCarthy *et al*., 1999). The technique has also been used to replace the bone of mandibles following tumour resection (Sawaki *et al*., 1996). It is also possible to use OD to advance the maxilla following Le Fort I osteotomies, for example, in patients with cleft lip and palate (Polley and Figueroa, 1998; Figueroa and Polley, 1999) and in Crouzon's and Apert's syndrome (Cedars *et al*., 1999). Even simultaneous OD of the mandible and maxillae has been attempted and reported (three cases) by Padwa *et al*. (1999).

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The procedure of mandibular OD involves sectioning cortical bone at the site of distraction, with care being taken to preserve the intra-medullary blood supply and, ideally, the periosteum. The distraction device is mounted either side of the corticotomy. This may be attached directly to the bone or via implants (Sawaki *et al*., 1996) or may be partially tooth borne (McGurk *et al*., 1997). The corticotomy site is left passive for a period of 5–10 days to allow organization of the primary callus. Gradual distraction is then performed at a rate of 1–2 mm per day, which may be done incrementally (McGurk *et al*., 1997). OD can be carried out by the clinician on an outpatient basis or by the patient at home. OD induces proliferation and finally bony in-fill between the two segments. The bone may be functionally loaded throughout its period allowing patients to eat and speak normally, and this is considered beneficial. After the desired lengthening period has been achieved a period of bone consolidation follows before the distraction device is removed (usually a 6-week period).

Initially, craniofacial and mandibular distraction devices were inserted through the skin, which lead to disfiguring scarring. Now, mandibular devices can be placed intra-orally, so eliminating skin scarring (Sawaki *et al*., 1996).

The majority of OD cases reported in the surgical literature involving distraction of the mandible or maxilla have been performed upon young growing children [some as young as 14 weeks old (Cohen *et al*., 1998)] with severe

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skeletal anomalies. In dentate children and the few reported adult cases, it would seem that orthodontics is not routinely carried out as a joint procedure. However, a joint approach has been eluded to, but not elaborated upon (Klein and Howaldt, 1995).

In the UK a significant proportion of an orthodontic consultant's workload involves treatment of adults with severe facial skeletal anomalies. These patients are currently treated using a combined orthodontic/orthognathic surgery technique. OD may be an alternative surgical approach, which offers a number of potential advantages to both maxillo-facial surgeons and orthodontists.

There are theoretical advantages of OD over a conventional mandibular osteotomy.

*Reduced ID nerve dysaesthesia.* There should be less risk of damaging the mandibular division of the trigeminal (V) cranial nerve during OD; most dysaesthesia is considered to be due to stretching of the nerve, which would be minimized utilizing a gradual distraction over several days (Michiele and Miotti, 1977).

*Seating of the condyle.* During rigid fixation procedures it is not always possible to ensure that the condyle is fully seated within the fossa and the mandible can inadvertently be placed in an anterior position. Post-operative settling reveals the incomplete skeletal correction. OD forces will always direct the condyle distally, so seating it fully.

*The bone can be loaded early.* Early functional loading could improve bony remodelling, since this is a physiological requirement of bone.

*Shorter in-hospital stay*. Mandibular OD has been performed under local anaesthesia as a day case procedure.

*Reduced post-operative pain and swelling*. Bony manipulation at operation is less with OD than with a conventional bilateral sagital split osteotomy (BSSO). However, soft tissue manipulation may be greater due to difficult access when placing the distracor.

*Increased stability.* Soft tissues can adapt over a longer period to the advanced mandibular position, and may therefore undergo a more physiological remodelling (Davies *et al*., 1998). This could reduce the contribution of the elastic soft tissue recoil to relapse.

*Reduced need for inter-maxillary fixation.* In a single jaw procedure rigid fixation is now routinely used to prevent the need for IMF. The distractor acts as a method of rigid fixation and so confers the same benefits as any rigid fixation.

There are, however, theoretical disadvantages to the OD procedure compared to a conventional mandibular osteotomy.

*Multiple daily out-patient visits.* The surgeon is required to see the patient daily to distract the mandible. In some centres, the patients are given responsibility for their own distraction, which would eliminate this problem. However, patient compliance would be of paramount concern. It is ironic that OD was 'discovered' because a patient of Ilizarov' persistently turned a compression screw in the 'wrong' direction.

*Poor 3D control.* Since distraction with most current commercially available devices is unidirectional, advancement of the mandible may lead to facial asymmetry or an iatrogenic dental lateral or anterior open bite, or unilateral crossbite. This can be compensated for (to some degree) by differential distraction at two adjacent distraction sites. Planning the correct 3D movement (vectorization) is therefore of considerable importance. The correct placement of the distractors, and ultimately bony movement, are planned using a combination of cephalometric radiographs (Stucki-McCormick *et al*., 1999), computerized tomographs and/or customized computer generated 3D models of the craniofacial complex (McGurk *et al*., 1997).

*Increased post-operative pain*. Manipulation of the healing corticotomy daily or several times a day could give rise to pain.

*Difficult access for the orthodontist*. During distraction and the stabilizing stage the distractors could obscure the buccal segment (Figure 3d). This denies access for the orthodontist, which could cause problems if teeth should debond or if complex guiding elastics are necessary.

*Difficult plaque control.* The distractors cover the buccal surfaces of the teeth (Figure 3d). This makes plaque control extremely difficult for the patient, and may increase the risk of periodontal damage, decalcification and even caries (Padwa *et al*., 1999).

*Damage to the TMJ.* Incorrect vectorization may result in flaring of the gonial angle and malposition of the condylar head. This could theoretically result in long term condylar disruption and in the short term can lead to pain. Experimentation on sheep has revealed anatomical, but not functional changes in the TMJ following OD (Karaharju-Suvanto *et al*., 1996).

This paper reports the results of the first three consecutive patients to be treated with mandibular OD as part of a planned combined orthodontic/orthognathic surgical approach at one unit (Blackburn Royal Infirmary, Lancashire, UK). No patient received surgery to the maxilla. OD was used for mandibular advancement on patients who would otherwise have undergone a mandibular advancement by BSSO and rigid fixation. It is envisaged that once a skills base is established, a randomized controlled trial comparing OD with conventional osteotomy techniques will be carried out.

## Methods

From a surgical standpoint, the mandibular bone is sectioned in a simpler manner than a BSSO, which is indicated by red wax in Figure 1. The buccal plate is sectioned with a surgical drill, and particular attention is paid to the lower border. The upper part of the lingual plate is likewise sectioned with a drill, and the remaining portion fractured using an osteotome. An intra-oral Medicon®

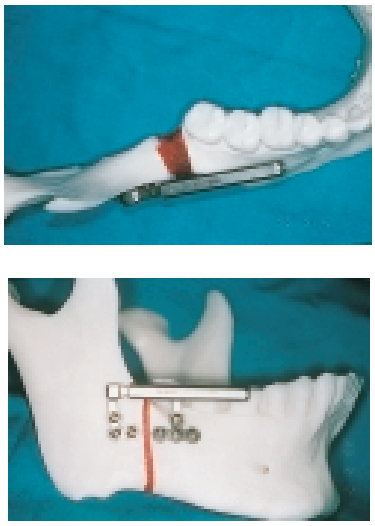


FIG. 1 A dry mandible showing the 'corticotomy' cut indicated with red wax. The Medicon® intra-oral distractor is placed parallel to the occlusal plane. The screw device is accessed from the mesial aspect of the assembly.

distractor is placed over this corticotomy site, parallel to the occlusal plane (Figure 1). This is followed by soft tissue closure. After 5 days the distractor screw is turned daily by the surgeon, on an out-patient basis. This is designed to result in 1 mm per day distraction of the bony segments and is continued until adequate advancement is achieved. The distractors are left *in situ* for a 6–8-week period of fixation, after which they are removed.

Pre-surgical orthodontic treatment is carried out to align and decompensate the arches. During the OD the use of intra-oral elastics is possible. After stabilization, orthodontic procedures continue to detail the occlusion and close any residual space.

## *Cases*

The case histories of the first three cases are outlined below. The full cephalometric analyses are presented in Table 1. Specific points of interest are highlighted for each patient.

*Case 1(JS).* A fit and healthy 28-year-old Caucasian female presented with a crowded Class II division 1 malocclusion and a 13-mm overjet, on a Class II skeletal base with a retrognathic mandible (see Figure 2). Her lower face height was clinically observed to be reduced and she had a traumatic deep overbite. The treatment involved no extractions, and upper and lower fixed appliances (pre-adjusted straight wire, Ormco®) were used to align the arches, and the upper arch was expanded to allow correlation. The lower arch was not levelled. After 17 visits (24 months) the patient underwent a bilateral mandibular corticotomy and placement of distractors. She remained in hospital for one night, and recovery was uneventful. After a 5-day latency period she returned for six consecutive days of distraction, until a Class I incisor relationship was attained. The orthodontist observed her fortnightly until the distractors were removed 6 weeks later. Orthodontic treatment then continued using Class II box elastics to further reduce the overbite and detail the occlusion. After three visits and good elastic wear (over a period of 4 months), the patient was debonded. An upper Hawley retainer was worn full time for 6 months, then nightly for 6 months, and a lower permanent bonded retainer was placed.

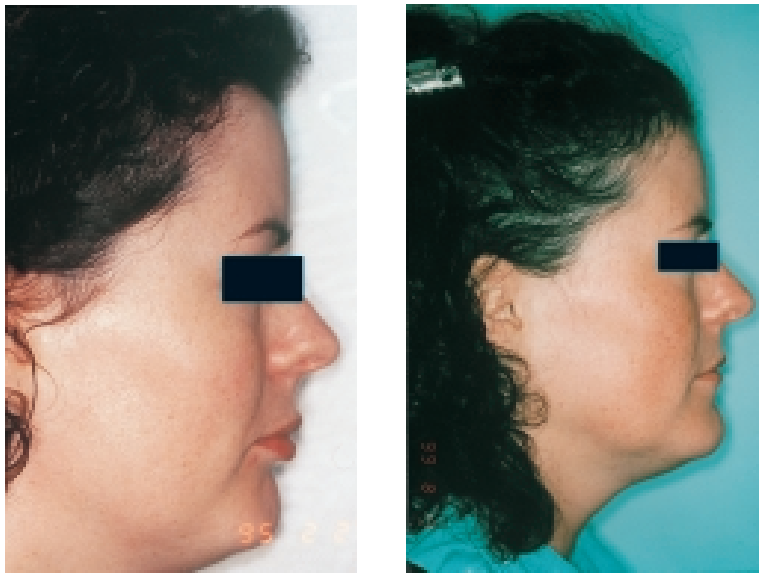
TABLE 1 *Cephalometric and other changes induced by distraction*

| Patient | JS | MB | SH |
|---|---|---|---|
| ANB pre-treatment (°) | 5 | 3 | 5·5 |
| ANB post-treatment (°) | 0 | 0 | 0·5 |
| ANB change (°) | -5 | –3 | –6 |
| ↑ Incisors: max plane pre-treatment (°) | 114 | 127 | 130 |
| ↑ Incisors:max plane post-treatment (°) | 107·5 | 122 | 112·5 |
| ↓ Incisors: mand plane pre-treatment (°) | 94·5 | 97 | 103 |
| ↓ Incisors:mand plane post-treatment (°) | 99 | 94 | 96 |
| Nos screw turns (°) | 6 | 6 | 5 |
| OJ change (mm) | 13→1 | 12→1 | 13→1 |
| Ar–Po change (mm) | 6 | 10 | 7·4 |
| In-patient stay (nights) | 1 | 2 | 0 |

Post-operatively her aticulare–pogonion (Ar–Po) length has increased by 6 mm and her ANB angle has reduced by 5 degrees. Her maxillary mandibular planes angle (MMA) has increased slightly (1·5 degrees) and her overbite reduced from 3 to 1mm. Her upper incisor angle was corrected to 107·5 degrees, but her lower incisors remained proclined. One year after debond, her dental and facial correction has been maintained, and the patient is extremely happy with the result. She has a small area of altered sensation on her left lip.

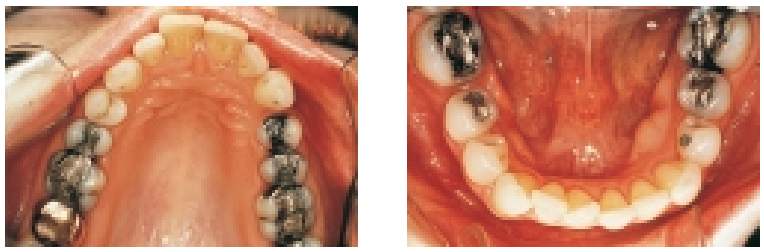
*Case 2 (MB).*
A fit and healthy 19-year-old Caucasian female presented with a crowded Class II division 1 malocclusion with a 12-mm overjet, on a Class II skeletal base with a clinically retrognathic mandible (see Figure 3). Her lower face height was reduced (MMA 15 degrees) reflected by a deep overbite, which was atraumatic. She had reasonably aligned arches, except for a lingually rotated lower left second molar. Following extraction of all third molars, upper and lower fixed appliances (pre-adjusted straight wire, Ormco®) were used to align the arches. Buccal cross-elastics were used to upright 37. The upper arch was expanded to allow correlation. The lower arch was not levelled. After 12 visits (15 months) the patient underwent a bilateral mandibular corticotomy and placement of distractors. She remained in hospital for two nights and recovery was uneventful. She returned on six consecutive days for distraction, after a 5-day latency period. The orthodontist observed her fortnightly until the distractors were removed 6 weeks later. It is of interest that this patient felt that she experienced more pain and discomfort from the earlier removal of her third molars than at any point in the OD procedure. Despite good pre-surgical correlation, during OD a unilateral left posterior cross-bite developed. This was corrected using buccal cross elastics. Orthodontic treatment continued for eight visits (over 6 months) to detail the occlusion. The patient was then debonded, and an upper Hawley retainer is currently being worn full time and a lower permanent bonded retainer was placed.

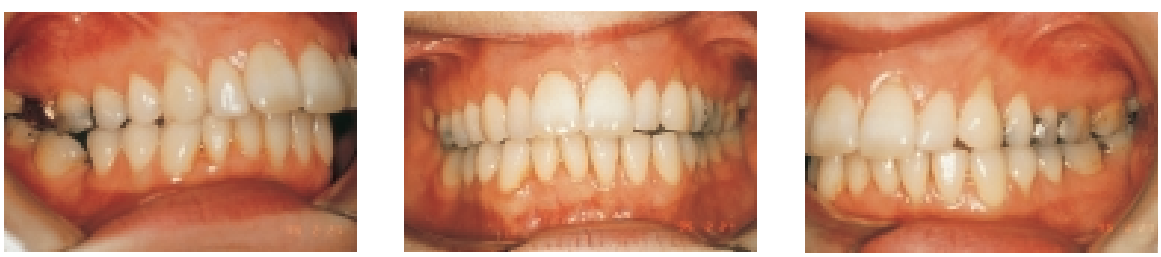
Post-operatively her mandibular length (Ar–Po) has increased by 10 mm and her overjet reduced to 1·0 mm, although her ANB has changed by only 3 degrees. Her



**(a)**

**(b)**



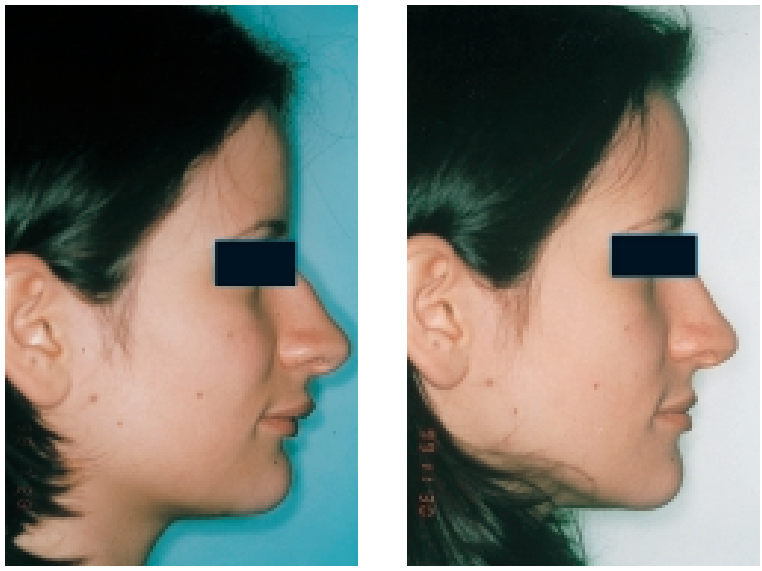


**(c)**

FIG. 2 Patient JS. (a) Extra-oral lateral pre- and post-treatment views. (b) Extra-oral facial pre- and post-treatment views. (c) Intra-oral pre-treatment views. (d) Intra-oral post-treatment views. (e) 1 year into retention.

MMA has remained unchanged (within tracing error) at 16 degrees, although her overbite has reduced from 4 to 0 mm. Her upper incisor angle has been reduced from 127 degrees, but the teeth are still proclined at 121 degrees. This reflects the non-extraction approach and reliance purely on expansion to create space for incisor retroclination. The patient has a slightly prominent chin, due to a pronounced chin button at the start of treatment. This could be corrected by a cosmetic genioplasty, but the patient and are family are very happy with her new appearance. Six months after the operation she has regained most of the sensation of her lower lip.

*Case 3 (SH).* A fit and healthy 18-year-old Asian male presented with a crowded Class II division 1 malocclusion and a 13-mm overjet, on a Class II skeletal base with retrognathic mandible (see Figure 4). His lower face height was reduced and he had a deep overbite, which was traumatic. The lower left central incisor had been extracted several years ago, due to severe crowding. The malocclusion was treated non-extraction, and upper and lower appliances were used to align the arches (pre-adjusted straight wire, Ormco®). The upper arch was expanded to allow correlation. The lower arch was not levelled. After six visits (8 months) the patient underwent a bilateral mandibular corticotomy and placement of distractors. He returned home the same day and recovery was uneventful. After a 5-day latency period he failed to re-attend, but did so 7 days post-operatively. He underwent five consecutive days of distraction, and the observed him fortnightly until the distractors were removed 6 weeks later. Despite good pre-surgical correction of the arches, a unilateral left-sided posterior crossbite developed. This was addressed using cross-elastics, which was effective in correction of the crossbite with the exception of the distobuccal cusp of the upper first molar. There was no displacement on closure. The patient was leaving the UK for a long visit to a third world country and so the residual crossbite was accepted. The patient was debonded after five visits (over 7 months). An upper Hawley retainer was fitted (although this was subsequently lost) and a lower permanent bonded retainer was placed.



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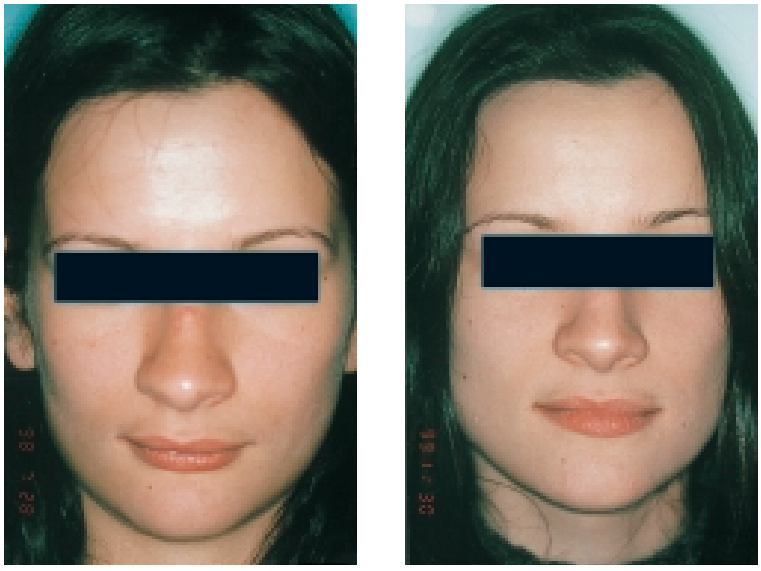

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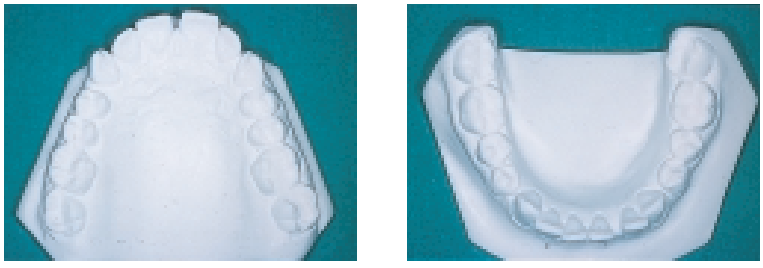
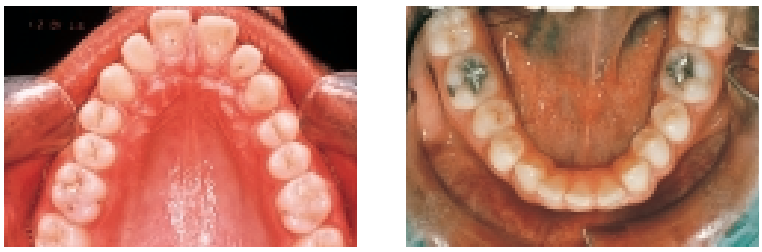


(c)


FIG. 3 Patient MB. (a) Extra-oral lateral pre- and post-treatment views. (b) Extra-oral facial pre- and post-treatment views. (c) Intra-oral pre-treatment views. (d) Intra-oral views during distraction. (e) Intra-oral post-treatment views. (f) Smiling, with distractors in place.

(a)

(b)



(c)

(d)

FIG. 4 Patient SH. (a) Extra-oral lateral pre- and post treatment views. (b) Extra-oral facial pre- and post-treatment views. (c) Intra-oral pre-treatment views. (d) Intra-oral post-treatment views.

Post-treatment, the mandibular length (Ar–Po) has been increased by 7·4 mm, and ANB has been altered by 6 degrees, from 5·5 degrees to –0·5 degrees. Despite this Class III value, SH's facial appearance is still slightly Class II, and the final dental occlusion is Class I, with a 12-mm overjet reduction to 1 mm and overbite reduction to 1 mm. The incisal relationship has been improved with decompensation of the upper incisors to 112 degrees from 130 degrees, and the lower incisors from 103 degrees to 96 degrees.

SH has some persistent unilateral left-sided dysaesthesia, which is continuing to improve at 6 months post-surgery.

## Discussion

The proposed advantages and disadvantages for OD were outlined earlier, and will be addressed using the above small case series.

### *The advantages*

*Reduced ID nerve dysaesthesia.* All patients experienced some reduced, but improving sensation on the lower left lip 6 months post-surgery. Inferior alveolar nerve disturbance following BSSO is generally expected to be present in 100 per cent patients in the first three post-operative months, light touch being restored after a further 3 months in 50 per cent of patients (Fujioka *et al*, 1998). These distracted patients compare favourably with this. Sixteen months post-surgery JS reports a persistent small area of altered sensation.

*The bone can be loaded early.* All patients reported reasonable ease of mastication and speech.

*Shorter in-hospital stay.* This would appear to be borne out by this small patient sample, who returned home after 1–2 days, as compared with and average stay of 3 days (at this unit) for BSSO patients.

*Reduced post-operative pain and swelling.* It is the author's subjective impressions that OD patients appear less swollen than conventional BSSO patients. Indeed, one patient (MB) found the experience less unpleasant than her third molar surgery.

*Increased stability.* Only a long-term randomized controlled trial will settle this question. SH has been followed for 6 months (still in retention) and JS for 1 year (end of retention). Both have maintained a Class I occlusion. Radiographic examination of JS at the end of retention (16 months post-operatively) shows no relapse.

*Reduced need for IMF.* No patient required IMF.

### *The disadvantages*

*Multiple daily out-patient visits*. One patient (SH) failed to attend on two consecutive days. This increased the risk of early bony union, which could have prevented further distraction. Fortunately this did not occur. If the patient had control over the distraction themselves, would they have been more or less compliant?

*Poor 3D control.* No patient developed lateral or anterior open bites. Two patients demonstrated left-sided unilateral posterior crossbites at the end of advancement (MB and SH). This was fully corrected in one patient (MB), but the other was visiting a third world country and complete correction was not possible before departure.

*Increased post-operative pain.* No patient considered the daily distraction to be unduly painful, and none required analgesia for the procedure.

*Difficult access for the orthodontist*. This was a cause for concern, since repairs would have been impossible to perform. Fortunately no breakages occurred.

*Difficult plaque control*. Plaque control became extremely difficult for all patients, more so than for those undergoing

a BSSO. However, it is the authors opinion that there was no clinically evident increase in decalcification around these area at debond.

Prior to OD the aims of pre-surgical orthodontics are to decompensate and co-ordinate both arches. However, as OD offers flexibility in the amount of advancement it may be possible to offer surgery earlier in the process of orthodontic treatment. This may reduce overall treatment time considerably, as final occlusal intercuspation and settling of the occlusion can be carried out post-surgically. During OD use of intra-oral elastic traction is possible and this improves the occlusion. The gradual advancement of the mandible allows the maxillo-facial surgeon and orthodontist to determine the final amount of mandibular advancement jointly. This would be determined by both facial and occlusal treatment goals.

## Conclusions

This is a very exciting development in orthodontics. OD could be a viable alternative to BSSO, in some cases, for the treatment of discrepancies with a combined orthodontic/orthognathic surgical approach. This technique seems to offer a number of advantages to orthodontist, maxillo-facial surgeon and the patient, and warrants further investigation.

## Acknowledgements

The authors would like to thank C. MacDade, formerly consultant orthodontist at Blackburn Royal Infirmary.

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