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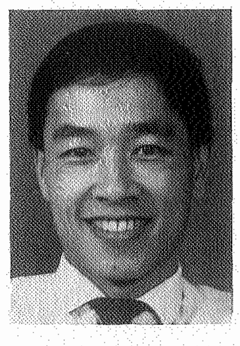

Early relapse following bilateral sagittal split advancement

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ABSTRACT: Early relapse following bilateral sagittal split advancement (BSSA) was assessed by evaluating the cephalograms of 47 patients. The records were assigned to either screw fixation (SF: n=25) or wire osteosynthesis (WF: n=22) groups and subdivided if additional Le Fort I osteotomy was performed. 9 skeletal parameters were evaluated. The results showed that there were relatively minor differences between the screw and wire osteosynthesis groups in the first 6 weeks following surgery. Relapse of 11 percent and 22 percent was recorded respectively but this difference was not statistically significant.

Relapse was not correlated with the preoperative mandibular plane, altered posterior facial height, gonial angle or changes in gonial arc radius in either group. A clear association between condylar displacement and relapse tendency was not expressed. This suggests that whilst condylar position remains important, early postsurgical relapse is due to multifactorial influences.

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MeSH words: cephalometry; mandibular surgery
Key words: Relapse, bilateral sagittal split advancement, screw fixation, upper border wire fixation

INTRODUCTION

Early postsurgical relapse following the bilateral sagittal split osteotomy has not been resolved despite refinements in technique. Relapse has been reported to range from 11 percent to 71 percent (Ive et al. 1977) in the first six weeks following surgery with upper border wire osteosynthesis. By comparison, negligible relapse has been reported when more rigid internal fixation is used (Van Sickels et al. 1988). A multiplicity of aetiological factors is involved in relapse but the individual contribution of each remains uncertain. Intraoperative condylar distraction, soft tissue resistance and the method of fixation are most commonly implicated.

Improper condylar position is considered by many to be the major factor in relapse (Isaacson 1978, Kohn 1978, Schendel et al. 1978, MacIntosh 1981, Schendel and Epker 1980, Epker 1981, Lake et al. 1981, Epker and Wessberg 1982, Sandor et al. 1984 and Hase 1988). Meticulous manual manipulation of the proximal segment posterosuperiorly may not guarantee accurate location because of the possible effects of muscle relaxant, intracapsular oedema (Wade 1988) and tissue tension (Will et al. 1984). Condylar locating devices have been recommended (Leonard 1976, Zecha et al. 1978, Leonard 1985, Luhr 1985, Raveh et al. 1988) but have not found universal acceptance.

Will et al. (1984) have challenged the role of condylar relation in relapse claiming that 37 percent net relapse was seen in their study despite accurate repositioning of the condyle. This suggests that condylar position may be overemphasised and underscores the multifactorial nature of postsurgical instability. Smith and his colleagues (1985) reported condylar return post-surgically but they remarked that neither changes across the osteotomy site or proximal segment location could account solely for their observed relapse of 31 percent.

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The contribution of muscular interaction has been acknowledged (Poulton and Ware 1971, Farrell and Kent 1972, Wickwire et al. 1972, Steinhauser 1973, Epker et al. 1978 and Sandor et al. 1984) and it is widely accepted that attempts to increase resting muscle length will encourage relapse. As a result, Wolford and his colleagues (1978) recommended suprahyoid myotomy to counter muscular resistance in large mandibular advancements. Others however, have raised doubts about the validity of suprahyoid myotomy (Schendel and Epker 1980, Wessberg et al. 1982). Schendel and Epker's (1980) results showed that relapse was not controlled by myotomy and reasoned that the remaining attached soft tissues and muscles still provided a substantial relapsing influence. MacIntosh (1981) postulated that the impetus for relapse comes from the proprioceptive effects of the masticatory muscle complex to reestablish the preoperative equilibrium. He felt that the masticatory or suprahyoid muscles were not primary factors in relapse. From animal studies, Carlson et al. (1987) found that suprahyoid lengthening occurred at the muscle-tendon and muscle-bone interfaces in non-myotomy advancements. They concluded that suprahyoid myotomy was an acceptable procedure in selected cases but it could be avoided if stable fixation could be guaranteed.

Stability has been enhanced by the refinement of fixation methods over the past two decades. McNeill and his co-workers (1973) carried out a retrospective cephalometric evaluation which indicated that dental structures were not stable during intermaxillary fixation (IMF). They concluded that some form of osseous fixation was necessary to minimise skeletal relapse. Skeletal methods of fixation bypass the relatively mobile periodontal ligament and potentially improve stability (Mayo and Ellis 1987). Circummandibular wiring at the osteotomy site as proposed by Obwegeser (1964) has largely been superseded by upper border wiring (Epker 1977, Epker 1980), combined dentoskeletal fixation (Epker and Wessberg 1982) and lower border wiring

(Booth 1981). Multiple screw fixation either alone or in combination with miniplates (Spiessl and Tschopp 1974, Spiessl 1976, Paulus and Steinhauser 1981, Jeter et al. 1982) has reportedly shown the most promising long term results.

The contention of most authors experienced in the use of upper border wire osteosynthesis and IMF is that most relapse occurs in the early retention phase (Kohn 1978, Kraal and Valk 1981, Lake et al. 1981, Jeter et al. 1984). Several authors have stressed the importance of cephalometric evaluation six weeks after surgery (Kohn 1978, Lake et al. 1981). Although this period has been well documented when wire fixation is used there are relatively few reports which examine the skeletal changes with screw fixation. Van Sickels et al. (1988) have remarked that this period is still a critical time of evaluation irrespective of the method of fixation. This study was therefore undertaken to:

1. compare screw fixation with wire osteosynthesis to show whether there are any significant differences in the early (6-8 weeks) postsurgical phase following bilateral sagittal split advancement (BSSA).
2. assess the role of condylar position in early relapse following BSSA.

MATERIALS AND METHODS

Records were retrieved from the Oral and Maxillofacial Surgery Unit, The University of Adelaide for 47 patients who underwent surgical advancement of the mandible via bilateral sagittal split ramus osteotomies. The modified sagittal split osteotomy (Dal Pont 1961, Epker 1977) was used by 6 surgeons who followed the same operative technique. The patient records were assigned to one of four groups determined by procedure and method of fixation.

Group 1: 11 cases had BSSA only and were stabilised with 2.0mm Wurzburg® bicortical non-compression screw fixation.

Group 2: 14 patients had combined Le Fort I osteotomies (Wurzburg® miniplate fixation) and BSSA secured with 2.0mm Wurzburg® bicortical non-compression screw fixation.

Group 3: 16 BSSA cases had 26 gauge upper border wire osteosynthesis (WF) and intermaxillary fixation (IMF).

Group 4: 6 patients had combined Le Fort I osteotomy, BSSA, wire osteosynthesis and IMF.

Thin occlusal wafers which permitted incisal contact at the time of surgery were retained for six weeks in conjunction with light Class II elastics (groups 1 and 2) or IMF (groups 3 and 4). Standardised lateral head films were classified according to the following time intervals:

T1: at completion of presurgical orthodontics

T2: within three days of surgery

T3: during the sixth postoperative week after removal of the wafer (and IMF).

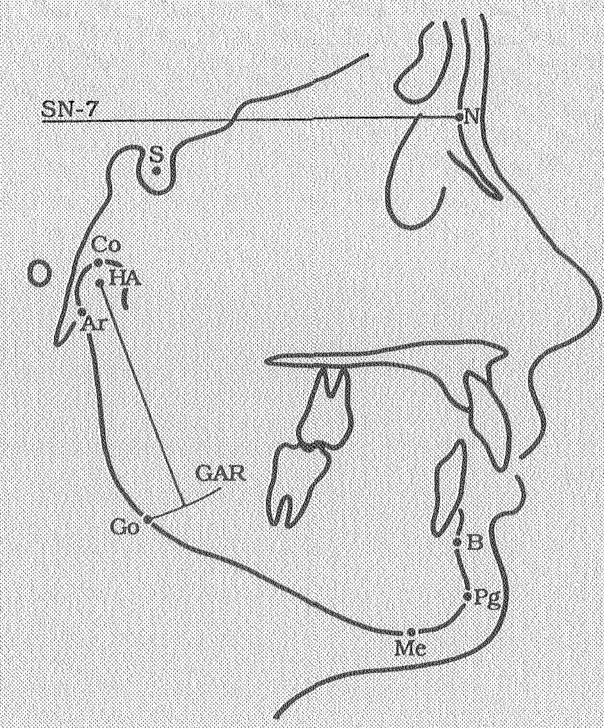

Figure 1.
Landmarks and parameters.
Sella (S): the centre of the pituitary fossa of the sphenoid bone determined by inspection.
Nasion (N): the junction of the frontonasal suture at the most posterior point on the curve of the bridge of the nose.
Condylion (Co): the most superior point on the head of the condyle.
Hinge axis (HA): the centre of the head of the condyle determined by inspection.
Articulare (Ar): the point at the junction of the contour of the external cranial base and the dorsal contour of the condylar processes projected in the midsagittal plane.
Gonion (Go): the midpoint of the angle of the mandible found by bisecting the angle formed by the mandibular plane and a plane through articulare and posterior border of the ramus.
Down's B point or supramentale (B): the deepest point in the midsagittal plane between infradentale and pogonion, usually anterior to and slightly below the apices of the mandibular incisors.
Pogonion (Pg): the most anterior point on the contour of the bony chin relative to a perpendicular to SN-7 plane.
Menton (Me): the most inferior point on the symphyseal outline.
Gonial arc radius (GAR): the radius of an arc passing through gonion with HA as the centre of rotation (Kohn 1987).

Cephalometric Analysis

Each preoperative radiograph was placed over a fluorescent light box and traced on Ortho Trace 0.08mm matte acetate sheet with a sharp HB lead pencil. A mandibular template was constructed to transfer condylion (Lake et al. 1981) and gonion on the proximal segment. A template of the distal segment was used to transfer menton, pogonion and B point to avoid incorporation of 'extremal' landmark errors (Moyers and Bookstein 1979). The preoperative tracing was superimposed over the two corresponding postoperative cephalograms for best fit on sella turcica, nasion and cranial base structures (Buschang et al. 1986). The mandibular structures from T2 and T3 were added to the acetate sheet. Eight hard tissue points were selected in order to quantify the hard tissue response following surgery (*Figure 1*). Cephalograms were digitised with a Hewlett Packard 9874A digitiser interfaced with an Apple IIe PC. The software program which resolves input into cartesian coordinates was developed for cephalometric research (Brown 1986 - in a personal communication) and modified for the purposes of the current study. The reference plane SN-7 registering at sella was chosen as its reliability has been confirmed in previous investigations (Pancherz and Hansen 1984, Ghafari et al. 1987). All tracings and digitisations were performed by the one observer.

Statistical Analysis and error of the method

Student's t-tests for paired data were used to compare 9 parameters between each interval within the 4 subsets. Analysis of variance (ANOVA) was used to determine if differences existed between the four groups. Student's t-tests for unpaired data were used to calculate the significance of differences between the SF and WF groups. Measurement error was assessed using a modification of the method described by Will et al. (1984). Three randomly selected cases, each consisting of 3 films, were traced, superimposed and digitised 4 times. Digitising error was determined by digitising one tracing 4 times. The overall error for tracing and digitising was 0·8 ± 0·26mm for measured distances and 1·7 ± 0·36° for angles which was comparable to the error reported by Will and her associates.

Pearson product-moment correlations (r) were calculated by combining the four groups (n=47). An r value greater than 0·6 was considered high, between 0·4 and 0·6 moderate and less than 0·4 low. Specious associations (Brown 1973) were taken into account when the correlations were interpreted.

RESULTS

Table 1.
Early skeletal changes (±SEM) following BSSA

Parameter	Gp 1: BSSO (SF) n=11			Gp 2: BSSO/LFI (SF) n=14		
	T1-T2	T2-T3	T1-T3	T1-T2	T2-T3	T1-T3
B point (x)	4.9±0.44††	-1.1±0.54	3.8±0.58††	5.8±0.57††	0.6±0.55	5.2±0.44††
Pogonion (x)	4.1±0.67††	1.0±0.59	3.2±0.77†	5.7±0.77††	-0.6±0.59	5.1±0.70††
SNB	3.2±0.21††	-0.8±0.97†	2.4±0.33††	3.7±0.23††	0.6±0.30	3.2±0.20††
Gonial arc radius HA-Go	1.0±0.36†	-1.3±0.36††	-0.3±0.31	1.1±0.64	-1.2±0.40†	-0.1±0.34
Gonial angle ArGoMe	4.7±0.76††	-0.1±0.55	4.7±0.77††	4.3±1.30†	0.9±0.53	5.2±1.40††
Ramal angle SNArGo	-2.5±0.78†	0.4±.58	-1.5±0.96†	-3.5±0.76†	-0.7±0.48	-4.0±0.91††
Mand. plane angle SNGoMe	2.0±0.66†	0.3±0.40	2.3±0.61†	0.8±0.93	0.4±0.39	1.3±0.86
Post. facial height S-Go	0.5±0.32	-1.2±0.37*	-0.7±0.35	0.2±0.34	-1.3±0.34††	-1.1±0.35*
Ant. facial height N-Me	6.3±0.79††	-1.6±0.48†	4.7±0.64††	4.0±0.75**	-1.2±0.38*	2.8±0.74††

Parameter	Gp 3: BSSO (WF) N=16			Gp 4: BSSO/LFI (WF) N=6		
	T1-T2	T2-T3	T1-T3	T1-T2	T2-T3	T1-T3
B point (x)	5.9±0.52††	-1.5±0.30††	4.4±0.34††	6.0±1.99†	-0.3±0.58	5.7±1.66†
Pogonion (x)	5.4±0.55††	1.9±0.30††	3.5±0.35††	5.8±2.34	-0.5±0.64	5.3±2.06†
SNB	4.1±0.31††	-0.8±0.14††	3.3±0.23††	3.6±0.93†	-0.4±0.27	3.2±0.81†
Gonial arc radius HA-Go	1.9±0.53††	-1.9±0.61†	0.01±0.49	1.5±0.84	-1.8±0.96	-0.2±0.82
Gonial angle ArGoMe	8.0±0.98††	1.9±0.77†	9.9±1.20††	7.7±0.91††	1.8±0.48†	9.4±0.85††
Ramal angle SNArGo	-4.7±0.90††	-0.3±0.72	-5.1±0.80††	-7.7±1.43†	-0.8±0.44	-8.5±1.11††
Mand. plane angle SNGoMe	3.3±0.35††	1.6±0.45††	4.8±0.46††	-0.1±1.73	0.9±0.32†	0.9±1.50
Post. facial height S-Go	0.9±0.47	-1.9±0.49††	-1.0±0.48	0.7±0.67	-1.9±0.92	-1.2±0.83
Ant. facial height N-Me	7.1±0.42††	-0.5±0.44††	6.5±0.48††	2.2±1.38	-1.6±0.73	0.6±1.00

††P ≤ 0.005; †P ≤ 0.05

Screw fixation (SF)

Group 1: BSSA (n=11). The mean mandibular advancement of 4·9 ± 0·44mm at B point was accompanied by statistically significant ($p < 0·01$) changes in all but one of the measured parameters (posterior facial height-PFH). Over the next 6 weeks a small decrease in anterior facial height (AFH) and PFH ($p < 0·01$ was noted. Gonial arc radius (GAR) which increased (1·0 ± 0·36mm) at surgery decreased (-1·3 ± 0·36mm) during the first 6 weeks and was possibly associated with resolving intracapsular and facial oedema. There was a small but statistically significant decrease in SNB.

In comparing preoperative and 6 week films, the significant net changes resulting from surgery were a mean mandibular advancement of 3·8mm, flattening of the gonial angle and increased AFH.

Group 2: BSSA & LFI (n=14). Autorotation and surgical advancement of the mandible resulted in a mean change of 5·8 ± 0·57mm and increased SNB of 3·7 ± 0·23°. A combination of anterosuperior proximal rotation and increased AFH was observed. Six weeks after surgery small but significant decreases were noted for PFH, AFH and GAR. The net advancement of 5·2mm was accompanied by a slight decrease in PFH (-1·1mm), anticlockwise rotation of the proximal segment (SNArGo –4·0°, ArGoMe +5·2°) and increased AFH (2·8mm).

Wire fixation (WF)

Group 3: BSSA (n=16). Surgical advancement of the mandible averaged 5·9 ± 0·52mm. The gonial arc radius increased 1·9 ± 0·53mm ($p < 0·005$) and was associated with marked anterosuperior proximal segment rotation ($p < 0·001$). Cephalograms taken immediately after IMF release and wafer removal show that B point relapsed 1.5mm ($p < 0·01$). The condyle appeared to resume its preoperative location as gonial arc radius and PFH both decreased 1·9mm ($p < 0.001$) suggestive of condylar distraction during IMF. The net changes due to surgery included a mandibular advancement of 4·4mm and increased SNB of 3·3°. Increases ($p < 0·001$) occurred in anterior facial height (6·5mm), mandibular plane (4·8°) and gonial angle (9·9°) but there was no significant change in PFH or gonial arc.

Group 4: BSSA & LFI (n=6). Surgical mandibular advancement of 6·0 ± 1·99mm was recorded in this group.

Proximal segment rotation occurred in this group ($p < 0·01$) but there was no significant change in mandibular plane. None of the other values reached a level of significance. At the six week comparison ArGoMe increased 1·8° ($p < 0·05$) and SNMP increased (0·9°, $p < 0·05$) suggestive of minor spatial changes at the osteotomy sites during healing.

Overall changes which resulted from surgery were a net advancement of 5·7mm, an SNB increase of 3·2° and a more obtuse gonial angle. No significant change was noted in mandibular plane angle, PFH or AFH.

Analysis of variance showed that there were differences between the two subsets within the WF category. SNArGo (T1-T3) increased 5·1° in group 3 ($p < 0.001$) whereas the LFI wire osteosynthesis group had a net decrease (-8·5°). The LFI group experienced the least net gain (T1-T3) in AFH (0·64mm, $p < 0·001$) compared to the other group highlighting the effect of maxillary impaction. No significant differences were observed between the screw fixation subsets. Therefore, groups 1 and 2 were combined (SF: n=25) for further statistical comparison with group 3 (BSSA-WF: n=16).

Two-tailed Student's t-testing for unpaired data showed that SNB was the only significant ($p < 0·05$) value to differ in comparing the two groups preoperatively. Although mandibular advancement (T1-T2) was similar for both groups (5·4 and 5·9mm) gonial angle (ArGoMe) differed at the 1 percent level. This angle for the wire group (8·0°) was almost twice the mean of the SF group (4·5°) representing a flatter gonial angle as mandibular plane opened and anterior facial height increased. At the six week review (T2-T3) the only difference was in mandibular plane (0·4° vs 1·6°, $p < 0·05$). Net horizontal relapse measured at B point was less for screw fixation (11·1 ± 0·07%) than wire osteosynthesis (22·1 ± 0·05%) but this difference was not statistically significant. Comparisons between T1-T3 values demonstrated differences in anterior facial height (3·6 vs 6·5mm, $p < 0·001$), gonial angle (5·0° vs 9·9°, $p < 0·05$) and mandibular plane (1·7° vs 4·8°, $p < 0·001$) indicating that increased facial height was achieved at the expense of increased gonial angulation.

Gonial arc radius and relapse were also assessed using two-tailed Student's t-testing for unpaired data. Gonial arc radius was considered stable if the change at T2 did not exceed 1.1mm, the limit of linear measurement error. Thus 2 subsets (≤ 1.1mm and > 1·1mm) within the SF group and 2 subsets within the WF group were created (*Table 2*). No significant differences were found between the SF subsets in either GAR or percent relapse. A significant difference for GAR ($p < 0·01$) was found within the WF group but there was no statistical difference in percent relapse.

Table 2.
Change (△) in Gonial Arc Radius (GAR) and relapse tendency at six weeks for screw and wire fixation

	SF N=25		WF N=16	
△GAR (T1-T2)	≤1.1mm	>1.1mm	≤1.1mm	>1.1mm
Cases	12	13	6	10
Mean △GAR (mm)	0.6±0.51	1.5±0.56	0.3±0.33	2.9±0.63
	NS		P<0.001	
Relapse %	10.1	12.1	14.9	26.4
	NS		NS	

A moderate correlation was found between mandibular advancement and relapse (r= 0·53). When relapse was expressed as a percentage of the advancement the r value was low (0·35). A weak correlation existed between gonial arc and relapse at B point (r= 0·32). There was no correlation between relapse and posterior facial height (r= 0·01) or gonial angle (r= 0·01).

DISCUSSION

The results of this study showed that there were relatively minor differences between the screw and wire osteosynthesis groups in the first 6 weeks following surgery. The most conspicuous difference was the increased gonial angulation for the WF group. This was double the change recorded for the SF group. Singer and Bays (1985) related this loss of the gonial angle to rotation of the proximal segment and commented that this may present aesthetic concerns. In reviewing our results, proximal segment rotation occurred in both groups but the change was relatively small. The increase in gonial angle for the WF group related more strongly to increased anterior facial height with a lesser contribution from proximal rotation. Freihofer and Petresevic (1975) noted that increased gonial angle was associated with relapse however, we were unable to demonstrate a correlation. This study did not show a clear association between condylar displacement and relapse tendency. Gonial arc radius increased for both groups in 23 of the 47 (49%) cases but had returned by 6 weeks. This observation of condylar return has been reported by others (Kohn 1978, Lake et al. 1981, Smith et al. 1985). Assessment of the data (*Table* 2) showed that relapse was independent of gonial arc radius.

Both groups had comparable mean mandibular advancement but the relapse tendency was higher for the WF group (22%). This difference between each group did not reach statistical significance. Relapse in the SF group was 11 percent and conflicts with previous investigations on the stability of screw fixation (Van Sickels and Flanary 1985, Van Sickels et al. 1986, Lindorf 1986, Kirkpatrick et al. 1987, Van Sickels et al. 1987). The magnitude of advancement and the operative technique were comparable to other studies using screw fixation.

It has been argued that lag screws may displace the condyle from the fossa if improperly applied (Rittersma et al. 1981, Nickerson 1983, Sandor et al. 1984). However, our unit has been using bicortical non-compression screw fixation which is less likely to distract the joint since the bone segments are held in a passive relationship. The use of a bone clamp to temporarily stabilise the segments is also discouraged as its use has been associated with iatrogenic posterior open bite (Jeter et al. 1984, Muller and Bach 1989) and condylar torquing (Raveh et al. 1988). Since our sample size was limited, prospective studies should demonstrate whether this trend towards relapse becomes less pronounced. It is apparent that the early postoperative period remains an important time for postsurgical evaluation.

The amount of relapse in the WF group compares favourably with the literature. Although the sample was relatively small, the results are close to those recorded during Lake's assessment (26%) of 52 patients (1981). Will et al. (1984) reported 37 percent relapse for 41 patients during the same period. This suggests that some relapse is inevitable when upper border wiring is used and consideration should be given to overcorrection during surgical planning.

Relapse appeared to be associated with the amount of surgical advancement and is in agreement with Lake et al. (1981), Smith et al. (1985) and Van Sickels et al. (1985). We recorded a moderate correlation (r= 0·53) but this could be partially attributed to topographical association. Brown (1973) has commented that specious correlations may arise from variables sharing the same components, topographical association, or through the commonality of the reference plane. However, the presence of a specious association did not rule out the possibility of a biological effect rather, that the correlations should be interpreted with some caution.

When relapse was expressed as a percentage of the advancement the r value was low (0.35) confirming the findings of Ive et al. (1977). Lake et al. (1981) were able to show a moderate correlation (r= 0·05, p < 0·001) between gonial arc radius and relapse at pogonion but this relationship was only weakly correlated (r= 0·23) in this study. Relapse was not correlated with the preoperative mandibular plane, altered posterior facial height or changes in gonial angle in either group.

Although a statistical difference in relapse was not shown between groups, screw fixation appears to offer significant promise in terms of stability. In view of the finding that condylar position was not a primary determinant of relapse, it would appear that screw fixation provided greater resistance to the displacing forces which encourage relapse. Longer term studies clearly demonstrate the superior surgical stability of screw fixation over conventional wire osteosynthesis (Van Sickels et al. 1986, Kirkpatrick et al. 1987, Van Sickels et al. 1988). Finn et al. (1980) described the accentuated force coupling which follows mandibular advancement. If the paramandibular complex lengthens with time in a manner similar to the description by Carlson et al. (1987), then stronger fixation may control relapse whilst this lengthening occurs. We believe that larger diameter screws or an increased number of screws may resolve the problem of early relapse and are currently investigating this postulate.

CONCLUSIONS

1. The results of this study showed that there were relatively minor differences between the screw and wire osteosynthesis groups in the first 6 weeks following surgery.
2. Early relapse was not correlated with the preoperative mandibular plane, altered posterior facial height, gonial angle or changes in gonial arc radius in either group.
3. This study suggests that several factors, including condylar displacement, may contribute to relapse following sagittal split advancement. The resistance from paramandibular soft tissues offers the most logical relapse factor and requires continued investigation.
4. The early postoperative phase remains a critical period in evaluating surgical relapse. Relapse of 11 percent and 22 percent was recorded for the screw and wire fixation groups respectively. Although this difference was not statistically significant, prospective long term studies should confirm whether or not screw fixation improves stability following bilateral sagittal split advancement.

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