European Journal of Orthodontics 21 (1999) 377–386

A long-term evaluation of treated Class II division 2 malocclusions: a retrospective study model analysis

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SUMMARY Pre-treatment, end of treatment, and post-retention study models of 30 subjects with a Class II division 2 malocclusion were assessed, after a period of at least 3 years, in order to evaluate the long-term changes in occlusion, alignment, and arch dimensions.

Molar relationship correction was found to be stable after retention. There were no variables which could be used to establish a prognosis of vertical stability. Over-correction of overbite was seen to relapse. Ten per cent of the cases showed unacceptable anterior maxillary irregularities after retention. Mandibular arch width and length usually showed a decrease after retention. An increase in lower intercanine width and arch length achieved by orthodontic treatment always relapsed. This relapse was associated with post-retention mandibular irregularity and crowding. Nine cases (30 per cent) showed an unacceptable degree of mandibular irregularity after retention. Pre-treatment crowding in the mandible showed a relationship with post-retention lower irregularity and crowding. There was a correlation between the number of years which had elapsed after retention, overbite relapse and post-retention mandibular irregularity.

Introduction

Orthodontic correction of Class II division 2 malocclusions is known to be difficult and prone to relapse. The recurrence of a deep overbite, upper anterior crowding, and a steep axial inclination of the upper incisors is often seen after retention. Different types of treatment and various methods of achieving stability have been advocated and discussed in the literature. Maintenance of post-treatment results depends on the intensity and direction of facial growth, both during and after retention (Payne, 1964; Simons and Joondeph, 1973; Nemeth and Isaacson, 1974). Over-correction of the deep overbite to prevent vertical relapse (Riedel, 1960), relative decrease of the lower lip cover (Van der Linden, 1983), and torque of the incisors and interincisal angle (Ludwig, 1966; Simons and Joondeph, 1973) have all been cited. Berg (1983) considered that an interincisal angle of less than 140 degrees after treatment was an important factor in long-term stability, whilst the final position of the lower incisors has also been identified (Houston and Edler, 1990).

Previous reports have shown the possibility of an increase in intercanine width (Shapiro, 1974) or the modification of the lingual position of the lower incisors to bring about long-term stability (Berg, 1983). However, most of the research into stability has not been conclusive, mainly because of the low number of cases studied and the lack of a sufficient long-term post-retention period.

The aim of this investigation was to evaluate the long-term changes in occlusion, alignment and arch form of Class II division 2 malocclusion patients who had received orthodontic treatment and had been out of retention for at least 3 years.

Selection of subjects

The material consisted of the study models of 30 subjects treated orthodontically. The criteria for inclusion in the sample were as follows:

1. The existence of a disto-occlusion and retroclination of two or more upper incisors. For each patient three sets of diagnostic casts were available: before treatment (T1); at the

Table 1 Sample characteristics – age in years.

	n	Mean	SD	Minimum	Maximum
Age					
Pre-treatment	30	11.99	2.83	8.25	21.5
Post-treatment	30	15.14	2.99	10.08	24.58
Post-retention	30	22.19	3.59	15.5	30.16
Treatment period	30	3.16	1.15	1.50	5.75
Post-retention period	30	7.04	2.82	2.98	16.66

end of active treatment (T2); and a minimum of 3 years out of retention (T3).
2. The patients had undergone routine edgewise orthodontic treatment followed by varying periods of retention.

Any patient, irrespective of age, who met the criteria was included.

Subjects and methods

The study casts of 30 patients, 20 girls and 10 boys were included. Seven subjects were in the mixed dentition and 23 in the permanent dentition at the start of treatment. No extractions were carried out in any patient. The mean age was 12 ± 2.8 years at the start of treatment (T1). The mean length of treatment was 3 ± 1.2 years, and the mean period out of retention without any appliance was 7 ± 2.8 years (Table 1).

A dial caliper was used to take the following measurements (at 0.01 mm) in each case:

1. Irregularity index (IRI): the summed displacement of the anatomical contact points of the six anterior teeth in the upper or in the lower arch, as described by Little (1975).
2. Anterior crowding: the difference between the space available to accommodate a crowded anterior tooth and the mesiodistal size of the teeth.
3. Molar relationship: for the left and right sides, recorded in millimetres, as the distance parallel to the occlusal plane between the mesiobuccal cusp of the maxillary first molar and the labial groove of the mandibular first molar.
4. Overbite: mean overlap of the upper and lower central incisors. The cases were divided into three groups and the decision as to the range of these groups was arbitrarily defined: overbite over-corrected (<2 mm at end of treatment); overbite corrected (2.0–3.5 mm); deep bite (>3.5 mm).
5. Intercanine width: the distance between the cusp tips or estimated cusp tips in cases with wear faceting.
6. Intermolar width: the distance between the first permanent molars.
7. Arch length: the sum of the right and left distances from the mesial anatomical contact points of the first permanent molars to the interproximal contact point of the central incisors or the mid-point between the central incisors' contacts, if spaced.

The casts were measured on two separate occasions. The paired *t*-test was used to assess systematic inter-observer differences. Inter-observer correlation (*r*) was calculated to indicate the usefulness of each measurement considered (Table 2).

The mean changes together with their standard deviations were calculated for each variable at each stage of treatment and for each of the three time periods (T1–T2, T2–T3, T1–T3), and then tested by means of a paired *t*-test. Association between variables was evaluated by the Pearson correlation coefficient. The significance level was established at $P < 0.05$.

The sample was divided into groups according to sex and whether the long-term result was considered clinically acceptable or unacceptable.

Table 2 Error of the method: mean increments in millimetres. The result of paired *t*-test (systematic error) and the correlation coefficient between first and second measurement.

	Mean increments	Paired *t*-test *P*	Correlation *r*
Overbite	0.007	0.92	0.98
Overjet	–0.066	0.48	0.95
Upper crowding	0.013	0.89	0.99
Lower crowding	0.129	0.28	0.98
Upper irregularity	–0.043	0.76	0.99
Lower irregularity	0.042	0.67	0.99
Upper intercanine width	–0.181	0.16	0.96
Lower intercanine width	–0.070	0.58	0.95
Upper intermolar width	–0.122	0.28	0.97
Lower intermolar width	–0.035	0.76	0.97
Upper arch length	–0.056	0.86	0.95
Lower arch length	–0.076	0.50	0.98
Molar relationship	0.061	0.53	0.99

The cases were then divided into the following groups:

Pre-treatment mandibular crowding <5 mm.
Pre-treatment mandibular crowding >5 mm.

Treatment increase of mandibular canine width.
Treatment decrease of mandibular canine width.

Treatment increase of arch length.
Treatment decrease of arch length.

Post-treatment overbite <2 mm, overbite over-correction.
Post-treatment overbite between 2 and 3.5 mm, overbite correction.
Post-treatment overbite >3.5 mm, deep bite.

Differences between groups were assessed by a one-way analysis of variance.

Results

The mean ± SD of the variables are shown in Table 3.

Molar relationship

The mean post-retention relapse in the molar relationship was 0.6 ± 0.8 mm. All the cases manifested acceptable post-retention molar occlusion. There was a significant correlation ($r = 0.8$) between the end of treatment and post-retention stages.

Overbite

The mean overbite decrease during the period of active treatment was 3.5 ± 1.8 ($P < 0.001$) and following retention, the mean overbite increase was 0.9 ± 1.2 mm. The correlation between post-retention overbite increase and post-retention lower crowding, although statistically significant, was weaker than would be expected ($r = 0.52$, $P < 0.01$).

The over-corrected group showed the greatest overbite and lower irregularity increases after retention. However, the deep bite group showed overbite stability and the lowest mandibular irregularity increases (Table 4). The mean post-retention overbite did not differ between the groups (Table 5).

Maxillary arch

There was no association between treatment changes in the maxillary arch width or arch length, and post-retention irregularity, crowding, and overbite. There was a significant increase in upper intercanine width during active treatment (mean 2.35 ± 2.2 mm). However, no changes occurred after retention (Table 3). Net changes

Table 3 Mean and SD of the variables in millimetres and age in years.

	T1	T2	T3
Overbite	6.40 ± 1.7	2.96 ± 1.0	3.92 ± 0.9
Overjet	6.12 ± 1.4	3.93 ± 1.1	3.99 ± 0.8
Upper crowding	–3.25 ± 3.3	0.58 ± 1.2	–0.19 ± 0.9
Lower crowding	–2.88 ± 3.0	–0.23 ± 1.0	–1.60 ± 1.6
Upper irregularity	10.7 ± 5.1	0.90 ± 0.9	2.13 ± 1.2
Lower irregularity	5.41 ± 4.7	1.33 ± 0.9	3.61 ± 2.4
Upper intercanine width	32.4 ± 2.1	34.8 ± 2.0	34.6 ± 2.0
Lower intercanine width	25.1 ± 1.9	26.4 ± 1.6	25.3 ± 1.4
Upper intermolar width	45.2 ± 2.2	47.5 ± 2.2	46.7 ± 2.2
Lower intermolar width	40.6 ± 1.9	41.7 ± 1.6	41.1 ± 1.9
Upper arch length	65.9 ± 4.1	70.6 ± 5.2	67.6 ± 5.1
Lower arch length	58.2 ± 3.2	60.7 ± 3.0	57.9 ± 3.6
Molar relationship	3.06 ± 1.7	–0.48 ± 1.1	0.11 ± 1.3
Age	12.0 ± 2.8	15.1 ± 3.0	22.2 ± 3.6

Table 4 Lower irregularity index development in different groups.

		Lower Irregularity Index		
Groups	Number of cases	T1	T2	T3
Pre-treatment mandibular crowding <5 mm	24	3.92 ± 1.87	1.4 ± 0.79	3.04 ± 2.16
Pre-treatment mandibular crowding >5 mm	6	11.3 ± 3.72	1.1 ± 0.69	6.02 ± 3.89
Increase mandibular canine width	16	5.37 ± 4.56	1.56 ± 0.94	4.33 ± 3.01
Decrease mandibular canine width	7	4.17 ± 3.03	1.13 ± 0.66	1.45 ± 1.46
Increase mandibular arch length	23	6.25 ± 5.23	1.24 ± 0.72	4.10 ± 3.43
Decrease mandibular arch length	7	3.28 ± 2.44	1.48 ± 0.89	2.07 ± 1.13
Overbite over-correction	6	3.37 ± 2.12	1.40 ± 0.87	5.92 ± 3.54
Overbite correction	16	7.07 ± 5.97	1.44 ± 0.90	3.30 ± 2.06
Deep bite	8	3.82 ± 2.56	1.30 ± 0.78	2.82 ± 1.70

Table 5 Overbite development in different groups.

		Overbite (mm)		
	n	Pre-treatment T1	End-treatment T2	Post-retention T3
Overbite over-correction	6	5.88 ± 1.42	1.28 ± 0.36	3.55 ± 0.98
Overbite corrected	16	6.66 ± 1.61	2.87 ± 0.31	3.80 ± 0.83
Deep bite	8	6.22 ± 1.54	4.04 ± 0.33	4.31 ± 0.46

in upper intercanine width showed an association with the patient's age at the start of treatment ($r = 0.56$).

There was a significant increase in upper intermolar width during active treatment (2.3 ± 2.0 mm). The mean post-retention decrease was 0.8 ± 1.1 mm. The upper arch length showed an increase during active treatment (4.7 ± 4.5 mm). The mean post-retention decrease was 3.0 ± 2.4 mm.

Maxillary alignment

There was no relationship between the values for irregularity index and crowding of the anterior maxillary teeth. The correlation coefficient between irregularity index and crowding was 0.42 pre-treatment and 0.02 post-retention.

The mean decrease in upper anterior crowding during active treatment was 3.85 ± 3.1 mm. The post-retention increase was 0.8 ± 1.1 mm. All patients showed post-retention crowding values of less than 2.5 mm (which was seen as clinically acceptable). There was no association between post-retention maxillary crowding or any of the other variables.

The mean decrease in the upper irregularity index during active treatment was 9.85 ± 5.4 mm. The post-retention increase was 1.2 ± 1.4 mm. There was an association between end of treatment and post-retention irregularity index ($r = -0.53$). Three patients showed post-retention irregularity index values greater than 4.5 mm (which was considered to be clinically acceptable).

Mandibular arch

Seven patients in the permanent dentition showed a decrease in intercanine width during active treatment. This group, who had undergone a reduction in intercanine width during treatment, showed a large degree of post-retention stability, with minimal lower irregularity after retention. However, 16 other subjects treated in the permanent dentition showed canine expansion of more than 1 mm. In this group intercanine width completely relapsed after retention, and seven of the cases showed unacceptable mandibular irregularity after retention (Table 4).

The changes in intercanine width during retention were weakly associated with post-retention incisor lower irregularity ($r = -0.46$, $P < 0.01$).

There were no changes in mandibular intermolar width during treatment or following retention.

Mandibular alignment

There was a relationship between irregularity index and crowding values in the anterior mandibular teeth. The correlation coefficient between irregularity index and crowding was 0.88 pre-treatment and 0.82 post-retention. The mean post-retention increase in irregularity index of the lower arch was 2.24 ± 2.6 mm, and the post-retention lower crowding increase was 1.4 ± 1.5 mm. The sample was characterized by a marked variation in post-retention response. There was a relationship between the number of years out of retention and post-retention lower irregularity ($r = 0.62$, $P < 0.001$) or lower crowding ($r = 0.59$, $P < 0.01$). Also, post-retention irregularity index and crowding in the lower arch showed little association with overbite relapse and lower intercanine width relapse ($r < 0.55$).

The patients were then divided into groups of moderate (<5 mm) and severe (>5 mm) pre-treatment crowding. In the severe group ($n = 6$) five subjects (83 per cent) had an unacceptable mandibular irregularity index post-retention (Figure 1), whereas in the moderate group ($n = 24$), only four cases (17 per cent) had an unacceptable lower irregularity index after retention ($P < 0.05$) (Figures 2 and 3, Table 4).

Discussion and clinical implications

With regard to the net changes, the overbite over-correction group was not improved in the long-term, as reported in other investigations (Ludwig, 1966; Simons and Joondeph, 1973; Binda *et al.*, 1994). Surprisingly, these patients showed a greater net mandibular crowding deterioration in comparison with their pre-treatment stage. The findings of previous studies have suggested that treatment induced increases of the occlusal plane angle and relapse after retention (Simons and Joondeph, 1983; Binda

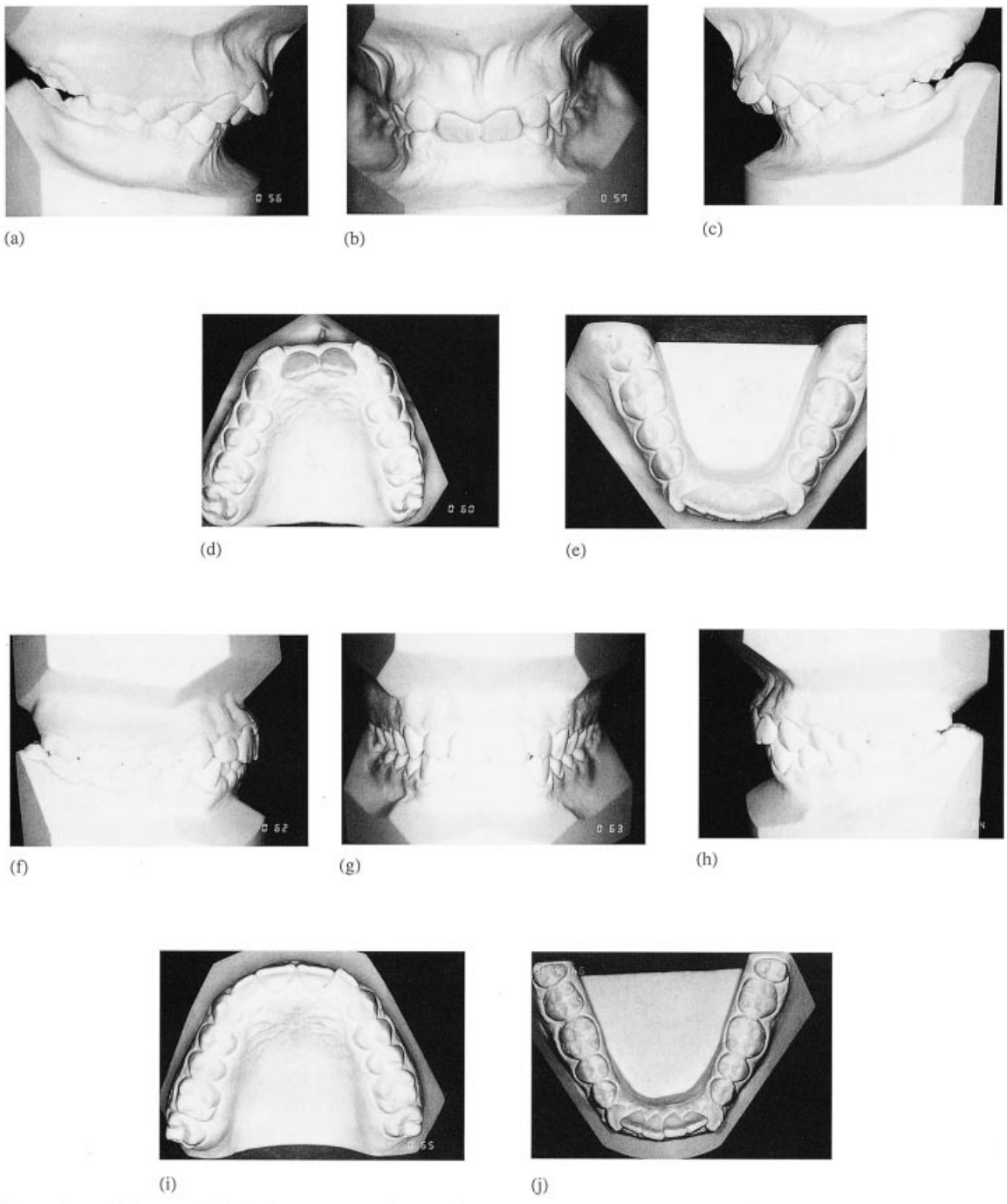

Figure 1 A 10.9-year-old girl before treatment (a,b,c,d,e). The occlusion at 20.6 years of age (f,g,h,i,j) 8 years post-retention.

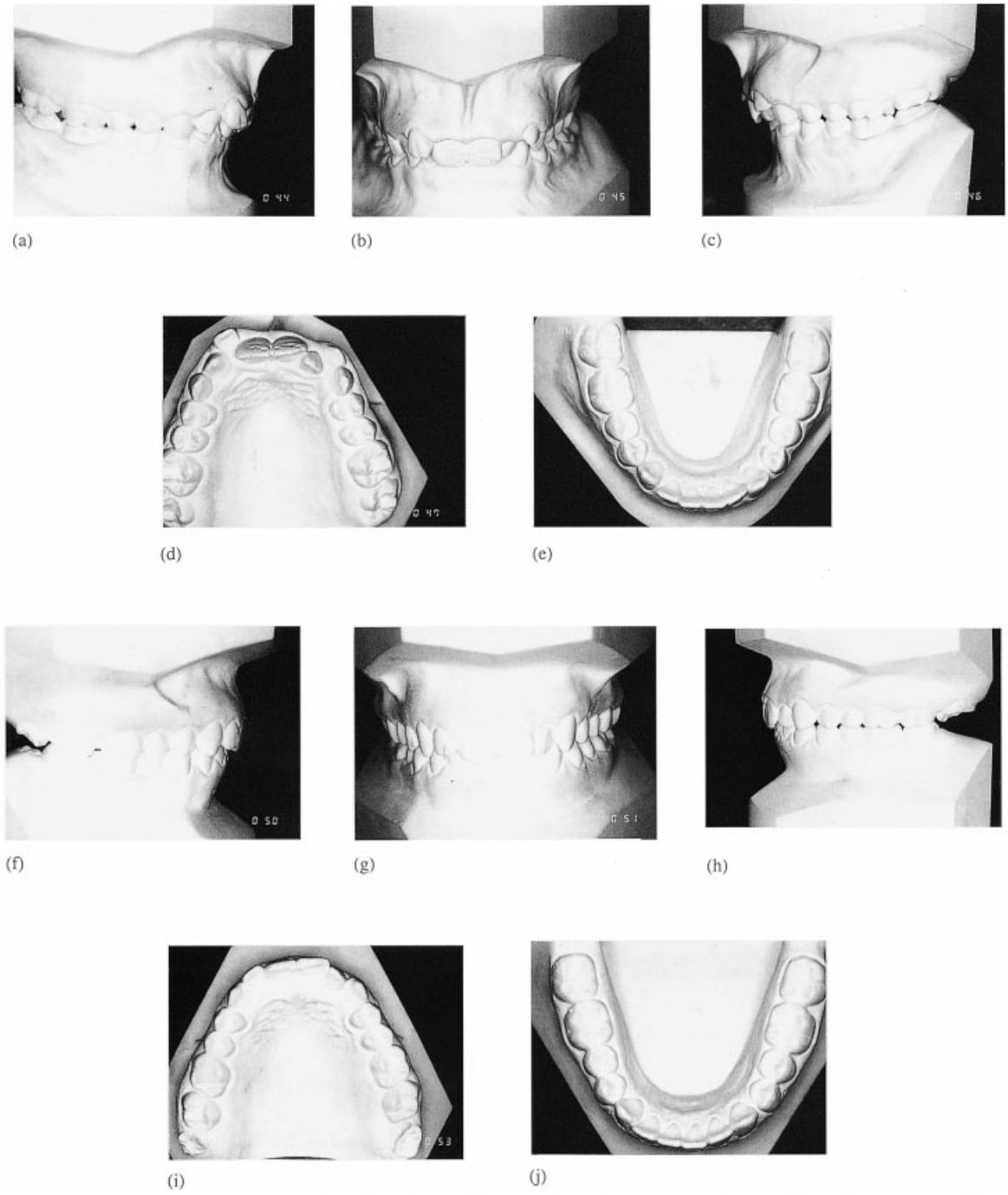

Figure 2 A 12.3-year-old girl before treatment (a,b,c,d,e). The occlusion at 21.8 years of age (f,g,h,i,j) 7 years post-retention.

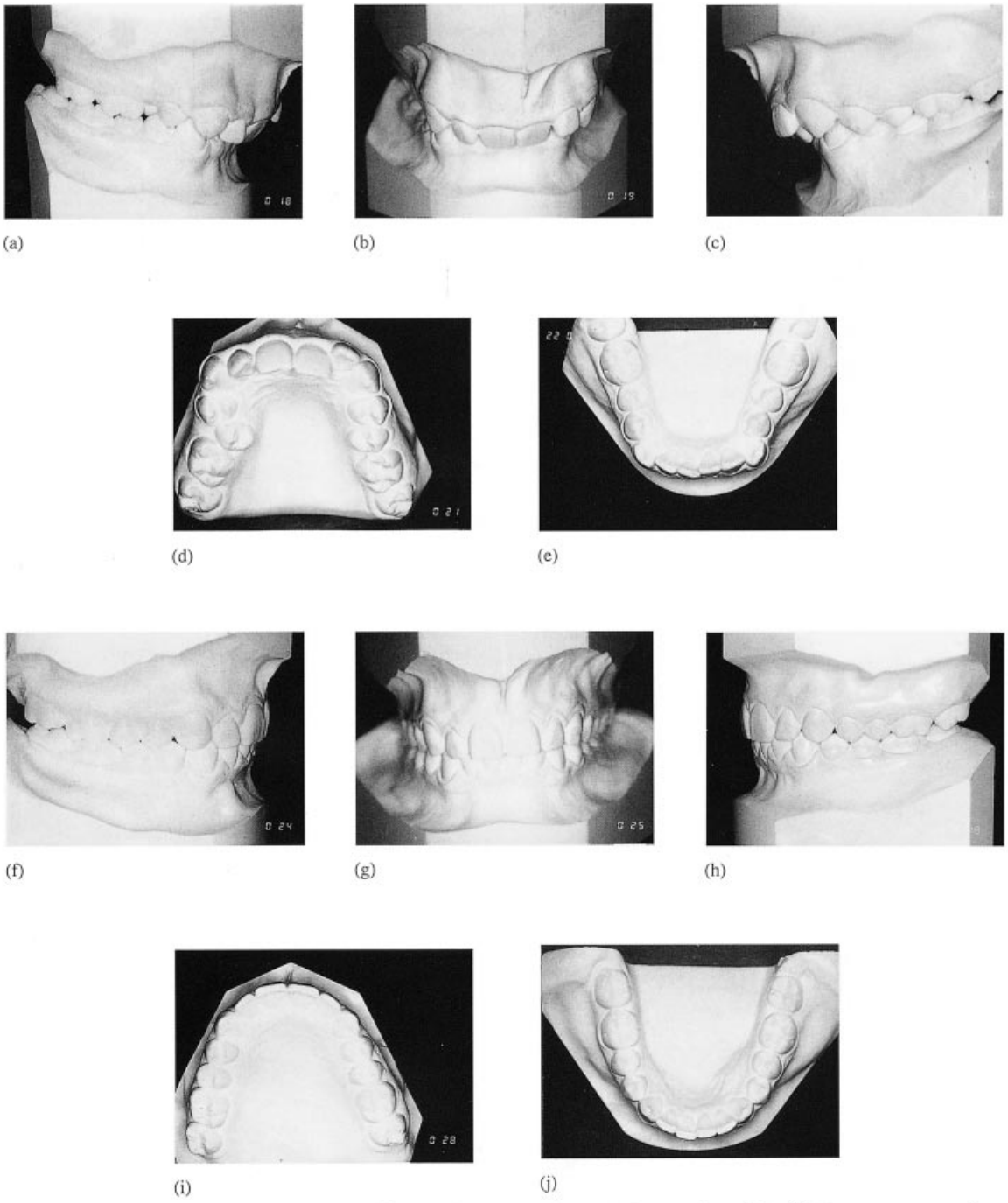

Figure 3 A 12-year-old girl before treatment (a,b,c,d,e). The occlusion at 31.8 years of age (f,g,h,i,j) 14 years post-retention.

et al., 1994). Moreover, treatment protrusions of lower incisor, in the long-term, generally relapse back to the original position (Shields *et al*., 1985; Houston and Edler, 1990). It is possible that overbite over-correction may be associated with unstable movements. After retention, relapse of the lower incisors and posterior occlusal plane rotation caused a relapse of the overbite correction. The findings show that over-correction is a poor predictor of long-term overbite.

In agreement with previous reports, maxillary intercanine width and crowding presented minimal long-term relapse (Sadowsky and Sakols, 1982; Uhde *et al*., 1983). The extent of changes in these variables was similar to those shown in untreated subjects with normal occlusion during adolescence and early adulthood. However, three patients (10 per cent) showed unacceptable (more than 4.5 mm) maxillary irregularity after retention. Allred (1986) reported that two subjects (6.5 per cent) showed unacceptable clinical relapse in a sample of 31 cases, 9 years after retention and, in a control group observed by Edwards (1988), there were relapses of 49 per cent with regard to maxillary irregularity. There was no correlation between post-retention upper irregularity and crowding values in our sample (Figure 2). The preponderance of evidence also suggests that post-retention upper malalignment consists of a rotational relapse of the position of the incisors, without perimeter arch loss. This may explain why circumferential supracrestal fibrotomy showed excellent results 12 years after retention, but only in the maxillary arch (Edwards, 1988).

In the typical untreated subject, mandibular arch, width and length are seen to decrease, together with an increase in crowding during adolescence (Sinclair and Little, 1983). Not surprisingly, all subjects who had received orthodontic treatment showed the same arch development after retention. Little (1990) and Little *et al*. (1988) concluded that prediction of the long-term post-retention result for an individual case is not possible. The results of this investigation showed the same evidence in subjects with Class II division 2 malocclusions.

There was a correlation between lower irregularity and crowding pre-treatment and post-retention, as previously reported (Puneky *et al*., 1984; Plasencia, 1986). The evidence shows that, in the mandibular arch, the forces, movements, and factors involved in anterior lower crowding, play an important role in the development of post-retention malalignment (Figure 1).

It is clear in this sample that maintenance of the original lower intercanine width and arch length during treatment was no guarantee of stability. On the other hand, treatment increases of mandibular size relapsed and showed an association with an unacceptable degree of long-term mandibular crowding after retention. The response in the initial well-aligned group ($n = 13$) is interesting. All but three subjects, showed a net deterioration over the pre-treatment stage, but only the four patients with lower arch size treatment increase, resulted in unacceptable post-retention mandibular irregularity values. According to these results, subjects with a Class II division 2 malocclusion would seem to show a response to treatment with variations similar to all other Angle classes.

The limit of 5 mm in pre-treatment lower crowding was useful in establishing a prognosis in the sample studies. In the group with initial severe crowding, all but one subject (83 per cent) developed unacceptable lower irregularity after retention.

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Acknowledgements

The authors would like to thank Dr Eliseo Plasencia.

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