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Does a true knowledge of dental crowding affect orthodontic treatment decisions?

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Summary

Objectives - To assess whether a true knowledge of crowding alters treatment decisions compared to estimates of crowding.

Material & Methods - 36 orthodontists were asked to estimate crowding using visualisation on eight mandibular arch study models and to indicate possible extraction choices. For each model the intermolar widths, intercanine widths, and clinical scenarios were identical, but the true crowding varied from 0.2mm to 8.4mm as to a lesser extent did the curve of Spee. 11 orthodontists repeated the visualisation exercise after 2 weeks to assess reliability. All 36 of the orthodontists were asked to repeat the treatment planning exercise on the same models, but this time were provided with the true amount of crowding in each case.

Results – When the 36 orthodontists used direct visualisation of the models to assess crowding, the range of their estimates of crowding increased as the crowding increased. As might be expected, they also tended to move towards extraction treatments as the crowding increased ($p=0.013$, $OR=3$). Although the reliability of the repeat estimates of crowding were moderate, the mean estimates were greater than the true crowding for each model. When orthodontists were presented with the true amount of crowding, rather than their estimate of crowding, it had a significant effect on the decision to extract, with fewer orthodontists recommending extractions.

Limitations - The principal limitation of this study is that it was a laboratory based study and utilised just the mandibular arch model for estimation and treatment planning.

Conclusions - Direct visualisation may overestimate the amount of crowding present. When the true amount of crowding is known it can lead to more consistent treatment planning, with the decision to extract fewer teeth in the borderline cases. A formal space analysis is likely to assist with treatment planning.

Keywords: Crowding, extraction, non-extraction

Introduction

The accurate assessment of crowding is an essential part of orthodontic diagnosis and subsequent treatment planning and may be affected by a number of factors. The principal factors are the mesio-distal tooth widths and arch length. Other factors can include arch form, arch symmetry and curves of Spee, the correction of which may require, or sometimes create space and therefore affect the assessment of crowding (1). In an attempt to more accurately quantify the effects of these different factors a number of formal space analyses have been developed (2-7), the most popular probably being the Royal London Space analysis (8,9). The purported benefits of such analyses include consistency in treatment planning and as an aid for trainee orthodontists when assessing space requirements.

Part of a previous study investigating the reliability and accuracy of clinician's estimates of crowding, looked at which were the most popular methods of determining the degree of crowding present (10). Despite being offered instruments such as a ruler, calipers, brass wire or dividers to aid measurement "eyeballing" or direct visualisation was the only method employed by all 62 orthodontists taking part in the study. This was despite the fact that the majority admitted to having been trained in the use of a formal space analysis as part of their postgraduate education. In the same study, how estimates of crowding might be translated into diagnostic decision making was also investigated. Each orthodontist was asked to estimate crowding and state their preferred method for the relief of crowding on eight mandibular arch stone models, where the only differences were the degree of crowding present. Tooth size, arch size and arch shape were the same in all cases. Although the level of experience of the orthodontist did not affect the accuracy of estimating the amount of crowding, there were large differences in the estimates of crowding between and within the orthodontists over time. Estimates of crowding varied by as much as 15mm for the same model between orthodontists and by up to 3mm by the same orthodontist over time. Despite the large variation in estimates of crowding, there was less variation in the treatment decisions of whether to treat with extractions or not. In general as the degree of estimated crowding increased, so clinicians were more likely to move from a non-extraction towards an extraction treatment approach and from the extraction of second premolars towards the extraction of first premolars. The same clinicians were also more likely to agree on the treatment approach when there was either a small or significant amount of crowding present. However, the greatest disparities in treatment planning were seen when there was a moderate amount of crowding.

The validity of making extraction decisions based solely on a visual estimate of crowding on study models has been questioned in the past (11), with visualisation usually leading to an overestimation of the amount crowding present (12). In most cases, additional information from special investigations, such as radiographs, often adds little to the crowding assessment and subsequent treatment planning (13, 14, 15). The aim of the current investigation was determine whether knowledge of the true amount of crowding would lead to more consistent treatment planning. As yet no studies have investigated whether or not there would be a difference in proposed treatment plans if orthodontists were provided with information on the true amount of crowding present, versus purely visualisation of the crowding. If such a difference were to be found then this would be important for orthodontists as it would have an impact on the way in which data on the amount of crowding present should be collected, using methods other than direct visualisation.

The null hypothesis of the present study was that treatment decisions are independent of a knowledge of the true degree crowding.

Materials and methods

The typodont setups were as those produced for the Wallis *et al*. (2013) study on estimates of crowding (10). Eight typodont setups were used in this study to create eight mandibular arch study models. The acrylic teeth used were identical in each set up, as were the intercanine and intermolar widths. However, each typodont was set up with varying degrees of crowding (10). Silicone impressions were taken of the eight typodonts and the models cast in Kaffir D dental stone (Dentalstone KD Nottinghamshire, UK) (Figure 1). The models were then scanned using an Ortho

Insight 3D scanner (Motion View Software, LLC) and virtual casts produced. The mesio-distal widths of the teeth and arch length of each virtual cast were measured by two examiners on two separate occasions using the Motion View scanner software (Motion View Software, LLC). The sum of the mesio-distal widths of the teeth on the scans was subtracted from the arch length in each case in order to give a value for the dental crowding within each arch. The crowding for the eight mandibular models ranged from 0.2mm to 8.4mm. The figures differed slightly from the measurements of crowding in a previous study, which used the same typodonts (10), as the mesiodistal widths of the teeth were measured on the scans of the models, rather than directly on the acrylic teeth before placement in the typodont as had been done previously. It can be argued the measurements on the stone model scans would be a truer representation of the clinical situation, as it is more difficult to assess the precise position of the individual contact points on such models due to tooth overlap. It is for this reason the crowding was measured directly on the stone models in this study.

In order to determine clinician's estimates of crowding and then to determine the effect of a knowledge of the true crowding on their treatment planning, two separate questionnaires were used at two separate time intervals. The questionnaires were identical with respect to asking clinicians to list their preferred treatment options (*e.g*. non extraction, interdental stripping, expansion and extractions). The only difference being that in questionnaire 1 they were also asked to estimate the degree of crowding present using visualisation for each model, while in the case of questionnaire 2 they were instead told the amount of crowding present in mm for each model before determining a treatment plan. Questionnaire 2 was completed a minimum of 2 weeks after questionnaire 1.

The eight mandibular models were numbered using a random number table in order to ensure there was no pattern of increasing or decreasing crowding as the participants proceeded through the questionnaire using the models. A total of 42 orthodontists were invited to take part in the study and 36 completed both questionnaires 1 and 2. Of these, 6 were consultant orthodontists, 2 were orthodontists undertaking higher hospital training, 8 were specialist orthodontic trainees, 9 were specialist orthodontic practitioners, and 11 were dentists with enhanced skills in orthodontics. Eleven orthodontists repeated the estimation of crowding a minimum of two weeks apart and at least 2 weeks prior to completing questionnaire 2 where the true crowding value was also provided, in order to see how reliable they were in their estimates of crowding. Full ethical approval was gained from the University of Bristol, application number 121352. The sample size was calculated using G*Power 3, and for a one sample t-test, significance = 0.05, power = 0.8 and a medium effect size = 0.5 the required sample size was 34 orthodontists (16).

Results

Data were analysed using Stata 13.1 (STATA Corp, College Station, USA) with significance pre-determined at $\alpha = 0.05$. The null hypothesis was that the treatment decisions are independent of a knowledge of the true crowding. The responses for both the assessment of agreement, and before and after knowledge of the true crowding have 1-1 matching of data and are thus correlated (17). As a consequence McNemar's test for marginal homogeneity was used and the exact rather than the commonly used asymptotic probability were calculated, together with the odds ratio and its associated exact 95 % confidence interval. The decisions on extraction or not in the questionnaire were transformed to a no / yes response rather than which tooth would be extracted or not. The results are summarised in Table 1.

The results would indicate there were no statistically significant differences in the repeat data, *i.e* the estimation of crowding and treatment decisions made between the 11 orthodontists over the two time periods (Table 1). Agreement between these measures was also assessed using Lin's coefficient of concordance (18), ρ_c, and Bland – Altman limits of agreement (19), and the respective values were $\rho_c = 0.97$, LOA -2.2 ~ 2.5 mm and bias = 0.2 mm. However, when the questionnaire was repeated for the 36 orthodontists where they had initially estimated the crowding and were then provided with the true amount of crowding in mm, there was a significant effect with respect to intent to extract as shown in Table 1 (p=0.013 and OR=3). In addition there was also a change in extraction pattern amongst those who still advocated extraction. The extraction pattern was changed on 42 occasions when the true amount of crowding was known (Table 2). In total 288 treatment plans were included in the analysis (36 orthodontists scoring 8 models), with the extraction pattern being changed in 14.6% of cases when the true amount of crowding was provided.

The complete distribution of extraction choices is given in Table 2. As might be expected, the orthodontist's treatment plans were more likely to involve extractions with increasing crowding. Models 3 and 4 had the least amount of crowding of just 0.2mm and none of the orthodontists recommended extractions to relieve the crowding. For model 2 with 8.4mm of crowding, all of the treatment plans involved extractions when the orthodontists had estimated how much crowding was present. However, eight participants changed their extraction pattern when the true amount of crowding was presented at the time of questionnaire 2. For models 1, 5, 6, 7 and 8 with between 0.96 and 2.48mm of crowding, there was a greater variation in the treatment plans between orthodontists, ranging from non extraction, interdental stripping, expansion to extraction.

Summary statistics for the estimate of crowding are given in Table 3. In all cases the mean estimated crowding was greater than the true value, and in 5 out of the 8 models a one sample t-test showed a statistically significant difference between the true and estimated values. In general both the difference between the true and mean estimated value and the scatter increased with increasing crowding. For example, models 2 and 7 with the greatest degrees of crowding of 8.4mm and 4.3mm respectively resulted in the largest range of estimated values of crowding (5mm to 15mm for model 2 and 4mm to 14mm for model 7). Conversely the estimated difference was smallest when the true amount of crowding was very small, as was the case for models 3 and 4.

Discussion

The results of this study indicate that in most cases, orthodontists are not particularly good at accurately estimating the amount of crowding present using direct visualisation, particularly as the degree of true crowding increases. In the case of all eight models the estimated mean crowding was an overestimate of that determined using the 3D scan, which supports previous findings (20).

When looking at the chosen treatment plans following visualisation, it would seem that as the amount of crowding increases, so orthodontists are more likely to change from a non-extraction to an extraction approach. This is perhaps not unreasonable. However, whereas participants were more likely to agree on a treatment approach if there was very mild or bordering on severe crowding, there was more variability in the approach when the crowding was between these two extremes (mild crowding being 0 ≤ 3mm, moderate 4-8, severe >8mm). For example in the case of models 3 and 4 with just 0.2mm of crowding, all of the orthodontists chose to treat these cases without extracting teeth. Similarly in the case of model 2 with moderate crowding of 8.4mm all of the orthodontists stated they would treat this case with extractions, although they differed somewhat in their extraction choices between first and second premolars. The majority of orthodontists also treated models 5 (1.2mm crowding), 6 (2.1mm crowding) and 8 (1.1mm crowding) with only mild crowding, without extractions. Much greater variation was observed when the crowding was moderate. For example in the case of models 1 and 7, with 3.9mm and 4.3mm of crowding respectively, there was more variation in the prescription whether or not to extract.

Interestingly, when the true amount of crowding was presented to the orthodontists, the treatment was more likely to change from an extraction to a non-extraction approach (Table 2). This may be related to the overestimation of crowding that seems to occur when crowding is determined using direct visualisation (12). For example, in the case of model 1, which had 3.9mm of crowding as measured using the 3D scans, the crowding was overestimated by many orthodontists, with a maximum overestimate of 6.1mm (Table 3). When informed of the true crowding, on 42 occasions the extraction pattern was changed and most of the changes were seen in the case of models 1, 2, 6 and 7. For model 1 (3.9mm of crowding) when the crowding was estimated using visualisation, 50% of the orthodontists reported they would treat this case using an extraction approach and 50% non-extraction. When the true amount of crowding was provided, 10 orthodontists changed their treatment plan (27.8%), with seven changing from extraction to non-extraction, two changing from non-extraction to extraction and one changing the extraction pattern from a mandibular incisor to two mandibular first premolars.

The highest number of changes observed was for model 7 (4.3mm of crowding) where 14 orthodontists changed their treatment plan (38.9%). This model had the greatest difference between the true and mean estimated crowding, which may explain the number of alterations in treatment approach. Six orthodontists changed from extraction to non-extraction, 2 from non-extraction to extraction and 6 changed their extraction pattern.

There were no significant differences found for interdental stripping or arch expansion treatment approaches between estimated and true measurements of crowding. This is probably because when these treatment approaches were chosen it was in those cases with the smallest amount of crowding and where the direct visualisation estimates differed little from the true amount of crowding.

The reliability assessment using Lin's concordance (0.97) shows there to be moderate agreement in the estimation of crowding for the 11 orthodontists who repeated the estimation study. It has been suggested that a correlation coefficient of 0.9 to 0.95 indicates moderate agreement (21). Although it would seem that orthodontists are moderately reliable when repeating estimates of crowding using visualisation, it doesn't necessarily mean they are good at estimating the correct degree of crowding in the first place. This is shown by the results in Table 3 and is in agreement with the findings of previous work (10). However, the orthodontists did seem to be reasonably consistent in their estimation from one time period to the next.

A knowledge of the true amount of crowding had a significant effect on the decision to extract as part of the treatment plan and resulted in more non-extraction treatments, suggesting orthodontists are more consistent in their treatment decisions when the true amount of crowding is known. If treatment plans can differ so significantly for the same clinician between estimated crowding and a true knowledge of crowding, perhaps a more formal space analysis is indicated to ensure more accurate and consistent treatment planning.

Conclusions

The conclusions that can be drawn from this study are:

- Direct visualisation is likely to overestimate the degree of crowding present.
- Knowledge of the true amount of crowding does not lead to a change in treatment planning if the degree of crowding is very mild and interdental stripping or arch expansion is the treatment of choice.
- Knowledge of the true amount of crowding can lead to a change in treatment planning if extractions are to be used.
- The proportion of cases treated with extractions may be reduced when the true amount of crowding is known.
- Orthodontists are more consistent in their treatment decisions when the amount of crowding is known.
- A formal space analysis is likely to assist with treatment planning.

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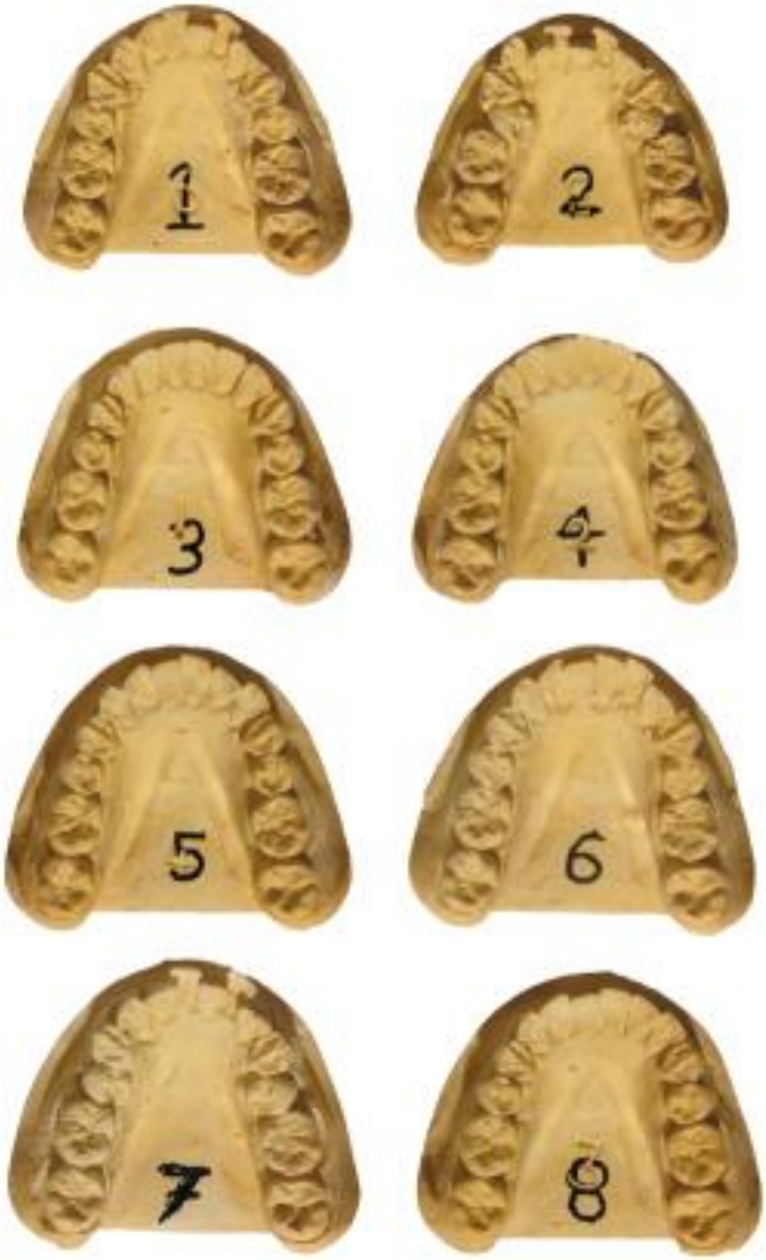

Figure 1 - The eight mandibular stone study models with different degrees of crowding but identical intercanine and intermolar widths.

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