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SCIENTIFIC SECTION

Extractions as a form of interception in the developing dentition: a randomized controlled trial

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Objective: To determine if the extractions of lower primary canines are an effective procedure to relieve crowding of the labial segment.

Study design: randomized controlled trial.

Subject sample: 83 cases were collected in clinics in Italy, Germany and Wales. The groups were followed over a 2-year period.

Method: Subjects were randomly allocated to a primary canine non-extraction or extraction group. Dental casts of the patients were collected at the start and at the recall period of the trial. The outcome measures recorded were lower incisor crowding, arch length, intermolar width, overbite, overjet, lower clinical crown heights and lower incisor inclinations.

Statistics: The Mann–Whitney test was used to compare the differences between the extraction and non-extraction groups.

Results: In both groups, crowding reduced 1.27 mm in the non-extraction group and 6.03 mm in the extraction group. The difference between the 2 groups was 4.76 mm ($P<0.05$). The arch perimeter decreased more in the extraction group by 2.73 mm ($P<0.05$). As the incisor inclination stayed essentially the same, the loss in arch length was attributed to the molars moving forward. The net gain from extracting deciduous canines was 2.03 mm.

Conclusions: There was a reduction in lower incisor crowding as a result of lower primary canine extraction. However, arch perimeter decreased more in the extraction group leaving less space for the eruption of the lower secondary canines.

Key words: Interceptive orthodontics, extraction of primary canines, incisor crowding, randomized controlled trial

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Introduction

In the developing dentition, clinicians are constantly confronted with the decisions concerning the potential for future incisor crowding. This has resulted in a variety of interceptive orthodontic measures being proposed to avoid or minimize lower incisor crowding and orthodontic treatment at a later date.[1] These include:

- discing deciduous teeth;
- balancing extraction of deciduous canines;[2–4]
- serial extractions;[5]
- space maintenance with orthodontic appliances.[6]

This paper is based upon the Chapman Prize winning essay of the British Orthodontic Society, awarded in 2002.

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As a general rule, children with crowding of between 4 and 9 mm traditionally had extractions of the primary canines.[7] This treatment was recommended to encourage the improvement of incisor alignment or to prevent a periodontal condition from developing. The extraction of primary canines is also believed to allow the mandibular permanent incisors to unravel.[7] For example, Killingback found that the loss of lower deciduous canines produced an improvement in the labio-lingual alignment of crowded lower incisors and also led to significant de-rotation of crowded lower incisors.[8] This occurred particularly where the primary canine was extracted shortly after the lower permanent incisors erupted.

The extraction of a tooth is an irreversible action having social as well as economic consequences.

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Extraction of deciduous canines costs the NHS in the general dental services £9.40 under local anesthesia and £16.60 under general anesthesia, with possible total yearly costs to the NHS in excess of £250,000. In a recent study of orthodontic extractions carried out general anesthesia, 49 per cent of the extractions carried out in the 10–14 per cent age group were for orthodontic reasons.[9] When Bradbury evaluated the patterns of extractions within the British Orthodontic Hospital Service,[10] he found that the greatest proportion of primary teeth prescribed for extractions were canines (40%) with 96 per cent of them being free from caries or restoration. The highest proportion of primary teeth were extracted in the 8–9 year-old age group this reflecting the general principle of interceptive measures taking place.

It is likely that approximately 50% of clinicians recommend extraction of primary teeth to alleviate lower incisor crowding, whereas 50% do not, as they believe there is to be no long-term benefit from the procedure and indeed feel there to be the possibility of increasing the crowding problem.[11]

Aim

The aim of this article is to determine if the extractions of lower deciduous canines are a worthwhile interceptive procedure to relieve crowding of the lower labial segment.

Null hypothesis

Extraction of primary canines has no effect on:

- lower incisor crowding;
- arch length;
- intermolar width;
- overbite;
- overjet;
- lower clinical crown height;
- lower incisor tooth inclination.

Subjects and methods

Patients were collected from dental clinics in South Wales, Italy and Germany. The sample size was determined from the parameter of arch length. With the likely change in arch length being half of the deciduous incisor (3 mm) with a standard deviation of 2.8 mm, a power of 0.85 with significance at the level of 0.05 would require a sample size of 35. A drop-out rate of 15 per cent was anticipated; therefore, a total sample of 80 would be appropriate. The inclusion criteria were as follows:

- patients should be Caucasian aged between 8 and 9 years old;
- crowding of the lower incisors greater than or equal to 6 mm, according to the irregularity index of Little (1975);[13]
- Class I type occlusion as indicated by the molar relationship;
- the lower molars should have a good long-term prognosis;
- overbite should be within normal limits.

Ethical approval

The project was approved by the relevant ethical committees and all patients were treated according to the Declaration of Helsinki.[12]

Random allocation method

Once the inclusion criteria were met the patients were allocated at random to extraction of primary canines or observation groups. Simple randomization was the method of allocation treatment. A restricted randomization of allocation was used in blocks of 50 to ensure that equal numbers of patients were allocated to each of the treatment groups. The random allocation was then concealed in envelopes labeled with the study identification number and held in a central place.

Impressions were taken when the patient agreed to the trial. This served as the baseline for the initial crowding (DC1). Final impressions were obtained when patients had been observed for a minimum period of 1 year (DC2).

Outcome measures

The outcome measures recorded from the dental casts at DC1 and DC2 were:

- Lower incisor crowding according to Little's Index.[13]
- Arch length.

The segmental arch length technique described by Bishara was used.[14] In this research, only the arch length mesial to the permanent first molars was measured. The tips of the measuring instrument were placed in the buccal embrasures near the contact points between the teeth or on the alveolar ridge, where the teeth are expected to contact one another in ideal alignment. Measurements were undertaken according to the following steps: the posterior parts of the arch from the mesial contacts of the first molars to the distal contacts of the canines were measured. The arch lengths around the canines were measured. These lengths were added to the lengths of the posterior segments. The anterior segments extend from a point on the cast between the central incisors to the mesial contact points of the canines. The sum of all these segments on both sides represents the arch length:

- intermolar width;
- overbite;
- overjet;
- lower clinical crown heights (recorded in mm);
- lower incisor tooth inclinations.

Measurement method

All linear measurements were recorded manually with Vernier Calipers. Tooth inclinations were measured with the Tooth Inclination Protractor and is a non-invasive method of measuring incisor inclinations on dental casts.[15,16]

Method error

Observer bias was reduced by ensuring that the examiner was blind to whether the patient had received an extraction or non-extraction treatment. All dental casts were measured in a random order so that the same patient's start and completion of trial casts were not measured consecutively.

Examiner calibration and reliability

Measurements made in this sample of patients were made by a single examiner. A pilot study consisting of 30 dental casts was used and 2 examiners (author and gold standard) carried out the calibration. Reliability was evaluated by RMS and Student *t*-test.

Statistics

The outcome measures recorded from the dental casts were analyzed using the Mann–Whitney test as the results were non parametric.

Results

Examiner calibration and reliability

The RMS value for the operator versus the gold standard for incisor inclination was 1.67 degrees. Paired *t*-tests indicated no systematic differences ($P<0.05$) between the recordings, indicating good consistency between first and second measurements. The mean difference of the scores for each of the outcome measures was less than 0.07 mm.

Trial profile and summary statistics

The trial profile of the patients involved in the study is shown in Table 1. Of the original 97 patients recruited in the study, 83 patients returned for the final records. This represented a success rate of 86 per cent. The primary reason for failure of the patients to return was because patients had moved away from the area.

Table 1 Profile of a randomized controlled trial to determine if the extractions of lower deciduous canines are a worthwhile interceptive procedure to relieve crowding of the labial segment

	Extraction (*n*)	Non-extraction (*n*)
Received treatment	55	42
Follow-up	53	30
Withdrawn	0	0
Intervention ineffective	0	0
Follow-up	2	12
Other	0	0
Completed trial	55	30

Total number of patients: $n=97$; randomization: $n=97$.

Table 2 Recall timings of extraction and non-extraction treatment in months

Type of treatment	*n*	Mean time	SD	Minimum	Maximum
Extraction	53	19	6	12	32
Non-extraction	30	16	5	12	32

The time of recall for the patients was 1–2 years after the initial impressions were taken. In the extraction group, the mean time of recall was 19 months, whilst in the non-extraction group, this was 16 months. Table 2 shows the distribution of the recall times for the different treatment modalities.

The outcome measures of the various parameters measured are reported below. These are summarized in Table 3.

Irregularity Index. The baseline Little scores were tested for normality and not found to be normally distributed. However, the changes in the Little's scores were normally distributed. The results using the Kolmogorov–Smirnov test indicated that there were no statistically significant differences between lower incisor crowding at baseline between the extraction and non-extraction groups. The Mann–Whitney test showed statistically significant differences in the change in Little's Index between baseline and follow-up ($P<0.05$). The improvement in crowding was 4.43 mm in the extraction group and 2.44 mm in the non-extraction group.

Arch length change. With respect to arch length changes, the total arch length decreased more in the extraction group compared with the non-extraction group. This

Table 3 Mean scores of the various parameters represented in the different treatment modalities

Treatment	Little's Index L1	Little's Index L2	L1–L2	Arch length change	Inter-molar change	Over bite change	Over jet change	Clinical height changes (incisors)				Incisor inclination changes			
								Right		Left		Right		Left	
								Lateral	Central	Centrals	Laterals	Lateral	Central	Centrals	Laterals
Extraction	$n=53$														
Mean	11.82	5.79	6.03	3.16	0.11	−0.76	−0.12	8.27	7.06	8.29	7.26	7.49	5.79	7.67	5.76
SD	4.12	4.74	4.44	2.95	1.31	0.98	1.06	0.65	1.37	0.73	0.73	0.97	1.23	0.85	1.35
Non-extraction	$n=30$														
Mean	10.02	8.75	1.27	0.43	−0.32	−0.37	0.28	7.63	6.63	7.76	6.66	7.39	5.71	7.34	5.84
SD	2.95	3.78	2.44	1.51	0.78	0.98	0.91	1.28	0.94	1.43	1.08	1.08	1.50	1.07	1.23
Total	$n=83$														
Mean	11.17	6.86	4.31	2.17	−4.71	−0.62	2.35	8.04	6.90	8.10	7.04	7.46	5.76	7.55	5.78
SD	3.97	4.62	4.46	2.84	1.16	1.00	1.02	0.97	1.08	1.02	0.91	1.00	1.32	0.94	1.30

was recorded at 2.95 mm compared with 1.51 mm for the treatment groups, respectively ($P < 0.05$).

Inter-molar change. The inter-molar distance showed little change in both groups, although there was a small decrease in the non-extraction group and a smaller increase in the extraction group This was revealed a 0.37 mm decrease and 0.11 mm increase, respectively ($P > 0.05$).

Overbite change. There was no difference in overbite in the extraction group compared with the non-extraction group ($P = 0.06$).

Overjet change. There was no difference in overjet between the groups ($P = 0.06$).

Clinical crown height. The clinical crown heights were statistically greater in the extraction group compared to the non-extraction group (mean heights for the four incisors) ($P < 0.05$).

Incisor inclination. There were no statistically significant differences in incisor inclination for extraction and non-extraction groups ($P > 0.05$).

Discussion

This randomized controlled trial studied the dental arch parameter changes of a group of patients between 8 and 9 years of age over a 2-year period. For both the extraction and non-extraction groups we found that incisor crowding reduced over time. Importantly, the arch perimeter decreased more in the extraction group and, as the incisor inclination stayed essentially the same, the loss of arch perimeter must have resulted from greater forward movement of the lower molars in the extraction group. This means that the space for the erupting lower permanent canine has been compromised. As a result, despite extraction of the deciduous canines, significant crowding was still present.

The series of photographs in Figures 1 and 2 shows 6 sets of lower study models. It represents the range of changes in the amounts of incisor crowding with time in both types of treatment modalities at T1 and T2. In the extraction set of treatment cases, some cases showed a significant improvement of incisor alignment (but at the expense of arch length Figure 1, Case 1), whereas other cases showed little if no improvement in incisor irregularity (Figure 1, Cases 2 and 3).

In this study, an improvement of incisor crowding was deemed to have occurred when there was a 50 per cent reduction in incisor crowding from the original score or when a remaining irregularity score of less than 0.5 mm per contact point (total score of 2.5 mm) was recorded.

In the extraction cases, there were improvements in incisor crowding in 15 out of the total of 53 extraction cases. This meant that 72 per cent of the cases showed no clinically significant improvement according to the set criteria. Therefore, there is a 1 in 4 chance of improving incisor irregularity.

However, when the total amount of crowding in the arch was taken into consideration (this was done by adding the loss in arch length to the incisor irregularity), the number of cases with less than 2.5 mm of crowding was 3 out of 53. This meant that 94 per cent of the cases showed no clinical improvement in incisor alignment and a decrease in arch length according to this set criteria. This represented 1:20 chance of the lower incisor improvement as a result of extractions.

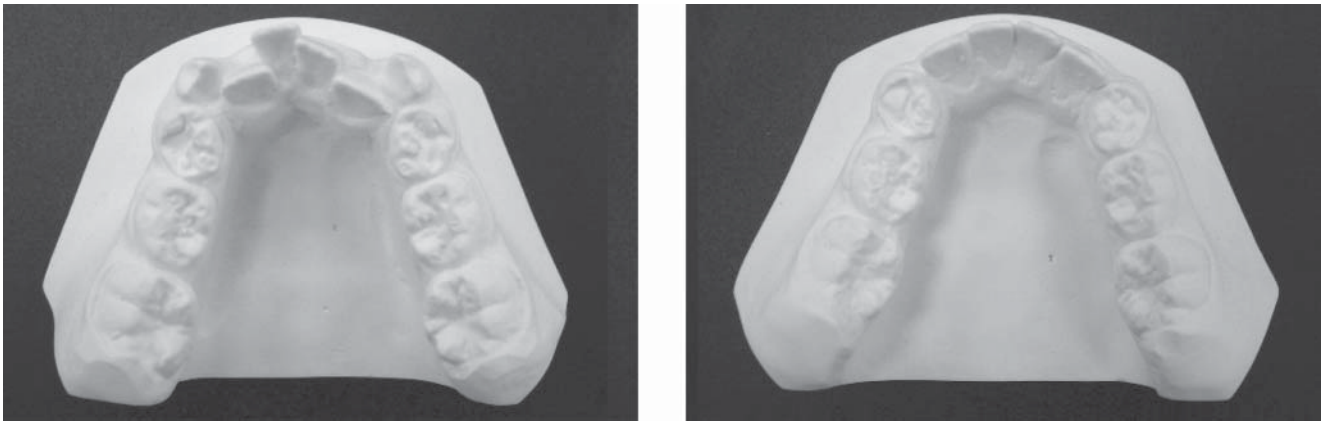
In the non-extraction group of cases, a range of incisor crowding changes was also seen. These are represented as 3 sets of lower study models in Figure 2, Cases 1–3. These cases show the difference in incisor crowding at the start of the study, T1 and at the end of study, T2. In all of the extraction cases, the total crowding score at the end of treatment was in excess of 2.5 mm with only 2 out of 30 exhibiting a 50 per cent improvement in incisor irregularity.

Crowding is present at the end of the trial in both groups and it seems that there is no real added benefit in extracting primary canines. In fact, the overall arch perimeter has been reduced and may contribute to greater crowding once the permanent canines have erupted. In addition, no reliable predictors have been found to identify parameters that can predict the amount of incisor crowding with time.[17,18] The evidence from this study and from the reports discussed shows that, when cost effectiveness and risk/benefit assessments are added to the treatment outcome, the efficacy of early extractions of deciduous canines, as a treatment modality is questionable.

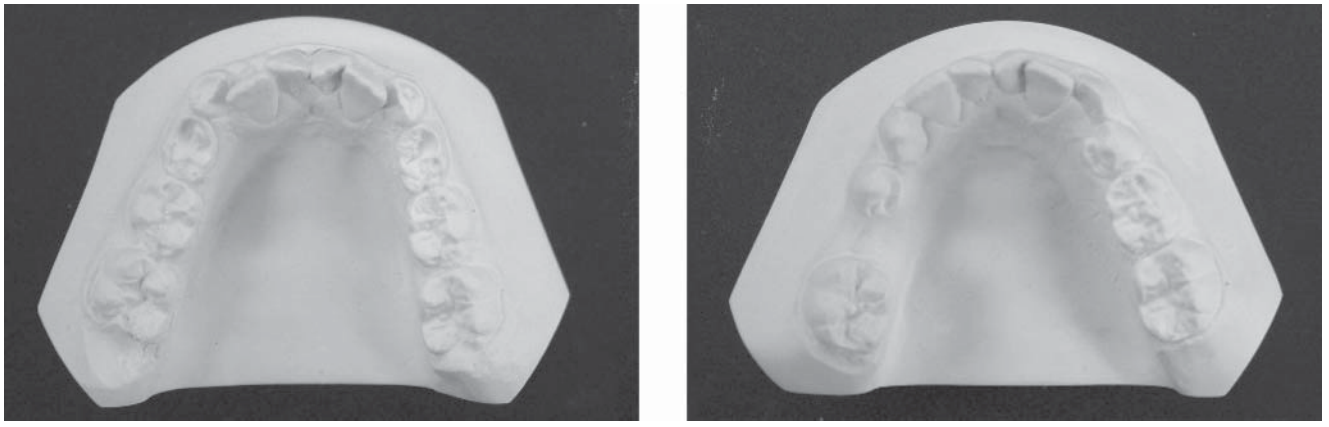
The changes in incisor angulations were similar for both the extraction and non- extraction group. This suggested that the incisors behaved similarly whether extractions or non-extractions of the canines were carried out. This supports the evidence that there is no adverse movement of the lower incisors in a normal group of 9-year-old patients.[19]

These incisor inclination results seems to contradict other research reports[20,21] and one possible explanation may be the method used to measure the incisor inclinations. Most research studies have made use of conventional radiographs that are prone to errors as a result of the amount of 'noise' in the area of interest.[22–24]

Case 1



Case 2



Case 3

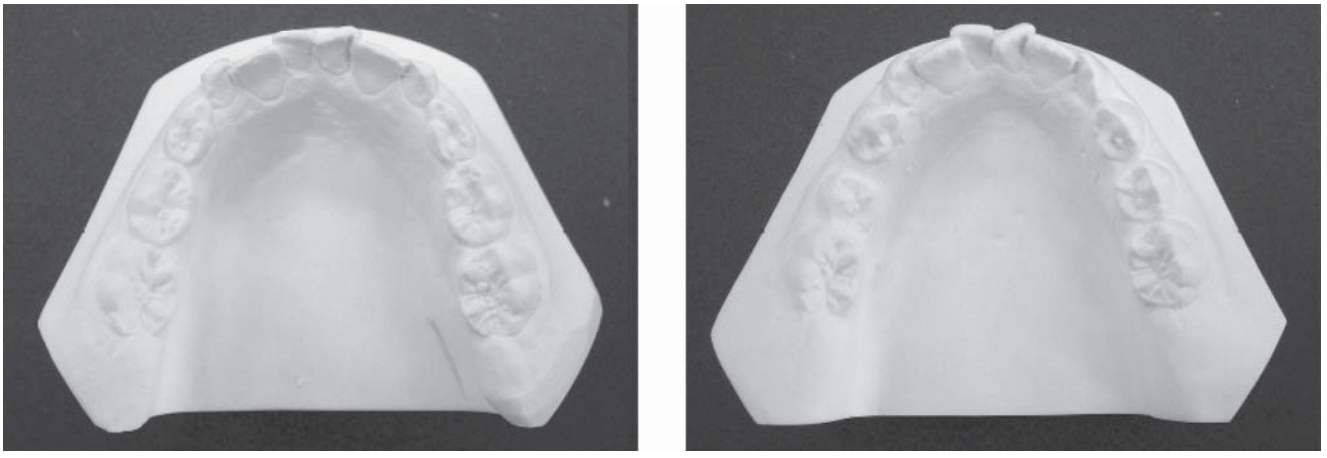
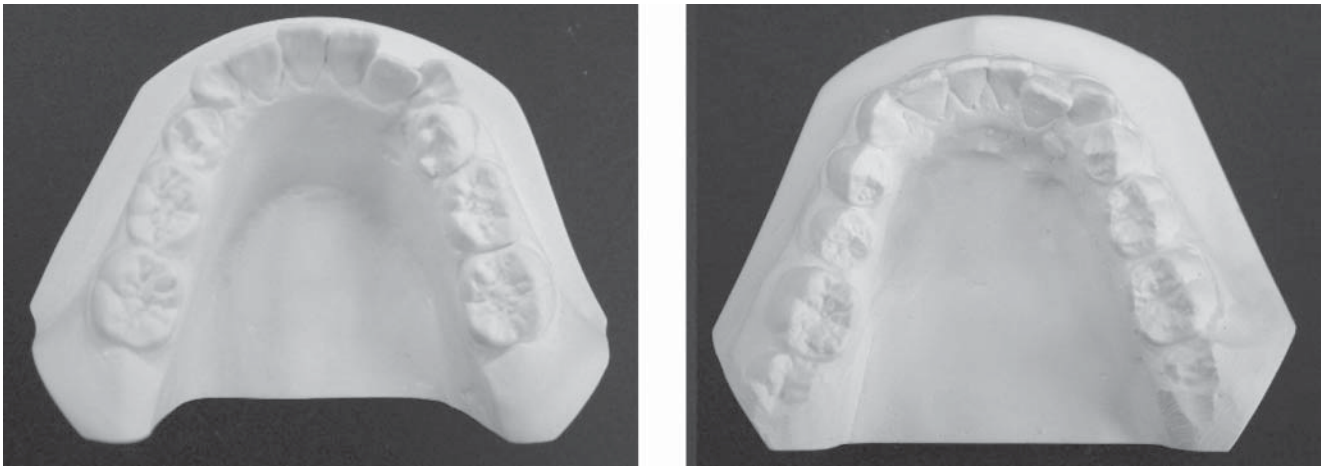
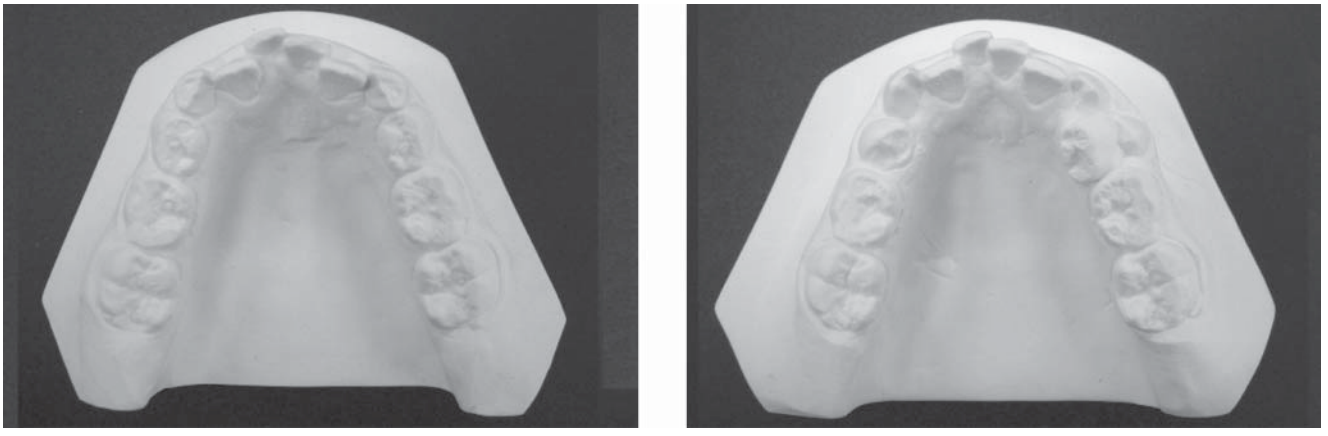


Figure 1 Extraction treatment case at T1 and T2

Case 1



Case 2



Case 3

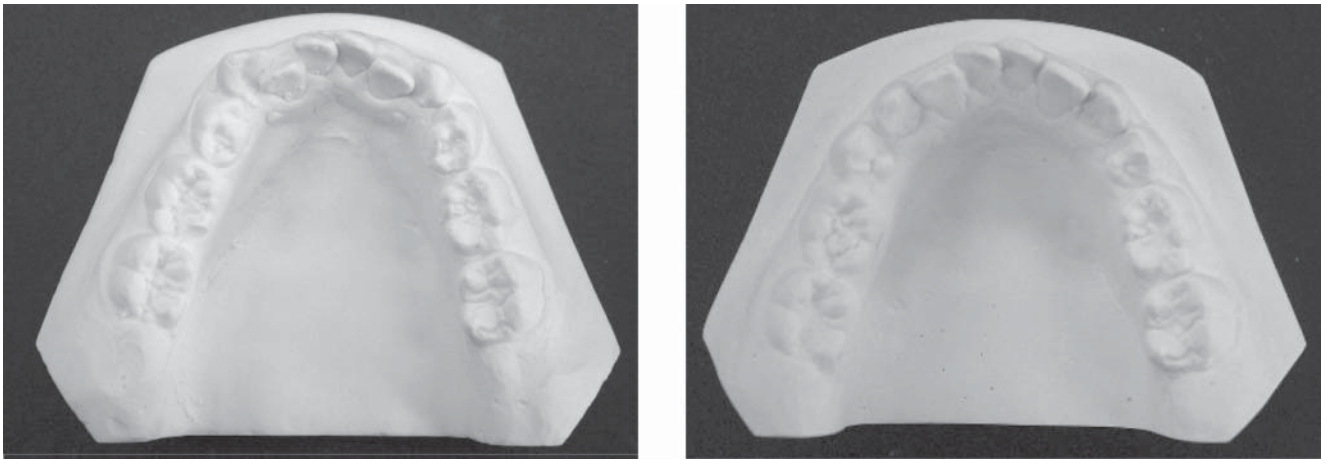


Figure 2 Non-extraction case at T1 and T2

Conclusion

The following conclusions may be drawn from this randomized controlled trial:

- The amount of lower incisor crowding was reduced to a greater extent in the extraction group.
- The arch length was reduced to a greater extent in the extraction group, suggesting the molars had migrated forward.
- There is a 1 in 4 chance the lower incisor crowding will be improved as a result of extractions but this will be at the expense of arch length.
- There is a only 1 in 20 chance that the amount of crowding will improve in the arch when extractions occur.
- It would appear that the benefits of extracting lower deciduous canines for the 'relief' of lower incisor crowding are questionable.

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Authors and Contributors

CHK was responsible for the recruitment of participants, obtaining funding, data collection, analysis of results, critical revision and final approval of the article. PD was responsible for obtaining funding, data analysis, critical revision and final approval of the article. SR was responsible for study design, obtaining funding, data analysis, critical revision and final approval of the article. FM was responsible for study design, recruitment of participants, data collection, contribution of comments to article and final approval. WH was responsible for study design, recruitment of participants, data collection, critical revision and final approval of the article. CHK is the guarantor.

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