A STUDY OF SMILE AESTHETICS PERCEPTION AMONGST DENTAL PROFESSIONALS, PATIENTS AND PARENTS TOWARDS IMPACTED MAXILLARY CANINE TREATMENT OPTIONS

by

LEONIE SEAGER

BDS, MJDF RCSEng, MFDS RCSEd

A thesis submitted to the University of Birmingham for the degree of

MASTER OF SCIENCE

Department of Orthodontics

School of Dentistry

University of Birmingham

November 2016

ABSTRACT

Introduction

The study was designed to evaluate the smile aesthetics of the different completed treatment options for impacted maxillary canines as perceived by orthodontists, dentists, patients and parents and also whether the treatment time influenced the treatment option chosen by patients and parents.

Methods

Piloted questionnaires consisting of digitally manipulated smile photographs of treated cases involving aligned canines, substituted first premolars, retained deciduous canines or gaps present were shown to four consecutive groups of Orthodontists, General Dental Practitioners (GDPs), patients and parents to complete. The visual analogue scale (VAS) was used objectively to perceive the smile attractiveness for each image. In addition, the patient and parent groups were given additional information regarding the average time taken to complete the treatment and asked to score on VAS.

Results

There were significant differences found in the VAS between the groups ($p = 0.002$) and between the treatment options ($P=<0.001$) There was no statistically significant difference found between the aligned canines and substituted premolars images by

the patient ($p = 0.2$) or parent group ($p = 0.5$). The patient and parent groups least preferred the treatment options where gaps were visible.

Conclusion

The patient and parent group showed similar perception in smile aesthetics for aligned canines and substituted premolars but patients and parents showed a strong dislike to any gaps present. The Orthodontist group was the most critical in terms of aesthetic perception.

DEDICATION

With heartfelt thanks to my family for their support.

ACKNOWLEDGEMENTS

I would like to thank the following people for their contributions to this research.

Dr Jinesh Shah - For enthusiastic supervision and guidance.

Professor Trevor Burke - For his belief in me, supervision and guidance.

Ms Helen Wright - For statistical advice and support.

Ms Michelle Minott - For clinical illustration support.

CONTENTS

Chapter 1: Literature Review

Chapter 2: Materials and Method

Chapter 3: Results

Chapter 4: Discussion and Conclusions

Chapter 5: Appendices and References

Appendices

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

BDA	British Dental Association
BDS	Bachelor in Dental Surgery
BOS	British Orthodontic Society
GDP	General Dental Practitioner
GP	Golden proportion
ICC	Intraclass correlation coefficient
ISFE	Intercollegiate Specialty Fellowship Examination (denotes Consultant level training)
LS	Leonie Seager (author)
MOrth	Membership in Orthodontics (denotes specialist in orthodontics)
PDC	Palatally displaced canine
RED	Recurring Esthetic Dental Proportion
VAS	Visual Analogue Scale

CHAPTER 1

LITERATURE REVIEW

Chapter 1 Literature Review

1.1 Background and incidence

The maxillary canine tooth is usually one of the last teeth of the permanent dentition to erupt, normally between the age of 11 and 12 years (Hägg and Taranger, 1986). With the exception of third molar teeth, the maxillary canine is also the most frequently impacted tooth and the prevalence of this has been reported to be between 0.2 - 2.8%, affecting female subjects 2.3 to 3 times more frequently than males (Peck, Peck and Kataja, 1994; Baccetti, 1998; Becker and Chaushu, 2015).

The majority of maxillary impacted canines are also ectopic. Ericson and Kurol (1987) reported an incidence of 85% being palatal to the dental arch and 15% buccal to the arch. A more recent study by Stivaros and Mandall (2000) found differing figures with 61% of their sample being palatal, 35% buccal and 5% in the line of the arch.

1.2 Aetiology of maxillary palatally impacted canines

There are many factors that could be involved when considering why the maxillary canine has become ectopic in a patient, with the exact aetiology being unknown. Becker and Chaushu (2015) describe four distinct groupings of causation;

1. Local hard tissue obstruction
2. Local pathology
3. Departure from or disturbance of normal incisor development
4. Genetics

Bishara (1992), advised that the most common cause for palatal canine impaction related to local factors, with important and often implicated features being the absence

of the lateral incisor, a variation in its size, or a disturbance in the timing of its root development and thus a departure from normal incisor development. This “guidance theory” suggests that the lateral incisor contributes to canine ectopia due to a loss in guidance for the eruption path of the canine, (Becker, 1995) which is the longest in the dentition, at a distance of 22mm. This theory has been supported in the literature, with research demonstrating a significantly increased incidence of maxillary canine impactions in patients with missing, peg-shaped or microdont lateral incisors (Becker, Smith and Behar, 1981; Mossey, Campbell and Luffington, 1994).

However, the aetiology for canine ectopia is often multi-factorial and several other factors have also been implicated in its aetiology (Bishara, 1992) such as;

- Discrepancies in tooth size to arch length
- Dilacerations of the canine root
- Ankylosis
- Pathology (such as a soft tissue cysts or neoplasm formation or hard tissue pathology such as odontomes and supernumeraries) causing displacement of the developing tooth
- An abnormal position of the canine tooth bud
- The presence of an alveolar cleft
- Prolonged retention or early loss of the deciduous canine.

The role of the prolonged retention of the deciduous canine in the aetiology of an impacted maxillary canine has been researched in depth. Lappin (1951) first postulated that the non-resorption of the deciduous canine was the cause of the impaction of the permanent canine. However, this conclusion was purely observational and it is equally

possible that the non-resorption of the deciduous canine root occurred due to an already aberrant location of its permanent replacement. Studies undertaken since Lappin's first observations have, however, demonstrated some evidence in support of this view, observing that the prophylactic removal of deciduous canines can in certain cases assist in the improvement and spontaneous eruption of the ectopically placed canine (Ericson and Kurol, 1986; Power and Short, 1993; Baccetti, Leonardi and Armi, 2008; Baccetti, Singler and McNamara, 2011).

These early studies however, were deemed by a subsequent Cochrane Systematic Review to be at high risk of bias due to lack of control groups and reporting issues and it was judged that there was "no reliable evidence with regard to the effects of primary canine extraction" (Parkin, et al., 2012). More recent well-designed randomised controlled studies have built upon the evidence base for effective interceptive intervention by demonstrating a 40% reduction in canine impaction when the deciduous canine was extracted (Naoumova, Kurol and Kjellberg, 2015), although variability in whether the permanent canine subsequently spontaneously erupted was high and the importance of the interception taking place when the patient is between 10 and 11 years old is emphasised (Bazargani, Magnuson and Lennartsson, 2014). This research though, fails to answer the question as to whether it is the retention of the primary canine that has directly caused the ectopia of the permanent canine or not.

Studies have contributed biological evidence pointing to genetics as a primary aetiological cause of canine impaction (Peck, Peck and Kataja, 1994) due to its association with not only other dental anomalies but also the presence of sex differences, population differences and familial occurrences. However, other authors

refute the basis of a purely genetic argument (Becker and Chaushu, 2015) citing that as well as unilateral canine impaction being more common than bilateral impactions (Ericson and Kurol, 1987), research has also not supported a finding of greater incidence in homozygous twins over dizygous twins (Camilleri, Lewis and McDonald, 2008) which might otherwise be expected if the aetiology was purely genetic. In a review of the latest literature regarding impacted canine aetiology, Becker and Chaushu (2015) assert that the evidence currently supports the endorsement that eruption of the maxillary canine is strongly influenced by environmental factors.

Peck, Peck and Kataja (1994) further describe that buccally impacted canines should be described as separate etiological entities to palatally impacted canines. Arguing that buccally impacted canines are usually associated with inadequate arch space, resulting in eventual eruption of the canine once space is made available. whereas palatally ectopic canines usually occur even in the presence of adequate arch space and most frequently result in the tooth becoming impacted, requiring subsequent surgical treatment to alleviate the impaction.

1.3 Risks and consequences

A palatally impacted canine usually requires treatment for a variety of reasons, including the avoidance of possible pathological sequelae such as tooth resorption (of both the canine and adjacent teeth), cyst formation and infection.

Root resorption of the adjacent lateral incisor as a result of canine impaction can be considerable, taking place rapidly and unpredictably but with a female preponderance (Ericson and Kurol, 1988). The incidence on plain radiographic films had been shown previously to be 12% (Ericson and Kurol, 1987) but this is now thought to be an underestimation of the actual incidence, with cone beam computer tomography (CBCT) scans showing a 48% incidence of root resorption affecting the lateral incisors (Ericson and Kurol, 2000).

The seminal and often quoted text by Shafer et al. (1963) suggests that canine impaction can also result in other negative sequelae such as;

- Migration of the adjacent teeth and loss of arch length
- Internal and/or external resorption of the canine tooth itself
- Follicular cyst formation
- Pain and infection
- Ankylosis
- Features considered to have negative aesthetic implications such as gaps and centerline shifts.

However, it is not certain that a palatally impacted canine will cause any of these negative aesthetic or pathological effects if it remains in-situ throughout the patient's entire life and no robust data is available indicating the incidence or impact of sequele

other than root resorption. Periodic radiographs, due to these potential complications, is recommended and the patient should be warned of the most common risks regarding the possibility of root resorption to adjacent teeth and cyst formation should they choose to leave the tooth in-situ (Ericson and Kurol, 1988).

1.4 Treatment choices

In line with the diagnosis and management of all patients, when a patient presents to the orthodontist they will undergo a comprehensive history as well as an examination, as other factors may well influence the choice of treatment and subsequently impact on the management choice selected for treating the palatally impacted canine. Several options will be discussed and patient factors, such as the desire to undergo orthodontic treatment, are as important (If not more important) than dental factors such as the status of the remaining dentition, position of the canine and presence of any other underlying malocclusion.

Making treatment decisions for cases with an impacted canine can often be difficult and, in many cases, several management options are available to the patient, giving both the clinician and patient a treatment planning quandary. On the one hand is the desire to align the tooth which is perceived to be important aesthetically and functionally, but also the knowledge that the treatment is likely to be time-consuming and potentially very difficult can also heavily influence the decision.

A national clinical guideline is available which discusses management strategies for the palatally impacted maxillary canine (Husain, Burden and McSherry, 2012),

although its evidence base is low. Should a palatally impacted maxillary canine be diagnosed, and interceptive treatment be deemed not appropriate or has failed to result in the successful eruption of the canine, then there can be several treatment choices which need to be presented and discussed with the patient including;

- No treatment and acceptance of the dentition as it is at presentation with either
    - maintenance of the deciduous canine (should it still be present) and acceptance it is likely to be exfoliated in the future
    - acceptance of a gap in the canine region should spacing be present
    - a prosthetic replacement if space is available in the canine region
- Surgical exposure of the canine and orthodontic treatment to align it
- Extraction of the impacted canine and orthodontic movement of the first premolar into its position
- Extraction of the impacted canine and acceptance of a gap or prosthetic replacement of the canine.
- Autotransplantation of the canine

Whilst surgical exposure and alignment of a palatally impacted canine is usually possible and is widely considered to be the gold standard treatment, it can substantially increase the overall treatment time and complexity. The success of the result being heavily influenced on whether its eruption and subsequent alignment was achieved without the occurrence of any damage to the adjacent teeth (Iramaneerat, Cunningham and Horrocks 1998; Stewart et al., 2001; Bazargani et al., 2012; Becker and Chaushu, 2003).

1.4.1 Alignment

Bishara (1992, p.4) stated that exposure and alignment of the impacted canine is "obviously the most desirable surgical choice," and whilst much of the evidence underlying this treatment choice is derived from case reports (Husain, Burden and McSherry, 2012), clinical experience demands a respect to the excellent results that can be achieved by the surgical exposure and orthodontic alignment of a palatally impacted maxillary canine. However, the view of this treatment being the 'gold standard' to be undertaken in the majority of cases is now being challenged, especially in the light of patients wishing to obtain quicker treatment, reduce treatment risks and balance resource efficiency with patient centred outcomes.

The generally perceived benefit of aligning an impacted canine tooth (even, at the expense of extracting a premolar unit when space is required to correct the overall malocclusion) is that a more acceptable occlusal result is achieved (i.e. canine guidance or mutually protective occlusion rather than group function) as well as optimizing the aesthetic result in terms of achieving dental symmetry, proportions of the upper anterior dentition and an ideal emergence profile. However the presence of a canine guided occlusion has not been shown in the literature to confer any great advantage over functional occlusions (Thornton, 1990) with a recent study demonstrating that whilst canine guided occlusion conferred some protective advantages, group function occlusion was found to have its own advantages of increased chewing efficiency and patient comfort (Miralles, 2015)

Two different surgical methods of exposing the canine have been documented, either

i) A closed exposure, where a gold bracket and chain is attached to the canine at the time of surgery and the overlying soft tissue flap replaced, or
ii) An open exposure, where the overlying soft tissue is removed allowing visualization of the tooth immediately following surgery.

A Cochrane systematic review of the literature published in 2008 (Parkin, et al., 2008, p.2) concluded that;

> "there is no evidence to support one surgical technique over the other in terms of dental health, aesthetics, economics and patient factors."

Evidence published since then has also failed to find a clinically significant difference (Parkin et al., 2015) although Becker et al. (2016) advised that, due to the variability in the factors involved in influencing the final outcome, it would be difficult to design and undertake a well-designed trial that would truly answer the question. Therefore, the choice of exposure if often left to the clinician's discretion and the preference of their previous experience.

However, despite canine alignment usually being considered as the preferred treatment choice by the orthodontic profession, adverse outcomes have been reported following orthodontic treatment to align an impacted maxillary canine, including differences in tooth colour, alignment, vitality of the canine tooth, probing pocket depth, crestal bone and gingival margin height (Woloshyn et al., 1994).

A study by D'Amico et al. (2003) which followed 61 children for 3.5 years after they had been treated orthodontically for impacted maxillary canines found that, whilst no patients were dissatisfied with the aesthetic result in terms of shape, alignment and inclination of the canines, evaluation of the result by orthodontists indicated only 57%

satisfaction when the tooth shape, tooth colour, tooth position in the dental arch and tooth inclination were aesthetically evaluated. However, the same orthodontists only identified 48% of the maxillary canines that had been previously impacted, thus casting doubt on the ability to aesthetically judge a canine tooth on whether it was previously impacted or not. The same authors also found a significant difference in the inclination of previously impacted canines compared to normally erupted canines, resulting in less frequent canine guidance on the working side during lateral excursion.

A more recent study by Parkin et al. (2015) examined the aesthetic result following alignment of palatally impacted maxillary canines that had either been treated by open or closed surgical treatment. The study again showed that there was an aesthetic impact of aligning impacted canines, with orthodontists and laypersons rating the un-operated side as looking the best in the majority of cases, although there was no difference between the closed and open exposure groups in terms of aesthetic judgment. Similar to the D'Amico (2003) study, orthodontists were only able to correctly identify the operated canine in 60.7% of cases, while laypeople only identified 49.7% correctly. This was calculated as being no more than chance. Although, as this was only a short-term follow up, the long-term significance is unknown.

Increased treatment times can also increase the risks with orthodontic treatment and apical root resorption as well as loss of hard and soft periodontal tissues being observed in teeth adjacent to the aligned canine (Woloshyn et al. 1994). The impact of increased treatment time on a patient's compliance is less clear cut, with patients exhibiting good oral hygiene from the outset being described as being more likely to

cooperate with other aspects of treatment and therefore in turn theoretically able to cope with treatment of a longer duration.

What is known, is that the opposite is true and that poor compliance demonstrated in missed appointments, failure to follow instructions and breakage of appliances definitely does increase treatment time (Skidmore, Brook and Thompson, 2006), thus making a lengthy treatment plan potentially even longer and further increasing risks.

The position of the unerupted canine can also further influence and add significant time onto the length of treatment, with Bazargani et al. (2013), showing that alignment of canines in “impaction zone 4 or 5” took on average 7.6 months longer than patients with canines in “impacted zone 1 or 2”. A review of the literature carried out by Mavreas and Athanasios (2008) also concluded that the presence of impacted maxillary canines prolonged treatment time, further compounded by the severity of the impaction as well as the patient’s age. However, there are no randomized controlled-trials available to be reviewed and therefore the evidence-base for the conclusion should be considered as low.

Despite recognizing these complications and the risks involved in aligning a palatally impacted maxillary canine, Szarmach, Szarmach and Waskiel (2006, p.220) concluded that;

“considering the major significance of the maxillary canine and its responsibility for the behavior of the frontal triad, it seems necessary to undertake surgical-orthodontic treatment in order to ensure proper occlusion and improve aesthetic appearance.”

1.4.2 Retaining the deciduous (primary) canine

Alternative options to impacted canine alignment include accepting the deciduous canine if still present, bonding resin composites to it to alter its appearance, accepting any residual spacing present or substituting the first premolar tooth for the canine. Possible reasons for selecting an alternative treatment option to the option of aligning the impacted maxillary canine include the wish to avoid the occurrence of complications, particularly in the presence of risk factors known to increase the difficulty of aligning palatally impacted canines such as an older patient, an unfavourable position of the canine tooth, and/or suspected ankylosis of the impacted canine tooth. Generalised factors such as the need or the wish to avoid lengthy and prolonged orthodontic treatment are also very important.

Bishara in his 1992 review (p.162) advised that,

"It should be remembered that the long-term prognosis for retaining the deciduous canine is poor, regardless of its present root length and the aesthetic acceptability of its crown."

This view however, is increasingly being challenged, as, whilst literature confirming how long a deciduous tooth can be expected to survive, its acceptability to patients as well as its impact on function is scarce, with only isolated case reports being available (Stanley, Collett and Hazard, 1996), many dental professionals have encountered patients where the deciduous canines have been successfully retained for several decades in terms of function and aesthetics in the view of the patient. Therefore, consideration of this treatment approach can be commended (Robinson and Chan, 2009).

There is also no evidence in the literature regarding how the retention of a deciduous canine may affect the aesthetics of the smile. The deciduous canine crown, in comparison to its permanent successor, is smaller in size but also lighter in colour. It is also likely to display an element of wear, although often if the deciduous canine lacks wear and exhibits a good size in relation to the permanent incisors, its presence may not be obvious at the patient's dental check-up, leading as a result to late diagnosis of an impacted permanent canine tooth.

One benefit of retaining the deciduous canine, especially if the root and coronal structure as well as its function and aesthetics are acceptable is that as well as minimal maintenance being required, bone and soft tissue architecture will be preserved. Should an aesthetic improvement be required this can be easily achieved with composite additions (Robinson and Chan, 2009). However, the patient should be warned that when the primary tooth fails, it is likely that there will be insufficient space for an ideal-size prosthetic replacement.

The patient may also be restricted in what prosthesis can be supplied in the future, with it being likely that inadequate bone or space will be available for a dental implant. A resin-bonded bridge is therefore likely to be the restoration of choice and with a 10-year survival of 65% (Pjetursson et al., 2008) it should be anticipated that the patient may require several replacements during their life-time, depending on the patients age at the time when the deciduous canine is lost. A minimally invasive, cantilevered design appears to be the bridge design demonstrating the lowest clinical failure rate (Wei et al., 2016).

1.4.3 Gaps

Should the patient's deciduous canine be subsequently lost, they may also choose to accept a gap in the canine region. Although there are no studies that have specifically examined the impact of a gap in the canine area, since the canine tooth is positioned in the aesthetic zone it can be postulated that it will have a significant impact on the patient's aesthetic concerns. Research has shown that a denture to fill a gap will most likely be requested if an anterior tooth is missing (Mukatash, Al-Rousan and Al-Sakarna, 2010).

Results of previous research have indicated that edentulousness can have serious negative psychological and social quality of life implications and it may therefore be a fair extrapolation that any missing maxillary tooth of the anterior segment may have a similar impact (Heinlein, 1980; Schwartz, 1987). Research has also shown that the replacement of these teeth with prostheses such as implants can subsequently improve psychosocial health (Chen, Yu and Zhu, 2012).

1.4.4 Premolar substitution

An alternative option of premolar substitution may seem particularly attractive when extractions would otherwise be required in order to make space for the subsequent alignment of the canine. In addition to a shorter treatment time, Thornton (1990, p.479) stated that, "There is no high-quality scientific evidence that one occlusal relationship is superior to the other…"

This statement still remains true and the alignment of a canine over its substitution by a premolar for the sole purpose of attaining improved function in canine guidance is not evidence based.

A paper by Simms (1977) also examined how, with orthodontics, premolars could substitute canines and concluded that, in many maximum anchorage cases with severe tooth-arch discrepancies, he could not see how the extra treatment time, patient compliance or mechanics required to align the impacted canine would be warranted. He suggested, quite pragmatically for the time, that further research into the ability of first premolar to function as a canine should be undertaken before any definitive answers could be given regarding the long-term success of this treatment option.

One of the reasons why it is postulated that the premolar might successfully be substituted for the canine is that the anatomy of the premolar crown has a buccal surface similar to the canine in terms of its convexity and cusp shape and therefore lends itself naturally to an effective camouflage. However, it also generally has a lower gingival margin and is usually narrower than the canine. Proponents of this treatment option therefore describe at depth in texts (Cobourne and DiBiase, 2015) how the premolar can be effectively camouflaged utilising techniques such as;

- Placing the premolar root more buccal in the maxilla to create a canine eminence
- Rotating the crown mesio-palatally to increase the mesiodistal tooth width, hide the palatal cusp and improve occlusal relation with mandibular canine
- Grinding the palatal cusp to reduce prominence
- Intrusion of the premolar to increase the gingival margin height combined with subsequent restorative build-up of cusp height.

However, there is no robust evidence available to advise the clinician on whether any of these techniques makes a difference in patient related or aesthetic outcomes. Only isolated case reports have been published in the literature describing this option of impacted canine extraction and premolar substitution (Altman, Arnold and Spector, 1979; Mirabella, Giunta and Lombardo, 2013). Whilst seeming a good treatment option for many patients, as these case reports showed good results and the achievement of a natural smile, there is currently no robust evidence in the literature reporting outcomes from on which to base this treatment choice on.

1.5 Smile psychology

The term ‘smile aesthetics’ in itself is vague and modern, encompassing that which is considered to be important in order to obtain what is perceived to be an attractive smile. The importance of its achievement in orthodontics and dentistry as a whole has gathered momentum over recent decades as society has placed greater emphasis on the desirability of an aesthetically attractive smile.

The importance of dentofacial attractiveness and its influence on the psychosocial well-being of an individual being has been well documented in the literature (Baldwin, 1980; Jenny, 1986; Shaw, et al., 1985; Graber and Lucker,1980) with the concept being underpinned by more recent studies by Van Der Geld et al. (2007) as well as a meta-analysis confirming this conclusion (Langlois et al., 2000). Malocclusion and a distinctive malposition of the teeth has been shown recently to have a higher psychosocial impact than the aesthetic details of the smile itself (Lukez, et al., 2015) Studies have also shown that individuals who are judged to be more attractive are also

regarded as more popular, desirable and attributed as being more intelligent with greater educational potential (Clifford and Walster, 1973; Huston, 1973; Shaw et al, 1985; Eli, Bar-Tat and Kostovrtzki, 2001; Newton, Probhu and Robinson, 2003).

1.6 The ideal smile

The concept of the 'ideal smile' is one that has been researched and developed in restorative dentistry as dentists strive to use modern materials and techniques to provide their patient with the most aesthetic smile possible. This branch of dentistry is often referred to as 'smile design' and a concise paper by Sharma and Sharma (2012) sums up the essential components in the assessment and formulation of the ideal smile.

The importance of this concept has also started to trickle into the world of orthodontics as orthodontists come to appreciate that subtle manipulations of fixed appliances along with the adjunct use of minimally invasive restorative techniques can be used to produce not just a Class I occlusal and incisal relationship but also a smile which is considered to be naturally beautiful. This requires an understanding of the relationships between the teeth, the gingiva and the lips and what it is that makes the smile aesthetic and desirable (Sharma and Sharma, 2012).

The 'ideal smile' is almost impossible to define due to variations across civilizations, cultures, ages and individuals. As cultures change, so does the perception of an aesthetic smile. Currently the concept of a white and expansive smile is usually seen

as the most attractive in Western culture but this perception will vary between groups and individuals.

True smile design is therefore about the clinician satisfying their patient's expectations as well as applying aesthetic principles and artistic creativity to match the patient's personality. It is therefore important that we do not use only our own judgment in what we perceive to be an attractive smile and recognise that the clinician's perception may not be the same as the patients or their peers, as studies have shown that there can be significant difference between the evaluations of different groups such as orthodontists, patients, dentists, parents and laypeople in terms of perceived smile aesthetics with them noticing and preferring different characteristics in the smile to each other (Brisman, 1980; Robertsson, Mohlin and Thilander; 2010; Cotrim et al., 2015).

1.7 Assessing the smile

The smile can be assessed in its relationships and features from four broad perspectives (Ahmad, 2005a-d);

- Facial
- Dento-Facial
- Dental
- Gingival

Examining the smile from the facial perspective allows its geometric properties to be judged in conjunction with other facial features such as the eyes and nose and its parallelism to such features as the interpupillary line, the incisal and occlusal plane.

The dento-facial perspective focuses on the lips relative to the anterior maxillary sextant in terms of midlines, the smile arc and the buccal corridor, whilst the dental perspective solely concerns the teeth and relates to the shape, size and inter-arch relationships of elements. The dental perspective is vital in the role of smile aesthetics, with features such as the presence of an ideal tooth width-length ratio (Cooper et al., 2012), the location of the incisal embrasures (Foulger et al., 2010), width of buccal corridors (Ioi et al., 2012) and even the inclination of the teeth (Xu et al., 2015) all being shown to have an impact on the attractiveness of the smile. Gingival aesthetics are also thought to be critical in patients with high smile lines and aspects such as the gingival zenith and gingival marginal heights should be evaluated.

The maxillary anterior sextant, of which the canine is a part, is the usual focus of research regarding smile aesthetics and therefore the canine is likely to have a role to play in the perceived attractiveness of a smile as well as in the definition of several concepts regarding smile aesthetics. Some of these concepts regarding the varying elements of a smile, along with their evidence base are described in the following section.

1.8 Components of a smile

1.8.1. Tooth shape

Although overall dental attractiveness has been found not to be dependent on only one feature of the dentition, in a hierarchy of importance in terms of dental attractiveness crown shape was ranked the highest (Ong, Brown and Richmond, 2006). Studies have since tried to determine the most aesthetic incisor shape, with Hussain et al. (2016) conferring with previous dental literature that the tapered-ovoid form is more preferable to the square tooth form, particularly in females, although there was individual variability and this must be taken into account during treatment planning if ideal and successfully perceived aesthetics are to be achieved. Previous work by Heravi, Rashed and Abachizadeh (2011) also found that rounded incisors were deemed as the most aesthetic by laypeople.

1.8.2 The smile arc

One concept defining anterior dental aesthetics is the attainment of a smile arc. Defined as the relationship of the curvature of the incisal edges of the maxillary incisors with the curvature of the lower lip in a posed smile (Sarver, 2001), in an aesthetic smile, the incisal edges of the maxillary anterior teeth should coincide with the curvature of the lower lip, the canine's incisal edge being in a close relationship with the lip.

A consonant smile arch with the lower lip is generally considered to be the most acceptable smile arc, although it is not a factor that solely seems to influence smile

attractiveness rating (Jansen et al, 2011). Kaya and Uyar (2013) found that differing smile arcs were preferred depending on the gingival display seen.

1.8.3 The dental midline

The dental literature (Johnston, Burden and Stevenson; 1999; Thomas, Hayes, and Zawaideh, 2003) suggests that dental midline discrepancies are the least noticed feature of the smile by laypeople, which is fortunate, as 39% of a population studied by Sheats et al. (1998) was observed to have a maxillary dental midline that did not coincide with the facial midline. Johnston, Burden and Stevenson, (1999) observed that maxillary dental midline discrepancies of up to 2mm were judged to be aesthetically acceptable, with this finding corroborated in another study by Silva et al. (2013). Instead, it seems that the axial angulation of the junction between the central incisors is judged as more important in terms of smile aesthetics, with angulations above 6 degrees being unacceptable when judged by orthodontists and 10 degrees when judged by laypersons (Thomas, Hayes, and Zawaideh, 2003).

1.8.4 Gingival contour and display

Achieving a healthy, balanced and symmetrical gingival contour is also considered to be a critical factor is achieving an aesthetic smile, especially in patients with high smile lines. The ideal class I gingival height is described as being bilaterally symmetrical with the gingival margins of the central incisors mirroring each other, being of a similar

height to the canine margins and with the lateral incisor gingival contour lying more coronal to that of the central incisors and canines (Rufenacht, 1990 pp 67-134).

The canine should also display a more elliptical gingival shape with the most apical point of the gingival outline positioned distal to the longitudinal axis of the tooth. This is known as the gingival zenith (Sarver, 2004). The interdental papilla should also completely fill the space below the contact area of the adjacent tooth, the presence of black triangles reducing the overall aesthetic outcome (Foulger et al., 2010).

An increase in gingival display has also been shown to negatively influence smile attractiveness scores and perception (Kaya and Uyar, 2013; Kaya and Uyar, 2016).

1.8.5 Proportionality

A sense of proportionality has also been established as a trait important to achieving an aesthetic smile.

Pythagoras, in 530BC, suggested that beauty could be defined as an exact mathematic concept, now described as the Divine or Golden Proportion (GP) (1/1.618=0.618) and this was also written about by Fibonacci in the Fibonacci sequence (Preston, 1993). The GP formula when applied to the smile emphasizes the relationships of the incisors with the canine and their relative proportions to each other when viewed directly from the front, thus the lateral incisor should be 62% of the width of the central incisor and the canine 62% of the width of the lateral incisor. This importance of proportionality and the application of the GP in smile aesthetics was first written about by Levin in 1978 when he observed that a ratio from 0.6 to 0.8 was viewed as being aesthetically

acceptable with harmony, (the chosen ratio being repeated from the central incisor) being more important than the actual ratio itself.

However, studies have shown that the GP is not often apparent naturally in the dentition (Hasanreisoglu et al., 2000; Ali Fayyad, Jamani and Aqrabawi, 2006) and achieving a perfect GP in the smile has also therefore fallen out of favour due to studies showing evidence for a preference instead towards the recurring aesthetic dental proportion (RED) when compared to the golden proportion (Ward, 2007).

The RED proportion takes into account the width-length ratio of the anterior maxillary sextant and therefore varies between individuals, factoring in the proportions of the tooth, face and body into its calculation. Its basis is similar to the GP in so far that the proportion of the successive widths of the maxillary teeth as viewed from the front should remain constant, progressing distally (Ward, 2001).

Different RED proportions have been shown to be preferred when correlated to different width-height ratios of teeth, with shorter teeth being favoured with a 80% RED proportion, average teeth favoured with a 70% red proportion and very tall teeth being preferred with the GP (62%) (Rosenstiel, Ward and Rashid, 2000). However, this study only evaluated the preferences of dentists.

A study by Sterrett, Oliver and Robinson in 1999 revealed that the ideal maxillary central incisor should have a width-to-length ratio of 0.75-0.85 and that it should be the dominant tooth in the smile. A similar figure was suggested by Cooper et al, (2012) who found the 82% width-to-height ratio as being perceived the most attractive, although significant differences between the aesthetic perceptions of their three groups (dentists, technicians and patients) were found.

The width-to-length ratio of the canine should also be similar to the incisors. If the aesthetics of Ward's (2007) study are to be taken into account then this ideal width-height ratio should be complemented by a 70% RED ratio progressing distally.

When judging the teeth sizes not from the front but individually, for an aesthetic maxillary tooth arrangement it is also stated that the canine, on average, should be between 8.9 and 10.1mm in length and 7.1-7.6mm in width, with the central incisor being wider than the canine by 1-1.5mm. The canine should also be of a similar crown height to the central incisor, being on average 1-1.5mm longer than the maxillary incisors (Sharma and Sharma 2012).

In terms of proportionality, due to differences seen in the literature, achieving a balance and harmony either side of the midline to provide a sense of symmetry is probably more important in making a smile attractive than following a set of figures.

1.8.6 Inclination

Axial inclination is also deemed important to smile aesthetics, with the long axis of the maxillary anterior teeth following a progression from the midline distally. When viewed from the midline the degree of mesial tipping should progressively increase.

Results of a recent study examining the effect of buccolingual inclinations of maxillary canines and premolars on perceived smile attractiveness indicated that smile aesthetics was significantly compromised when the canines were lingually inclined more than 12 degrees or 15 degrees when the premolar was evaluated. Buccally tipping the canines more than 6 degrees also reduced smile aesthetics (Xu, et al.,

2015). This is in line with the current preferred aesthetics of an overall broad full smile with minimal buccal corridor space (Moore et al., 2005) and corroborates previous findings and opinions that increased buccal corridors decreased smile attractiveness (Ioi, Nakata and Counts, 2009; Ioi et al., 2012; Zachrisson, 2003).

1.9 The role of the canine in smile aesthetics

Whilst research has assessed the perceptions of dental attractiveness in situations where canines are camouflaged as lateral incisors (Raynor, Barber and Spencer, 2015; Bukhary et al., 2007; Robertsson, Mohlin and Thilander et al., 2010; De-Marchi et al., 2014), there are few studies that have assessed the perceptions of dental attractiveness in relation to the substitution of premolars for canines and the other alternative treatment options for alignment of palatally impacted maxillary canines. It is also interesting that in the papers examining the aesthetics of canine substitution for lateral incisors, in the photographs evaluated by different groups often no mention is made of the fact that a premolar will need to substitute the canine. In this regard, in the computer simulated photographs there is usually still a tooth of canine proportions and gingival height next to the canine that has now been camouflaged for the lateral incisor.

Whilst the canine is not the most visualized tooth the maxillary anterior sextant, it has been said that; “The cumulative visual impact of the anterior dentition often transcends the sum of the individual parts.” (Morley and Eubank, 2001, p39). The canine may theoretically be considered as an important part of the aesthetic as well as the functional component of this sextant therefore, but is this actually true in reality?

A limited number of studies have been published assessing the aesthetic impact of altering smile aesthetic factors in the canine region. A study by Correa, Bittencourt and Machado (2014) examined the influence of altering the canine's gingival margin using digitally manipulated photographs and observed that laypeople were less sensitive than orthodontists with only asymmetry between the right and left canine greater than 1.5mm giving a significant difference in attractiveness rating for the layperson. This could have an important clinical application, as marginal discrepancy from the ideal may not only be apparent in premolar substitution cases but also when canines have been forcibly aligned. Although these gingival discrepancies may therefore be considered unacceptable to the orthodontist, it should be remembered that the patient's perception may not be the same and further treatment such as intrusion and restoration of the incisal edge of the premolar or gingival surgery to improve its gingival appearance may not actually be warranted and could be considered as overtreatment.

An opinion held by Anderson et al. (2005) that the shape of the maxillary incisors is more important that the shape of the canine in smile aesthetics was corroborated by a more recent study which assessed the aesthetic preferences for the shape of anterior teeth. In this regard, Heravi, Rashed and Abachizadeh (2011) found that the shape of the canines had no effect on laypeople's aesthetic perceptions.

In terms of the aesthetic results following different interventions for canine impactions, Altman, Arnold and Spector (1979), in their case series, reported that they could not detect any aesthetic difference between those patients who had impacted canine teeth aligned and those who had canine extractions. This data were not statistically analysed and the opinion of laypeople or patients was not taken into consideration in this

conclusion. Currently there are no other published studies that have compared the aesthetic perception of different types of impacted canine treatments or between the four groups likely to be involved in deciding between these treatment options.

As aesthetics has a huge influence on the perceived orthodontic outcome it is imperative that evidence-based information on this subject can be given to patients so they can make an informed treatment decision.

Patient concerns about their facial or smile appearance is likely to be influenced not by their GDP or orthodontist, but by their social environment and peers. Social status, cultural background and education level are all factors known to effect the evaluation of aesthetics (Heravi, Rashed and Abachizadeh, 2011).

Knowing that patients and orthodontists might judge clinical outcome differently is why examining aesthetic outcomes from the perceptions of different judging groups is important, as satisfaction criteria may vary considerably (Shaw, 1981).

1.10 Duration of orthodontic treatment

Being able to accurately predict treatment duration as well as prognosis may be considered a good practice builder, and studies have shown that patients who are given accurate information regarding treatment length also have a more reasonable expectation of treatment outcomes (Cunningham, Hunt and Feinmann, 1996).

The British Orthodontic Society (*Consent in orthodontics advice sheet*, 2015, p4) recommends that sufficient information regarding the likely length of treatment should be provided to the patient at the start of treatment. Whilst cost-efficiency in terms of

practice profitability or national health care is desirable, efficient and shorter treatment times may also be desirable in view of reducing the risks of any harmful side-effects of treatment.

1.10.1 Influence of impacted canines

Regarding impacted canines and treatment duration, results of a study by Irameerat et al. (1998) indicated mean treatment duration from exposure to de-bonding of 28.8 months, whilst a separate study by Stewart et al. (2001) demonstrated mean treatment duration of 28.3 months for the impacted canine group, being only 22.4 months for the control group who did not have an impacted tooth. The average duration of treatment for patients with bilaterally impacted canines increased to 32.3months.

However, this treatment time has also been shown to be significantly influenced by the position of the canine, with those in ‘impaction zone 4 and 5 taking approximately 7.6 months longer to align, compared with those in zones 1 and 2 (Bazargani et al. 2012). Interestingly, when examining the success of impacted canine treatment, a study by Becker and Chaushu (2003) found that the success rate in terms of canine alignment was only 69.5% in their adult group compared to 100% in their adolescent group. The adult group also required more than twice as many appointments in order to align the canine. Advancing age, as well as the presence of a higher impacted canine and dilacerated incisors were also found to be predictors for a longer treatment time by Ho and Lioa (2011). Thus the alternative options to canine alignment may be seen as more favorable the older the patient is at presentation.

1.10.2 Impact on preference of treatment

There are no data published regarding the duration of treatment and its effect on the perception of preference between treatment options, so although It might be reasonable to expect that a patient or their parent (who is intimately involved in the treatment process through giving consent to the treatment plan and attending appointments) may find a smile less or more preferable when given the additional information that the result took more or less time than a different result, there currently is no evidence on which to base this assumption.

Having acknowledged deficiencies in our knowledge on the smile aesthetics of different impacted canine treatment options from the perception of different peer groups, and also how treatment duration information may affect the perception of treatment preference, the present study is designed to give understanding regarding whether there are differences in the aesthetic perceptions between these different treatment options between different peer groups and also what the perception of the preference of these treatment options are when the treatment duration for each treatment options is also made available to the patient and parent groups.

CHAPTER 2

METHOD

Chapter 2 Method

2.1 Objectives

To evaluate the potential post-orthodontic smile aesthetics of the treatment options for impacted maxillary canines as perceived by orthodontists, dentists, patients and parents.

To assess if treatment time influences the preference of treatment options available to treat impacted maxillary canines by patients and parents.

2.2 Null Hypothesis

There is no difference in the perception of smile aesthetics between the different treatment options available for treating palatally impacted canines as perceived by orthodontists, General Dental Practitioner's (GDP's), patients and parents.

There is no difference in the preference of treatment options by patients and parents with regard to the time taken for treating a palatally impacted canine tooth.

2.3 Study Design

2.3.1 Questionnaire part one (smile aesthetics)

The photographic database at Royal Stoke University Hospital Orthodontic department was reviewed by the author (LS) to identify photographs of patients who had completed treatment for impacted maxillary canine teeth using different treatment options and satisfying the inclusion and exclusion criteria listed in section 2.4. One photographic image that was judged to demonstrate a natural and attractive smile, as well as satisfying the inclusion and exclusion criteria of the study, was selected to represent a baseline image against which other images would be judged. The baseline photographic image showed a case where the impacted canine had been aligned and ideal smile aesthetics and occlusion had been obtained at the end of the treatment. The baseline photograph was cropped to display only the teeth, gingiva and lips, and the image was digitally manipulated to ensure that the right and left sides of the photographic image were symmetrical.

Three other patient photographic images displaying the other treatment options were then subsequently used to give a template for the required changes in the canine region for the baseline image. Adobe Photoshop software (Adobe Photoshop®, San Jose, Calif) was used to manipulate these templates on the baseline image using the layer function of the software so that all images were identical except for specific changes made in the canine region.

The manipulated post de-bond intra-oral frontal view and extra-oral frontal smile view photographic images were incorporated into the study questionnaire.

Four different groups of judges consisted of an Orthodontist group which included either hospital consultants or specialist orthodontic practitioners on the General Dental Council specialist list, a GDP group which included dentists who do not routinely carry out orthodontic treatment, a Patient group consisting of patients between the ages of 11 and 18 who were considered to be 'Gillick competent' and who were therefore able to make the decision to consent and participate in the study for themselves and a Parent group consisting of parents/guardians who accompanied the patients to their orthodontic appointments were recruited and asked to complete a piloted questionnaire.

The Orthodontist and GDP groups were recruited from professional events such as continuing professional development meetings, and meetings held by professional bodies such as the British Orthodontic Society and British Dental Association.

The Patient and Parent groups were recruited and asked if they would like to take part in the study when they attended for their routine orthodontic appointments at Royal Stoke University Hospital and Birmingham Dental Hospital Orthodontic Department. At no time were the patients and parents asked to attend for any additional appointments to participate in this study. All participants were recruited consecutively (i.e. all eligible patients and parents attending a clinic were asked if they would like to participate in the study until sufficient numbers of questionnaires were completed).

The following information was given to each participant before they completed the questionnaire:

- A study information leaflet (in different formats for Orthodontists/GDPs, Parent group and Patient group (Appendix 1-3)

- Consent/assent forms in different formats for adults and children (Appendix 4)

The study information leaflet was initially given to every participant who agreed to take part in the study to enable them to fully understand their involvement in the study. If the participant agreed to take part in the study, written consent was then obtained using the study consent form depending on the age of the participant.

The photographic images of the patients used in the study were completely anonymous and unidentifiable and consent had been obtained at the patient's de-bond appointment to allow their photographs to be used for research studies. If this specific consent had not been obtained previously then an invitation letter was used to obtain their informed consent for the relevant images to be used in the study (Appendix 5).

The design and layout of the questionnaire was very specific and, apart from the Patient and Parent group having a second section, they were all laid out identically (Appendix 6-8). The cover page contained all the necessary instructions for the participant and an example of how to mark the VAS scale was also made available to the judge in order to ensure standardization was maintained when completing the questionnaire. If any of the judges had any queries, the principle researcher, (LS) was also available to answer any queries. All assessors were asked not to discuss the questionnaire with each other when completing it.

Key demographic information was collected for all participants on this first page of the questionnaire and the categories varied depending on the participant group. Age, sex,

occupation (if applicable) as well as the first part of their post-code was requested from all participants and, for the Orthodontists and GDP groups, information on their educational background and experience were also collected. Otherwise, the remaining questionnaire were completed anonymously. The following pages of the questionnaire then displayed the four different photographic images, related questions and the Visual Analogue Scales (VAS), which the participants were asked to mark accordingly.

The clarity of the questionnaires and information sheets was piloted prior to using them for the main study by asking 5 prospective subjects form each group to complete the documents. This ensured that the layout of the questionnaire was unambiguous, appropriate and acceptable for the chosen groups of participants. The time taken to complete the questionnaire was also recorded during the pilot and this was then used to inform participants in the main study of the likely time required for them to complete the questionnaire.

The questionnaires were printed on good quality printing paper (at least 100gsm) to produce good quality photo images with the correct colour and contrast, and to maintain this quality the highest quality print setting for each image was selected as standard. All questionnaires were printed from the same laser inkjet colour printer. Each page was also headed clearly with the case number to ensure accuracy of data collection. Only one treated case was displayed on each page.

To ask the first question of the study, a visual analogue scale of 100 mm was placed underneath each case and the participants were asked to place a mark on the scale according to their perception of attractiveness they for each case. This scale was labelled on the left by the descriptor “very unattractive” and on the right “very attractive”.

For both study questions, quantitative scoring of the social acceptability of the smile and the perception of the acceptability of treatment was assessed by measuring the distance from the most extreme left point of the line to the marked cross on the VAS using a digital caliper by the same calibrated assessor (LS).

2.3.2 Questionnaire part 2 (preference of treatment influenced by time)

The second part of the questionnaire was given only to the Patients and Parents judging groups. Each participant was given information regarding the average length of time taken to complete the different treatment options. This information was standardized so that the same information was given to each participant. Regarding the case where the deciduous canine tooth had been retained, they were also advised that it would be likely that this retained “baby tooth” would be shed at some point during the patient’s life at which time the space could either be replaced by a restoration of a similar size and shape or the residual space accepted.

The patient and parent judging groups were then asked to complete another 100mm VAS scale which was anchored on the left “most likely” and on the right “most unlikely” and asked to rate how likely it would be that they would wish to choose the different treatment options considering the length of time of treatment for each option and the additional information given to them regarding future likely scenarios.

Given that the Patient and Parent groups were aware of what treatment each image involved and the average duration of treatment, they were then shown all four images

on the same page at the end of the questionnaire (after they had completed all VAS scores) and asked to rank the four images in order of their aesthetic preference for treatment.

2.4 Selection Criteria

2.4.1 Inclusion Criteria for photographic images

- Patient having had at least one maxillary palatally impacted canine surgically exposed and aligned in the arch (extraction of first premolar teeth)
- Patient having had at least one maxillary palatally impacted canine extracted and first premolar tooth substitution
- Patient having had at least one maxillary palatally impacted canine extracted and the deciduous canine retained. Deciduous canine to be of “average size” and “average appearance”
- Patient having had at least one maxillary palatally impacted canine extracted with residual spacing remaining
- Baseline image having an ideal Class I incisor and buccal segment relationship with good intercuspation and no obvious centreline discrepancies
- The smile line should allow for a natural and average visualisation of the maxillary teeth as well as some display of the gingival margin.

2.4.2 Exclusion Criteria for photographic images

- No anterior or visible restorations, white spot lesions or anterior caries
- No gingival pathology
- No fluorosis or mottling of enamel
- No abnormal morphology of anterior dentition
- No developmental absence of lateral incisor

2.5 Ethical Approval

An application for ethical approval was made for the research to be carried out at Royal Stoke University Hospital, part of the University Hospitals of North Midlands NHS trust as well as Birmingham Dental Hospital, part of Birmingham Community Healthcare Trust.

Ethical approval was granted via proportionate review from the National Research Ethics Committee Northwest Lancaster (Reference 15/NW/0678) and was also approved by the Research and Development departments at the Royal Stoke University Hospital (Reference ID 770 URCRN ID: N/A CSP) as well as the Birmingham Community NHS trust Research & Innovation department (Reference BCHCDent174243.NonPort).

2.6 Pilot Study

In order to test the questionnaire layout, time taken to complete the questionnaire and study design, the respective questionnaires were given to five different subjects from each group. The data collected is listed in Appendix 9.

Some minor improvements were made to the questionnaires following the pilot study to reduce confusion regarding the aims of the study and to make the data collection easier;

- The time taken for each group to complete the questionnaire was less than anticipated and the information sheets were therefore adjusted accordingly.
- A change to the wording in the patient group questionnaire to remove the word "occupation" from the demographic data collection list was made.
- The wording related to part 2 of the patient and parent group questionnaire was altered to ensure standardization, such as the standard use of months for treatment duration and to ensure that the patient group understood that the question asks how likely it is that the patient group would want that treatment for t*hemselves* and the parent group understood that is was regarding how likely it was that they would want that treatment for *their child* (Appendix 6 and 7).
- Removal of intra-oral images (without lip curtain), which had also been prepared using the same methods as described above in section 2.3.1. This was a major change from the original study design but it was considered that it was required, as several patients and parents in the pilot study commented that they didn't understand what they were assessing when they looked at these photos.

- Originally there was also a mark at the midpoint of each scale to act as a reference level of attractiveness, this was also removed as it was felt that this would lead to mid-point bias.

This pilot data were then entered into a mixed effect model using SPSS® software from Microsoft Excel® spreadsheet. This generated the standard deviation of 14mm, which was used to produce an accurate sample size calculation.

2.7 Reproducibility Study

A random 10% of the sample of questionnaires was re-assessed one month later by the same assessor (LMS) to test for the accuracy of measurement and intra-examiner reliability was assessed using the intra-class coefficient test (ICC).

To test intra-examiner reliability of the data, the test-retest reliability method was used and a random 10% sample from each judging group (questionnaires were numbered and a random number generator was used to select 10% from each judging group) were asked to complete the questionnaire for a second time approximately 6 weeks after the first questionnaire was completed. This timeframe coincided with the patients'/parents' next scheduled routine orthodontic appointment and meant that no additional appointments were necessary for the participants to partake in the reproducibility study. The second questionnaire was either given in person to the randomly selected dental professionals if possible or posted out along with a stamped addressed envelope if it was not possible to meet with them again within the time point. ICC values were then calculated from the data to test inter-examiner reliability.

Randomization to select either the questionnaires to be re-assessed or the individuals required to repeat the questionnaire was implemented using an on-line randomization table (www.randomizer.org).

2.8 Data recording and analysis

The data collected were then transferred to a Microsoft Excel® (2010) spreadsheet and data analysis subsequently performed using a statistical package SPSS® (The Statistical Package for Social Sciences) version 23.

The following analyses were carried out;

- Intraclass correlation (ICC) was used to evaluate intra and inter reliability of measuring the VAS scales and repeating the questionnaire on a second occasion after 6 weeks.
- Descriptive statistics were obtained by calculating mean and standard deviations

A two-way ANOVA (mixed between-within subject's ANOVA) was determined as being the test of choice to answer the research questions and measure associations. was chosen as this study has two independent variables as well as a continuous dependent variable:

  - Between subject's independent variable (groups)
  - Within subject's independent variable (treatments)
  - The continuous dependent variable was the VAS score.
- It was decided that descriptive analysis of the means would be used to compare the results of part one and part two of the questionnaire as well as to review the ranking of the treatment preference obtained from the patient and parent groups.

2.9 Sample Size Calculation

The number of judges required to be recruited in the study so that clinically valuable results could be reported was calculated using Altman's nomogram (Altman, 1991 as cited by Petrie, Bulman and Osborn, 2002) to generate a sample size for a two-way ANOVA. This calculation involved the use of four factors:

- The standard deviation of the variable. This was generated using the standard deviation calculated from the pilot data of 14.
- The 'detectable contrast' (minimal clinical difference) was set at 13
- Significance level of 0.05
- To give a high probability of detecting differences the power was set at 0.9 (90%)

With two factors (Treatment type and Judging Group) each with 4 levels, with a Standard Deviation (SD) of 14, examining an interaction between treatment and judges (rows * col) with a significance level 0.05 and a power of 0.9 (90%) and attempting to find a 'detectable contrast' (Minimal Clinical Difference) of 13, we determined that we would need 25 people in each Judging group.

However, in order to compare the results with other similar well conducted research studies (Kaya and Uyar, 2016) and to allow for dropouts so there is a sufficiently robust sample in each group it was decided to recruit 50 participants into each group.

CHAPTER 3

RESULTS

Chapter 3: Results

3.1 Demographics of study participants

Questionnaires were collected from a total of 200 participants, of which 79 (39.5%) were male and 121 (60.5%) were female, ranging in age from 11 years in the Patient group to 75 years in the Orthodontist group.

Fifty parents, 50 patients, 50 GDPs and 50 Orthodontists were recruited by quota sampling to complete the questionnaire. The demographics of these groups is listed in Tables 1-3.

The patient and parent groups were recruited from Stoke University Hospital and Birmingham Dental Hospital, in line with ethical approval and thus lived in the West Midlands geographical area with either a Staffordshire or Birmingham postcode. The geographical base of the Orthodontist and GDP groups in contrast varied significantly, due to professional groups recruitment occurring at national conferences and regional meetings (Appendix 10).

Table 1 Distribution of Gender between participants

Group	Male	Female
Orthodontists	27	23
GDPs	20	30
Patients	18	32
Parents	14	36
Overall count	79	121
Overall %	39.5%	60.5%

Table 2 Distribution of Age between participant's groups

Group	Minimum Age	Maximum Age	Mean
Orthodontists	29	75	45
GDPs	23	60	33
Patients	11	17	14
Parents	31	68	44

Table 3 Dental qualification status of Orthodontist and GDP groups (n = 100)

Dental Qualification	Count	Percent
BDS or equivalent (GDP)	50	25
MOrth or equivalent (Specialist orthodontist)	18	9
ISFE completed or equivalent (Consultant orthodontist)	32	16

3.2 Results Part 1 of questionnaire: Descriptive statistics

The objective of part 1 of this study was to evaluate the post-orthodontic smile aesthetics of patients presenting with impacted maxillary canines as perceived by Orthodontists, GDPs, patients and parents. This would be investigated by examining the aesthetic impact of the treatment shown on the VAS score.

The VAS score indicated how aesthetic the participants found that treatment option, with a higher score correlating to a higher aesthetic result.

The null hypothesis was that there would be no difference in the perception of smile aesthetics between the different treatment options available for treating palatally impacted canine tooth as perceived by Orthodontists, GDPs, patients and parents.

3.2.1 Mean VAS Score for treatment options

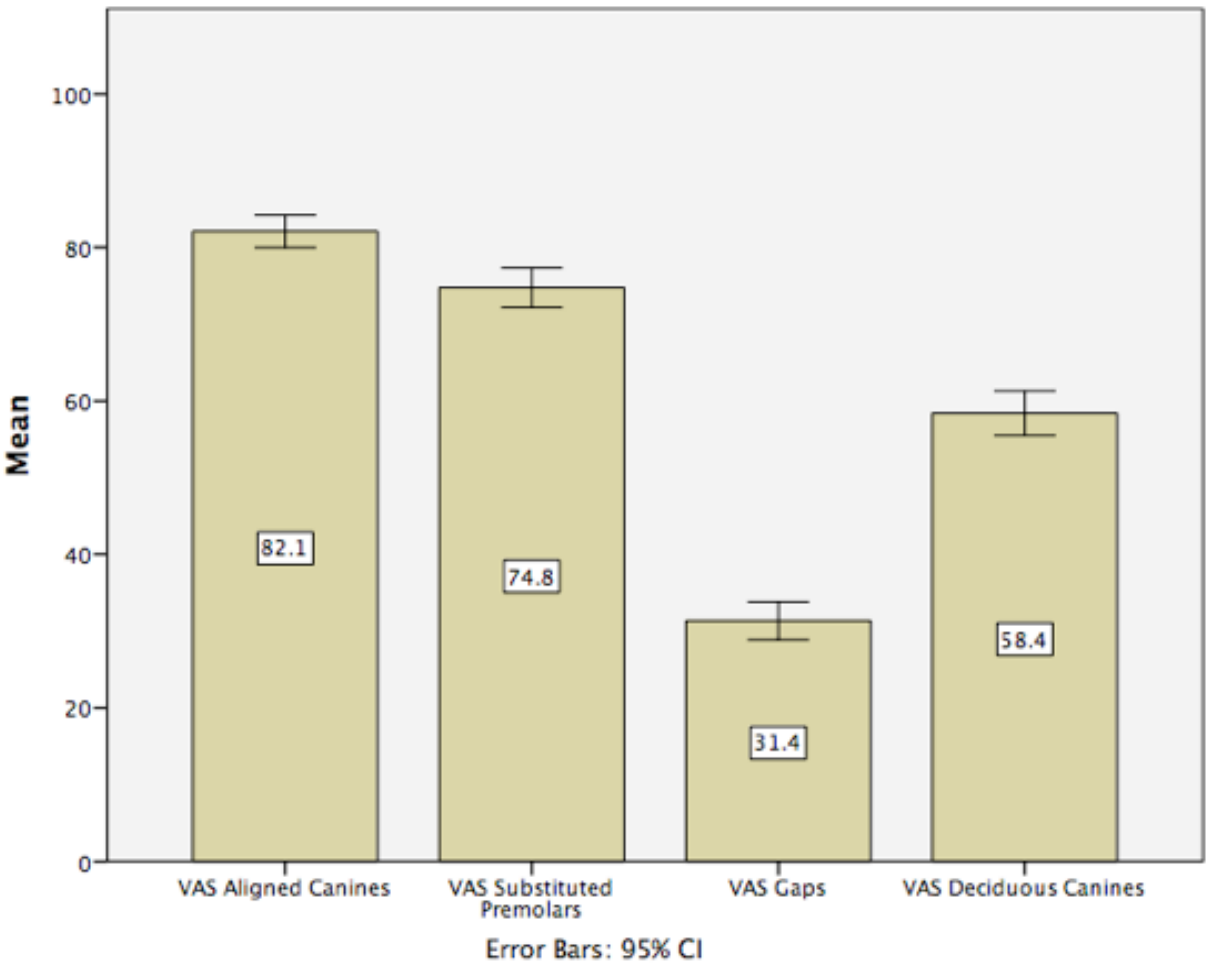
Descriptive statistics were first used to analyse VAS scores obtained from the first part of the questionnaire relating to the aesthetic perception of each treatment option.

Table 4 shows the mean VAS scores, 95% confidence interval (C.I) and standard deviation (S.D) of each treatment option when all of the 200 subjects completing the questionnaire were grouped together. Figure 1 displays the mean VAS score for each treatment option along with the 95% C.I.

Table 4 Mean VAS scores for each treatment option (higher scores indicated higher aesthetic result)

Treatment	Number of subjects assessing	Minimum VAS score	Maximum VAS score	Mean VAS Score	95% C.I	Standard deviation
Aligned Canines	200	25	100	82.10	79.98-84.22	15.2
Substituted premolars	200	5	100	74.8	72.19-77.35	18.4
Gaps	200	0	96	31.4	28.89-33.81	17.6
Deciduous Canines	200	6	100	58.4	55.50-61.31	20.8

Figure 1 Mean VAS score for each treatment option



This data clearly shows that when just the treatment option was taken into account the highest mean VAS score (highest aesthetic perception) was obtained for the Aligned Canines treatment, with the lower mean VAS score (least aesthetic perception) being the Gaps present option.

3.2.2 Assessing normality

Histograms (Figure 2-5) were compiled to assess the normality of the data obtained for each treatment option. Visual inspection of the histogram revealed that although there was a degree of skewness to the VAS Aligned Canines and VAS Substituted Premolars histograms, this was to be expected, particularly for the Aligned Canines image, as the skewness shows that all participants found the images aesthetic. The VAS Gaps and VAS Deciduous Canines' histograms are normally distributed. It was felt that using a robust test such as an ANOVA parametric statistical test would be appropriate, especially in light of the large sample size collected for each group.

Figure 2 Histogram VAS Aligned Canines

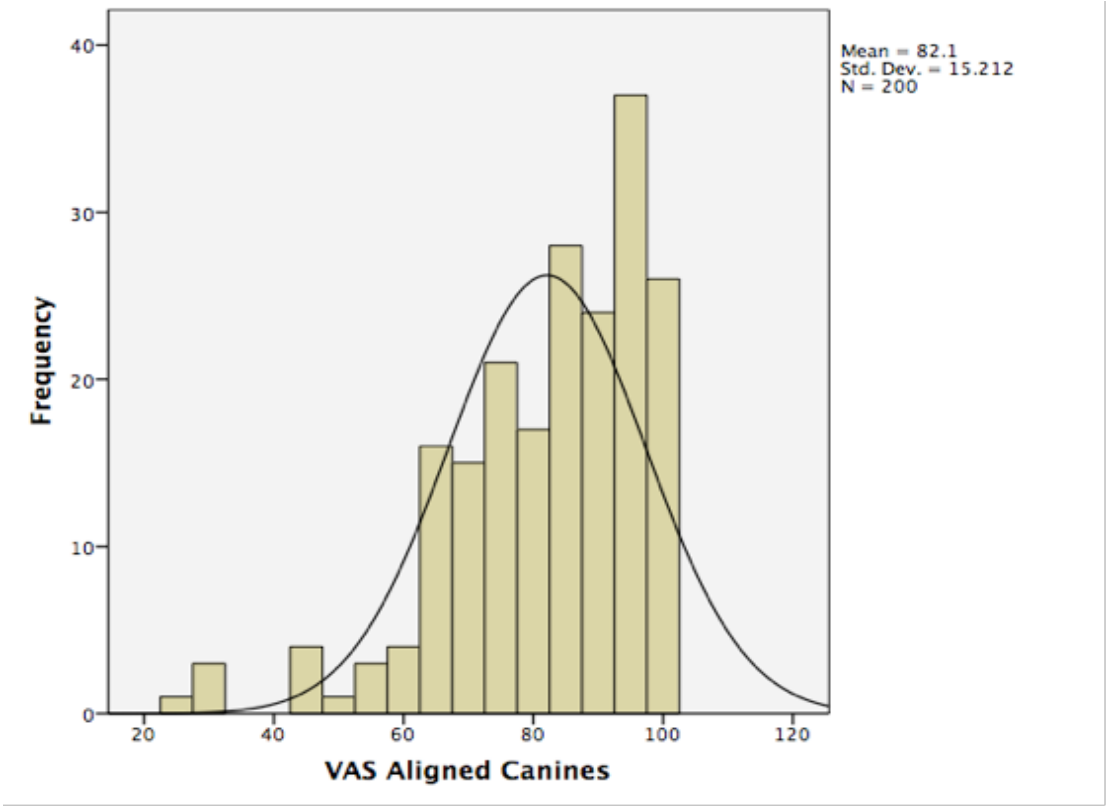


Figure 3 Histogram VAS Substituted Premolars

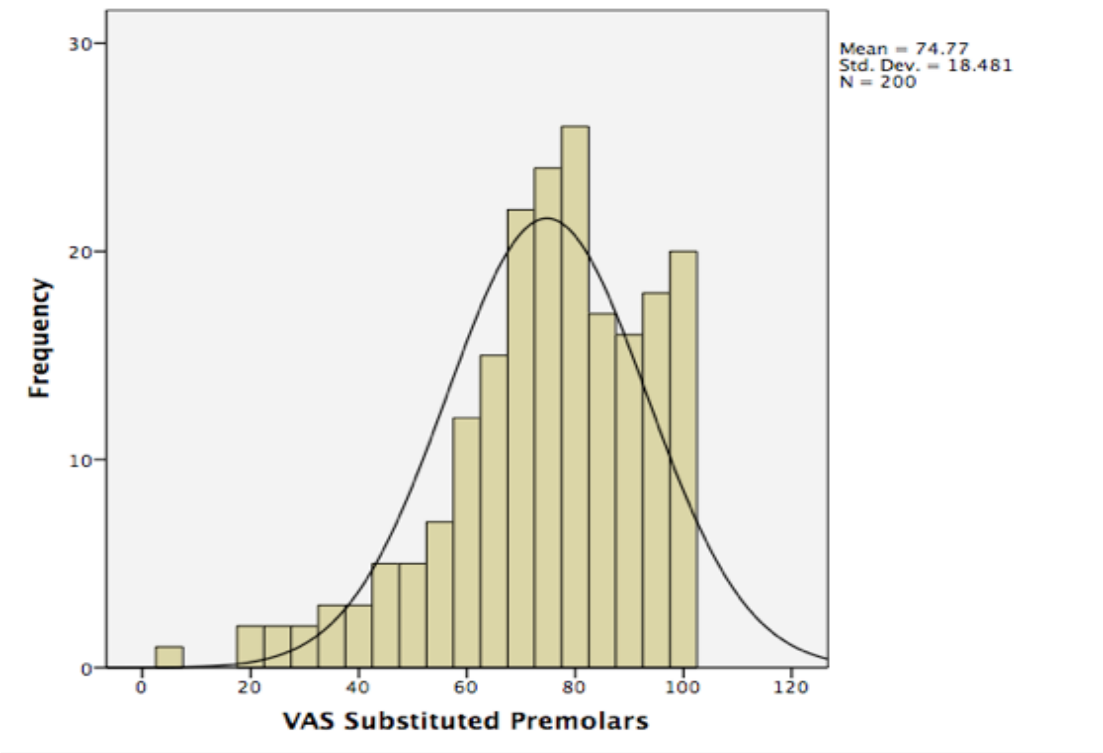


Figure 4 Histogram VAS Gaps

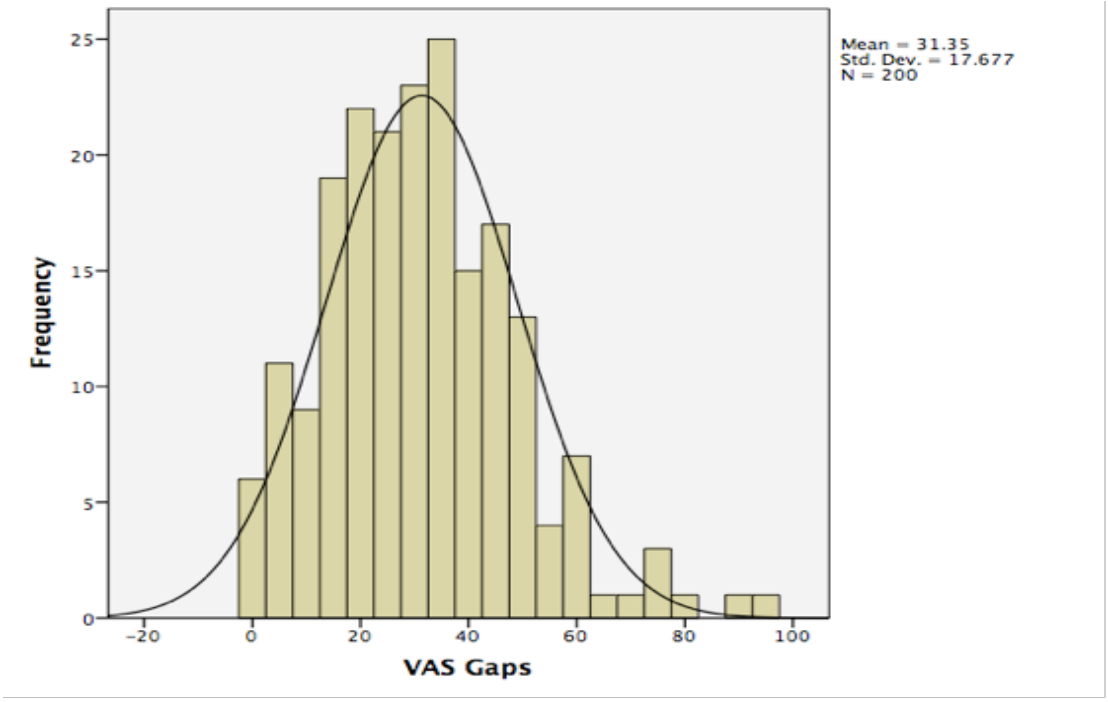
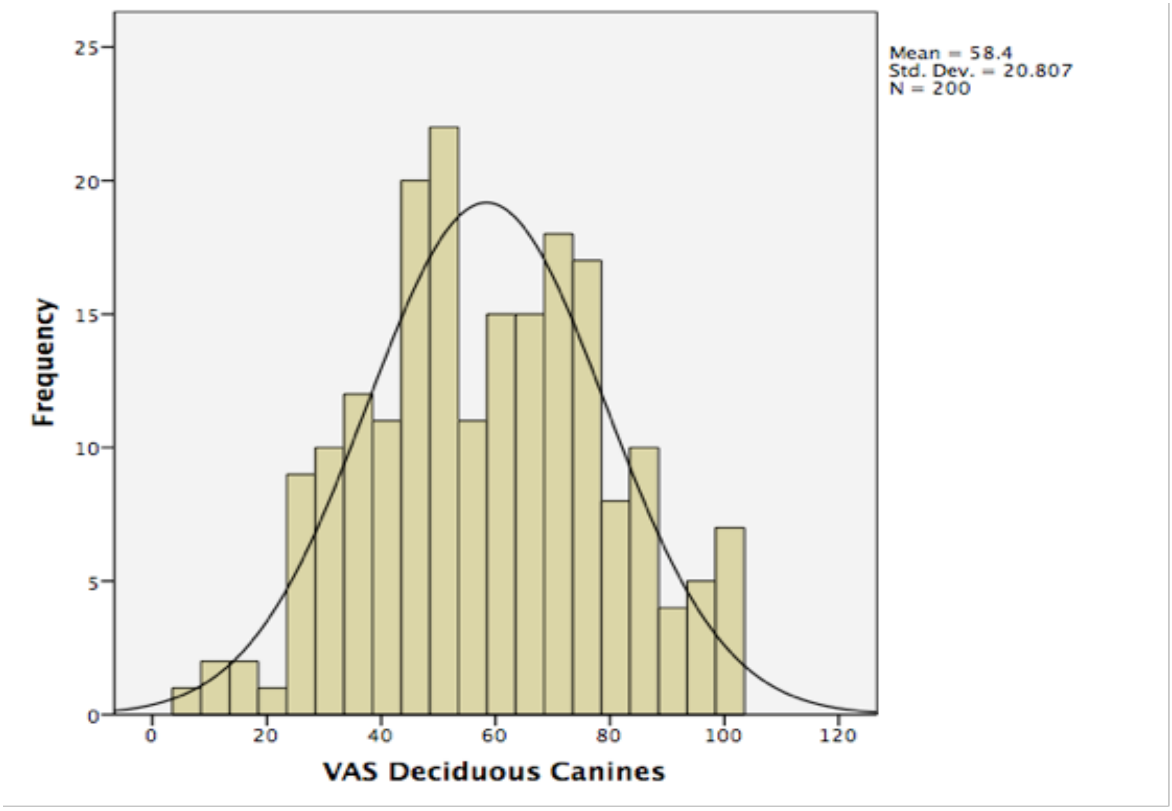


Figure 5 Histogram VAS Deciduous Canines



3.2.3 Mean VAS scores for each group

Table 5 Mean VAS score per group when treatments combined

Groups	No of subjects assessed	Mean	95% C.I
Orthodontists	50	55.5	51.8-59.2
GDPs	50	61.8	58.1-65.5
Patients	50	64.6	60.9-68.3
Parents	50	64.5	60.8-68.2

If the different treatments are not taken into account and instead an overall mean VAS score is obtained for each group, then it can be seen in Table 5 that the Orthodontists group gave the lowest overall mean VAS score.

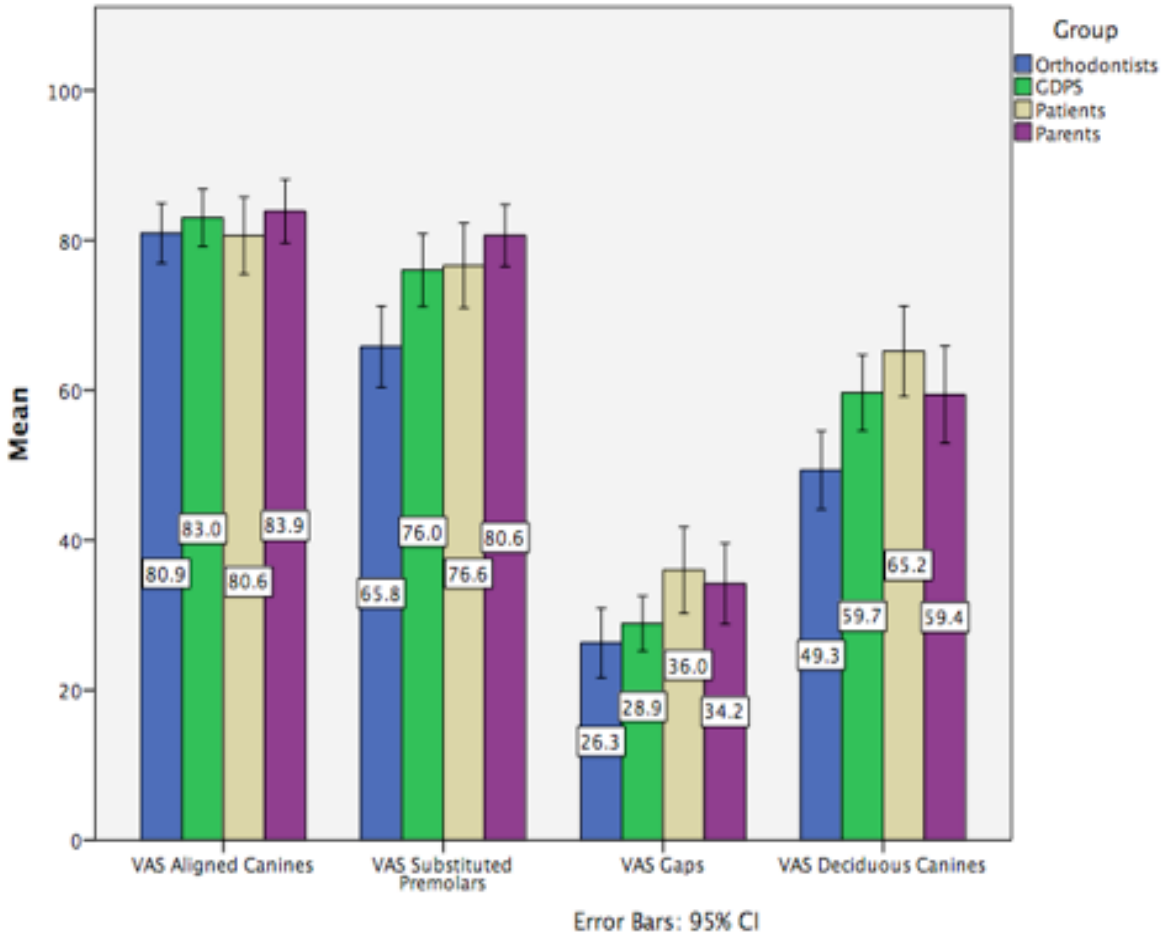
There was very little difference between the Patients and the Parents overall mean VAS score.

3.2.4 Mean VAS score for each treatment within each group

The mean VAS score given to each treatment option by each group is displayed graphically in Figure 6.

All groups were consistent when the mean VAS scores for each treatment was ranked within groups, with the highest mean VAS score achieved by the Aligned Canines treatment, the second highest score the Substituted Premolars, the third highest score the Deciduous Canines and the worst scoring treatment being the Gaps. This also mirrors the ranking of the mean VAS score seen for treatment options when groups are not taken into account.

Figure 6 Mean VAS scores for each treatment separated into different groups



When the mean VAS scores are separated into groups and compared, it is apparent that for each treatment option, the Orthodontists group gave the lowest mean VAS score when compared with the other three groups.

There is little difference in the mean VAS scores obtained for the Aligned Canines option between the groups. More variability exists between the mean VAS scores of each group when the other three treatment options are observed. The largest difference in mean VAS scores between groups were obtained between the Orthodontist and the Patient and Parent group, perhaps indicating a more severe difference in perception between these groups.

3.3 Results Part 1 questionnaire: Mixed between-within subjects' ANOVA results (split-plot ANOVA)

The first part of the research question evaluates the potential post-orthodontic smile aesthetics of the treatment options for impacted maxillary canines as perceived by Orthodontists, GDPs, patients and parents.

The proposed analysis was to use a mixed between-within subject's ANOVA. This test was chosen as this study has two independent variables as well as a continuous dependent variable:

- Between subject's variable (groups)
    - Orthodontists
    - GDPs
    - Patients
    - Parents
- Within subject's variable (treatments)
    - Aligned canines
    - Substituted premolars
    - Gaps
    - Deciduous canines

The continuous dependent variable was the VAS score.

This analysis will test whether there are main effects for each of the independent variables and whether there is an interaction between the two variables.

The null hypothesis was that there is no difference in the perception of smile aesthetics between the different treatment options available for treating palatally impacted canines as perceived by Orthodontists, GDPs, patients and parents.

3.3.1 Assumptions

As ANOVAs with repeated measures (within-subject's factors) are susceptible to the violation of the assumption of sphericity, Mauchly's test of sphericity was used to determine if this assumption had been broken.

Mauchly's Test of sphericity was significant (MW = 0.726 sig = 0.000), indicating that the assumption of sphericity had been violated. This means that the variances of the differences between all combinations of related groups are not equal and therefore there is a risk of increasing the type1 error rate.

In order to reduce this risk of Type 1 error, the Greenhouse-Geisser value with its corrected degrees of freedom was used to assess the significance of the corresponding F value. This correction increases the p value to compensate the violation of sphericity and elicit a more stringent significance value.

Table 6 Levene's test of equality of error variances

	F	Sig
VAS Aligned Canines	2.048	0.108
VAS Substituted Premolars	1.818	0.145
VAS Gaps	2.837	0.039
VAS Deciduous Canines	1.841	0.141

Table 6 indicates that the variances are homogenous for all levels of the repeated measures variable except for the VAS Gaps. This means that the spread of scores obtained for the VAS Gaps treatment was significantly different to the others.

The VAS Gaps variable value of less than 0.05 is significant. This variable therefore violates this assumption. This can compromise the accuracy of the F test for this group. However, as the groups were equal and as the study had a large sample size it was determined that it was not necessary to transform the data (Fields, 2013).

3.3.2 Main effect of Treatment

F (3,500) = 546.941 p = <0.001. Partial ETA Squared = 0.0736. Power 1.000 indicates that a significant main effect exists for the variable of treatment.

Table 4 and Figure 1 shows the mean VAS score given to each treatment option when all four groups were assessed together.

These mean VAS scores when all groups were combined indicated that the Aligned Canines option was judged as the most aesthetic outcome (mean VAS score = 82.1) closely followed by Substituted Premolars (mean VAS score = 74.8). The Deciduous Canines image was ranked as the third most aesthetic (mean VAS score = 58.4) with the Gaps image recording the worst VAS score (mean VAS score = 31.4).

Post-hoc tests were then carried out to analyse the main effect of treatment (Table 7). These Bonferroni corrected post-hoc tests showed that VAS scores between all four treatment options was significantly different.

Therefore, there was a statistically significant difference in the VAS scores obtained for each treatment option when all groups were combined. However, there was not a clinically significant difference between the aligned canines and substituted premolars treatment as the VAS score difference was less than the pre-determined clinically significant difference.

Table 7 Pairwise comparison within subject's effects (treatment)

Treatment	Treatment	Mean Difference	Sig * [a]	95% C.I for difference
Aligned canines	**Substituted Premolars**	7.3	<0.001	4.8-9.8
	Gaps	50.7	<0.001	47.0-54.4
	Deciduous Canines	23.6	<0.001	19.7-27.6
Substituted Premolars	**Gaps**	43.4	<0.001	39.6-472
	Deciduous Canines	16.3	<0.001	12.4-20.2
Gaps	**Deciduous Canines**	-27.0	<0.001	-30-7- -23.3

* the mean difference is significant at the 0.05 level

[a] Adjustment for multiple comparisons: Bonferroni

3.3.3 Main effect of Group

F (3-196) = 5.110, p = 0.002 Partial ETA Squared = 0.73, Power = 0.918 indicates a significant main effect for group.

This indicates that if the effect of the specific treatment being rated is ignored then there is a statistically significant difference between the overall mean VAS score obtained from each group.

As shown earlier in Table 5, the group with the lowest mean score when all treatment scores were combined was the Orthodontists group (mean VAS score = 55.5). The Patient and Parent mean VAS score was remarkably similar (Patient group mean VAS score = 64.6 and Parent group mean VAS score = 64.5). The GDP group scored between the other groups with a mean VAS score of 61.8. These mean scores indicate that the Orthodontist group was the most critical in terms of mean VAS score.

Post-hoc tests were carried out to analyse the main effect of group (Table 8). These Bonferroni corrected post-hoc tests showed that when only the effect of group was taken into consideration, it was the VAS scores between the Orthodontist and Patient/Parent groups that was significantly different, indicating a difference in the aesthetic perception between these groups.

Table 8 Pairwise comparison of between subject's treatment effect (Groups)

Group	Group	Mean Difference	Sig [*a]	95% C.I
Orthodontists	GDPs	-6.3	0.110	-13.3-0.7
	Patients	-9.0	0.005	-16.0- -1.9
	Parents	-8.9	0.005	-15.9- -1.8
GDPs	Patients	-2.7	1.000	-9.7-4.3
	Parents	-2.6	1.000	-9.7-4.4
Patients	Parents	0.08	1.000	-6.9-7.1

* the mean difference is significant at the 0.05 level

[a] Adjustment for multiple comparisons: Bonferroni

There was no statistical significance between:

- The Orthodontist and GDP group
- The GDP and Patient group
- The GDP and Parent group
- The Patient and Parent group

3.3.4 Interactions

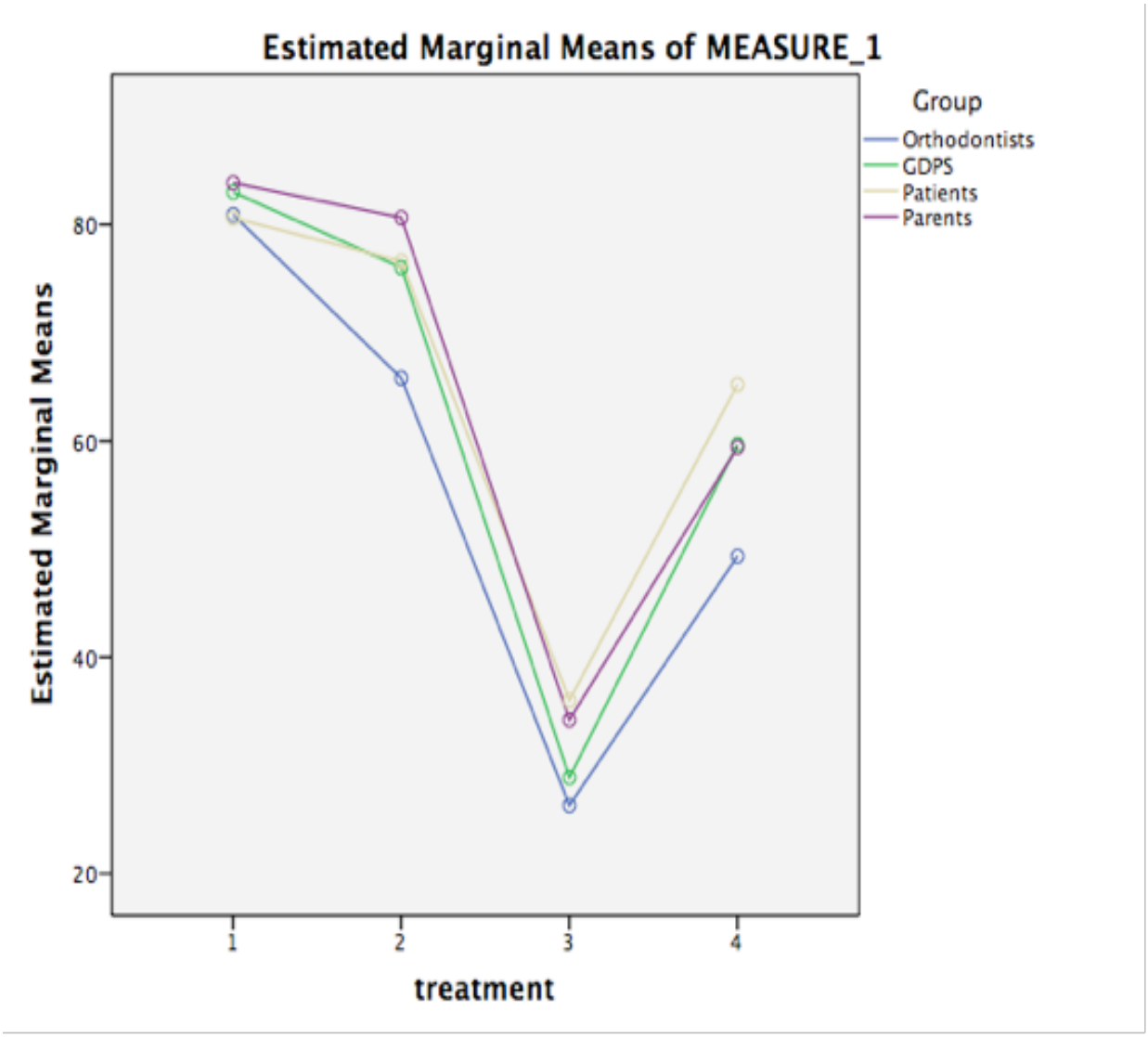
When the main effects are examined there is a statistically significant difference between the mean VAS scores of all four treatment options.

It is also apparent that when just the mean VAS score for each group as a whole are taken into account, there is a statistically significant difference between the VAS scores given by the Orthodontists group and the Patient/Parent group, with the Orthodontists group being more critical of aesthetics and giving a lower VAS score.

As this first part of the questionnaire aimed to evaluate the possible post-orthodontic smile aesthetics of patients presenting with impacted maxillary canines as perceived by Orthodontists, GDPs, patients and parents, it was necessary to assess if there was an interaction between the treatment VAS score and group perception and understand where any significance lies, i.e. do the aesthetic values (VAS score) differ for each treatment option within the same groups and how do the aesthetic values for each treatment option compare between the groups.

For the Effect of treatment and group interaction, $F(8,500) = 3.113$ $p = 0.002$ Partial ETA Squared = 0.046, power 0.961 indicates that a significant interaction exists between treatment and group. This is confirmed by visualization of Figure 7.

Figure 7 Estimates marginal means of measure



Post-hoc tests were then used to assess this interaction effect further.

3.3.5 Group*Treatment interaction

It is apparent from the main effect of treatment that there was a statistically significant difference between the mean VAS scores obtained for the four different treatment options. However, it is necessary to ascertain what effect the group had. Table 9 and Figure 7 shows the results of the interaction.

Table 9 Pairwise comparisons of the Group*treatment interactions

Group	Treatment	Treatment	Mean difference	Sig* [a]	95% C.I for difference
Orthodontists	Aligned canines	Substituted Premolars	15.1	<0.001	10.1-20.1
		Gaps	54.6	<0.001	47.2-62.0
		Deciduous canines	31.5	<0.001	23.6-39.4
	Substituted Premolars	Gaps	39.5	<0.001	31.9-47.0
		Deciduous canines	16.4	<0.001	8.6-24.2
	Gaps	Deciduous canines	23.0	<0.001	15.6-30.4
GDPs	Aligned canines	Substituted Premolars	6.9	0.001	1.9-11.9

Group	Treatment	Treatment	Mean difference	Sig* [a]	95% C.I for difference
Patients	Gaps	Deciduous canines	54.1	<0.001	46.7-61.5
		Gaps	23.3	<0.001	15.4-31.2
	Substituted Premolars	Deciduous canines	47.1	<0.001	39.5-54.7
			16.3	<0.001	8.5-24.1
	Gaps	Deciduous canines	-30.7	<0.001	-38.1- -23.3
	Aligned canines	Substituted Premolars	4.0	0.200	-0.9-8.9
		Gaps	44.6	<0.001	37.2 - 51.9
		Deciduous canines	15.4	<0.001	7.7-23.3
	Substituted Premolars	Gaps	40.6	<0.001	33.0-48.1
	Gaps	Deciduous canines	11.4	0.001	3.6-19.2
		Deciduous canines	-29.1	<0.001	-36.5- -21.7

Group	Treatment	Treatment	Mean difference	Sig* [a]	95% C.I for difference
Parents	Aligned canines	Substituted Premolars	3.2	0.500	-1.7 - 8.0
		Gaps	49.6	<0.001	42.2-57.0
		Deciduous canines	24.4	<0.001	16.5-32.3
	Substituted Premolars	Gaps	46.4	<0.001	38.8-54.0
		Deciduous canines	21.2	<0.001	13.4-29.0
	Gaps	Deciduous canines	-25.2	<0.001	-32.6- -17.8

Within the Orthodontists group, there was a statistically significant difference in VAS scores for all four treatment options. The smallest difference in VAS score was between the Aligned Canines and Substituted Premolars treatment but the difference was still statistically significant in favour of the Aligned Canines being rated as significantly more aesthetic that the Substituted Premolars treatment.

Within the GDP group, there was again a statistically significant difference in VAS score between for all four treatment options, in favour of the Aligned Canine being the most aesthetic treatment option. However, the mean difference in the VAS score

between the Aligned Canines and Substituted Premolar was much lower at only 6.9mm and thus less than the pre-determined clinically significant difference.

For both the Patient and the Parent group in contrast to the Orthodontist and GDP group no statistically significant difference was found between the Aligned Canines and Substituted Premolar VAS scores. There was, however, a statistical difference in the VAS score between the Aligned Canines and Substituted Premolars treatments when compared to the Gaps and Deciduous Canines treatment, with the Aligned Canines and Substituted Premolars being rated as significantly more aesthetic than the Gaps present or Deciduous Canines.

3.3.6 Treatment*Group interaction

For the main effect of group, it was found that there was a statistically significant difference in the mean VAS scores obtained between the Orthodontist group and the Patient and Parent group. However, it is necessary to ascertain what effect the treatment options had on the VAS score differences between the groups. This is shown by Table 10 and Figure 7.

Table 10 Pairwise comparisons of the Treatment*Group interactions

Treatment	Group	Group	Mean Difference	Sig* [a]	95% C.I for Difference
Aligned Canines	Orthodontists	GDPs	-2.0	1.000	-10.2 - 6.0
		Patients	0.3	1.000	-7.8 - 8.4
		Parents	-2.9	1.000	-11.1 - 5.2
Substituted Premolars	GDPs	Patients	2.4	1.000	-5.8 - 10.5
		Parents	-0.9	1.000	-8.9 - 7.2
	Patients	Parents	-3.2	1.000	-11.3 - 4.9
		GDPs -	10.2	<0.001	-19.7 - - 0.7
	Orthodontists	Patients	-10.8	<0.001	-20.3 - - 1.3
		Parents	-14.8	<0.001	-24.3 - - 5.4
	GDPs	Patients	0.6	1.000	-10.0- 8.8
		Parents	-4.6	1.000	-14.0- 4.9
	Patients	Parents	-4.0	1.000	-13.4 - 5.4
Gaps	Orthodontists	GDPs	-2.5	1.000	-11.8 - 6.6

Treatment	Group	Group	Mean Difference	Sig* [a]	95% C.I for Difference
		Patients	-9.7	0.030	-18.9 - -0.4
		Parents	-7.9	0.100	-17.5 - 1.3
	GDPs	Patients	-7.1	0.200	-16.3 - 2.1
		Parents	-5.3	0.800	-14.6- 3.9
	Patients	Parents	1.8	1.000	-7.4-11.0
Deciduous Canines	Orthodontists	GDPs	-10.3	0.067	-21.0 - 0.4
		Patients	-15.8	0.001	-26.6- - 5.1
		Parents	-10.0	0.079	-20.8 - 0.6
	GDPs	Patients	-5.5	1.000	-16.2-5.2
		Parents	0.2	1.000	-10.5-10.9
	Patients	Parents	5.7	0.900	-4.9-16.5

* the mean difference is significant at the 0.05 level

There were no statistically significant differences between the groups regarding the aesthetics of the Aligned Canines treatment option i.e. all four groups found the aligned canine to be similar in terms of their aesthetic perception.

Regarding the Substituted Premolar treatment, there was a statistically significant difference in the VAS scores obtained between the Orthodontist group and the other three groups with the Orthodontist group rating the Substituted Premolars as being significantly less aesthetic.

Regarding the Gaps treatment option there was a statistically significant difference seen in the VAS scores obtained between the Orthodontist group and the Patient group with the Orthodontist group rating the treatment as significantly less aesthetic than the Patient group.

For the Deciduous Canine treatment option there was a statistically significant difference in the scores obtained between the Orthodontist group and the Patient group. Again the Orthodontist group rated the treatment as much less aesthetic than the Patient group.

3.4 Results from Part 2 of questionnaire: Descriptive statistics

The second part of the questionnaire was only given to the patient and parent groups (100 subjects in total.) The same images as part 1 were shown to each participant but with additional information about the treatment option and the average treatment duration in months for each option.

This part of the questionnaire aimed to assess if treatment time influences the preference of treatment options available to treat impacted maxillary canines by patients and parents.

The null hypothesis was:
There is no difference in the preference of treatment options by patients and parents with regards to the time taken for treating a palatally impacted canine tooth.

The VAS score indicated the participant's preference for the treatment option with a higher score indicating a greater preference for treatment. This will be known henceforth as the VAS_with time score.

3.4.1 Mean VAS treatment with time scores

Descriptive statistics was used to analyse VAS_with time scores obtained from the second part of the questionnaire, showing preference for the different treatment options.

Table 11 shows the mean VAS_with time score, 95% C.I and standard deviation of each treatment option with the groups combined. Table 12 and Figure 8 further explores the means of the separated patient and parent groups.

Table 11 VAS_with time scores: Patient and Parent groups combined (a higher score indicates a higher preference for treatment)

Treatment	Number of subjects assessing	Minimum VAS score	Maximum VAS score	Mean VAS Score	Standard deviation	95% C.I
Aligned Canine_ withtime	100	3	100	73.6	23.0	69.3-77.9
Substituted premolars_with time	100	10	100	68.0	22.6	63.6-72.3
Gaps_ withtime	100	0	97	31.9	28.6	26.2-37.6

Treatment	Number of subjects assessing	Minimum VAS score	Maximum VAS score	Mean VAS Score	Standard deviation	95% C.I
Deciduous Canines_ withtime	100	0	100	61.1	24.1	56.3-66.0

The highest VAS score was achieved for the Aligned Canine image both when the groups were combined and independently assessed.

The worst VAS score was again for the Gaps present option, indicating that patients and parents combined together would choose that option the least. However, the VAS score difference between the Deciduous Canines, Aligned Canines and Substituted Premolars was narrower than the aesthetic VAS scores obtained in the first part of the questionnaire, particularly for the Patient group with the mean VAS_with time preference score for these three options falling between 62.0 and 65.4 (C.I 53.5-71.5).

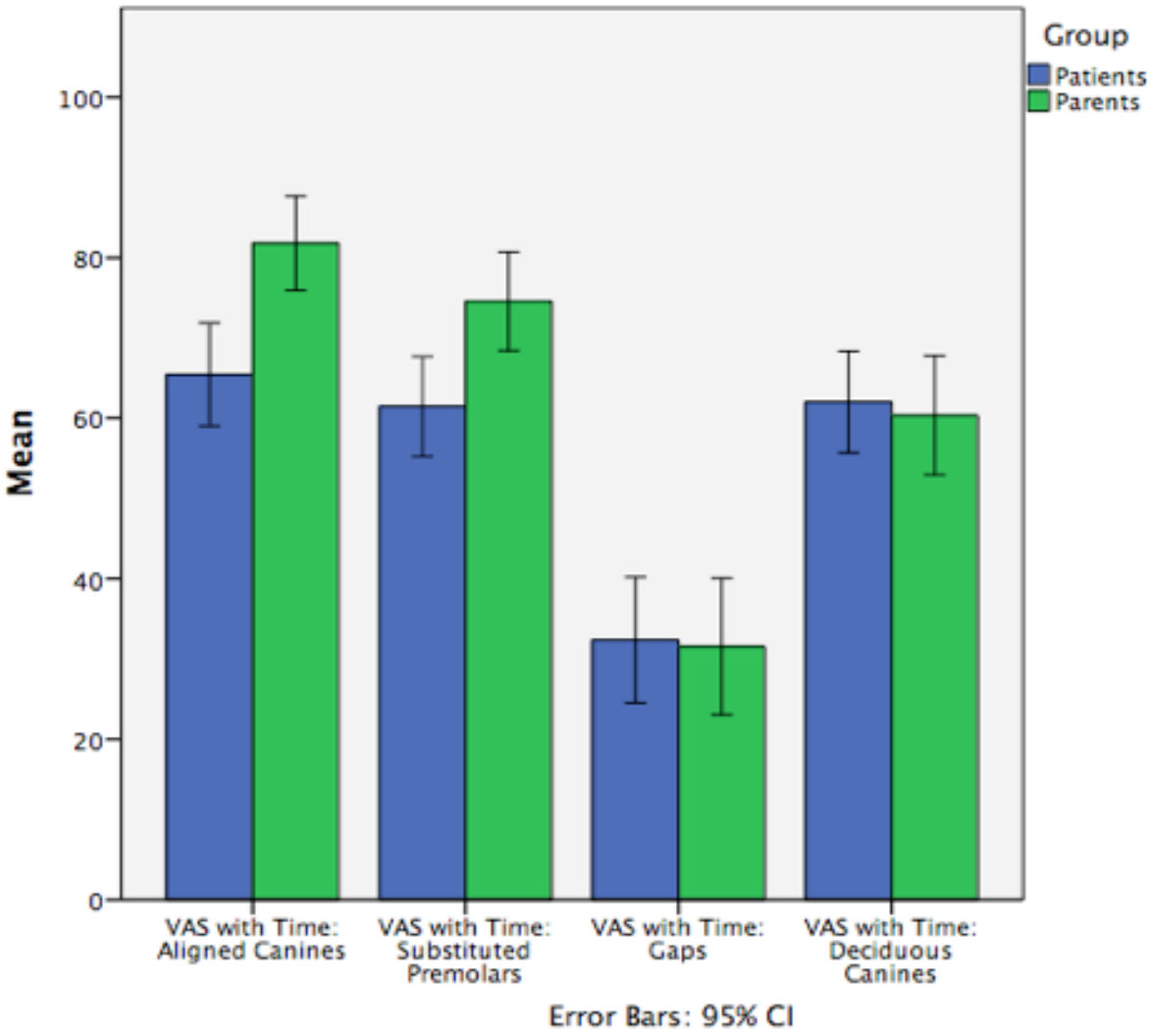
Table 12 VAS_with time preference scores: Groups

Treatment_withtime	Group	Mean	95% C.I
Aligned Canines	Patients	65.4	59.3-71.5
	Parents	81.8	75.7-87.8
Substituted Premolars	Patients	61.4	55.3-67.5
	Parents	74.5	68.4-80.6
Gaps	Patients	32.3	24.2-40.4
	Parents	31.5	23.4-39.6
Deciduous Canines	Patients	62.0	55.2-68.8
	Parents	60.3	53.5-67.1

Lower VAS_with time scores were given to the Aligned Canines' and Substituted Premolars treatment options by the Patient group in comparison to the Parent group.

The standard deviations relating to the VAS_with time scores were much wider than in part 1 of the questionnaire, indicating perhaps less group consensus in their opinions regarding the likelihood of choosing that treatment in comparison to aesthetic opinion.

Figure 8 VAS_with time mean preference scores



3.5 Mixed between-within subject's ANOVA Part 2 questionnaire (Split-plot ANOVA)

To answer the second part of the questionnaire to assess if treatment time influences the choice of treatment option by Patient and Parent groups it was decided to again use a split-plot ANOVA.

3.5.1 Assumptions

Mauchly's test of sphericity was significant (MW = 0.639 sig = <0.001), indicating that the assumption of sphericity has been violated. As previously described in part 1 of the results (section 3.3.1) the Greenhouse-Geisser F value was used to compensate for the violation of sphericity.

Table 13 Levene's test of equality of error variances

	F	Sig
VAS_with time: Aligned Canines	1.4	0.2
VAS_with time: Substituted Premolars	0.4	0.8
VAS_with time: Gaps	0.14	0.7
VAS_with time: Deciduous Canines	1.0	0.2

Table 13 indicates that variances are homogenous for all levels of the repeated measures variables.

3.5.2 Main effect of treatment_with time

F = (2,221) 81.2 p = 0.000. Partial ETA Squared = 0.453 indicates there is a statistically significant difference between the VAS scores regarding treatment with time.

Post-hoc tests (Table 14) show a significant main effect for a difference in preference between all treatment options, except between the options of Aligned Canines or Substituted Premolars. Thus the preference of the two groups was similar for the Aligned Canines and Substituted Premolars which were both found to be significantly more preferable than the option of Deciduous Canines or Gaps. There was a significant difference between the preference of the Deciduous Canines and Gaps, with the Gaps present treatment scoring a significantly lower score.

Table 14 Comparisons of VAS score between treatments with time

Pairwise comparison Post-Hoc Tests				
(I)Treatment	**(J) Treatment**	**Mean Difference**	**Sig * [a]**	**95% C.I**
Aligned canines_ with time	**Substituted Premolars_with time**	5.6	0.590	-0.1-11
	Gaps_with time	41.6	<0.001	31.7-51.5
	Deciduous canines_with time	12.4	<0.001	5.7-19.1
Substituted Premolars_ with time	**Gaps_with time**	36.0	<0.001	26.9-45.1
	Deciduous canines_with time	6.8	0.310	0.4-13.2
Gaps_with time	**Deciduous canines_with time**	-29.2	<0.001	-37.4 - -20.9

* the mean difference is significant at the 0.05 level

a Adjustment for multiple comparisons: Bonferroni

3.5.3 Main effect of group

Table 15 Means VAS preference scores for the main effect of group

Estimated marginal means			
Groups	**Mean**	**S.E**	**95% C.I**
Patients	55.3	2.3	50.6-59.9
Parents	62.0	2.3	57.4-66.7

In Table 15 it is apparent that the patient group overall gave a lower overall mean VAS score compared to the parent group.

A statistically significant difference for the main effect of group was found, F = (1,98) 4.1, p = 0.044. Partial ETA squared = 0.41.

Table 16 Pairwise comparisons between groups

Group	Group	Mean Difference	S.E	Sig * [a]	95% C.I
Patients	**Parents**	-6.7	3.3	0.044	-13.3- - 0.2

* The mean difference is significant at the 0.05 level

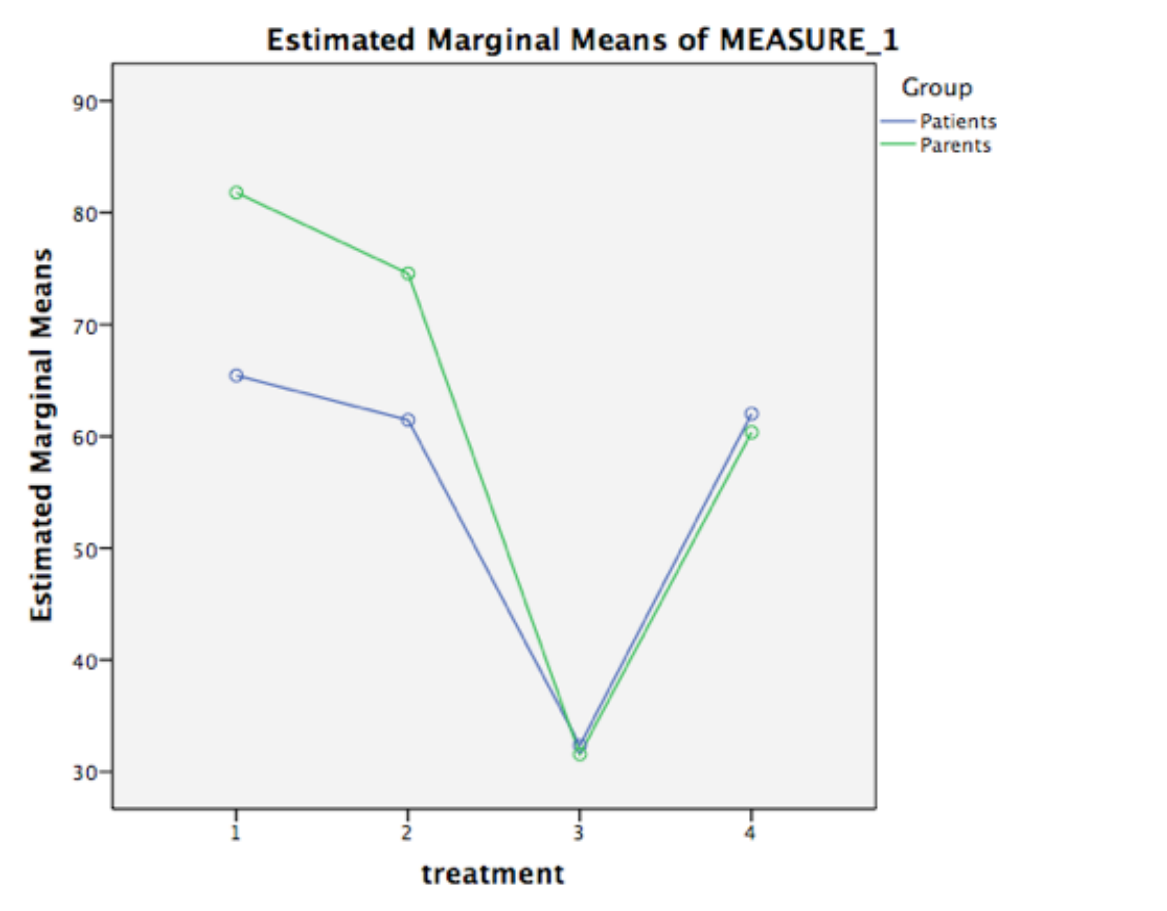
[a] Adjustment for multiple comparisons is Bonferroni

Post-hoc tests (Table 16) show a significant difference in VAS_withtime scores between the Patient and Parent groups. Although the mean difference was less than the predetermined clinical significance value.

3.5.4 Interactions

F = (2.263-221.744) 5.136, p = 0.005. Partial ETA Squared = 0.050 indicates a significant interaction between the effect of treatment_with time and group.

Figure 9 Estimated marginal means (treatment with time)



Post-hoc tests were used to assess this interaction effect further.

3.5.5 Group*Treatment_with time interaction

It was apparent from the main effect of treatment that there was a statistically significant difference between the mean VAS_with time scores between all the treatment options except for the Aligned Canines and Substituted Premolars. But it is necessary to ascertain what effect group has on this. Table 17 and Figure 9 show the results of further exploration into this interaction.

Figure 17 Pairwise comparisons of Group*treatment_with time interactions

Group	Treatment	Treatment	Mean difference	Sig *	95% C.I for difference
Patients	Aligned Canines_with time	Substituted Premolars_withtime	3.9	1.000	-4.1-12.1
		Gaps_withtime	33.0	<0.001	19.1-47.0
		Deciduous Canines_withtime	3.4	1.000	-6.0 -12.9
	Substituted Premolars_ with time	Gaps_withtime	29.1	<0.001	16.2 - 41.9
		Deciduous Canines_withtime	-0.5	1.000	-9.6-8.5
	Gaps-withtime	Deciduous Canines_withtime	-29.6	<0.001	-41.3- -17.9

Group	Treatment	Treatment	Mean difference	Sig *	95% C.I for difference
Parents	Aligned Canines_with time	Substituted Premolars_withtime	7.2	0.109	-0.8-15.3
		Gaps_withtime	50.2	<0.001	36.2-64.2
		Deciduous Canines_withtime	21.4	0.000	11.9-30.9
	Substituted Premolars_ withtime	Gaps_withtime	43.0	<0.001	30.1-55.8
		Deciduous Canines_withtime	14.2	<0.001	5.1-23.2
	Gaps_ withtime	Deciduous Canines_withtime	-28.8	<0.001	-40.4- -17.1

* The mean difference is significant at the 0.05 level

Within the Patient group, there was a statistically significant difference in the VAS scores between the Gaps_with time preference score and the other three treatment options. This indicates that the Patient group had a similar preference for treatment between the Aligned Canines, Substituted Premolars and Deciduous Canine treatment but have significantly less preference for choosing the Gaps treatment option.

The Parent group showed a statistically significant difference between all treatment options except between the Aligned Canines and Substituted Premolars options. This

was despite being informed that the Substituted Premolars option would, on average, take less time and the groups showing no statistically significant difference in their aesthetic perception between these two options in the first part of the questionnaire.

3.5.6 Treatment_with time*group interaction

For the main effect of group, it was apparent that there was a significant difference in VAS_with time preference scores between the two groups.

Table 18 and Figure 9 explores this further to determine where the significant interaction lies and what effect the treatment_with time option has on the VAS preference score differences between the groups.

Table 18 Interaction table of Treatment_with time*group

Treatment_ with time	Group	Group	Mean difference	Sig*	95% C.I for difference
Aligned canines	Patients	Parents	-16.3	<0.001	-24.9- -7.7
Substituted Premolars	Patients	Parents	-13.1	0.003	-21.7- -4.4
Gaps	Patients	Parents	0.80	0.890	-10.6-12.2
Deciduous Canines	Patients	Parents	1.6	0.733	-7.9 - 7.9

* The mean difference is significant at the 0.05 level

This data shows that for the Aligned Canines option, the Patient/ Parent group scored significantly differently in their preference for that option. The Patient group giving a significantly lower score, indicating lower preference for this treatment option compared to their parents.

There was also a significant interaction between Treatment_with time and group for the Substituted Premolars treatment option, with again the Patient group giving a significantly lower score, indicating a lower preference for treatment.

3.6 Descriptive comparison of part 1 and part 2 mean VAS scores

Table 19 Mean VAS scores for aligned canines

Group	Treatment	Mean	C.I
Patient	Aligned Canines	80.6	75.9-85.2
	Aligned Canines_withtime	65.4	59.3-7.5
Parent	Aligned Canines	83.8	79.1-88.5
	Aligned Canines_withtime	81.8	75.7-87.8

On a descriptive basis it can be seen in Table 19, that the Patient group, on average, scored the Aligned Canines higher in terms of aesthetics than for their preference for treatment.

However, this option came on top both in terms of the highest VAS score for aesthetics and treatment preference when compared to the other treatment options. The Parent group score changed very little.

Table 20 Mean VAS scores for substituted premolars

Group	Treatment	Mean	C.I
Patient	Substituted premolars	76.6	71.7-81.5
	Substituted premolars_withtime	61.4	55.3-67.5
Parent	Substituted premolars	80.6	75.7-85.5
	Substituted premolars_withtime	74.5	68.4-80.6

The largest difference in VAS score for the Substituted Premolars option was in the Patient group, whose aesthetic score was much higher than their preference for this type of treatment (Table 20).

Table 21 Mean VAS scores for gaps

Group	Treatment	Mean	C.I
Patient	Gaps	36.0	30.5-41.5
	Gaps_withtime	32.3	24.2-40.4
Parent	Gaps	34.2	28.6-39.7
	Gaps_withtime	31.5	23.4-39.6

With regards to the gaps treatment option there was little difference between the low aesthetic score given and the low preference score given for both groups (Table 21).

Table 22 Mean VAS scores for deciduous canines

Group	Treatment	Mean	C.I
Patient	Deciduous Canines	65.2	59.0-71.3
	Deciduous Canines_withtime	62.0	55.2-68.8
Parent	Deciduous Canines	59.4	53.2-65.5
	Deciduous Canines_withtime	60.3	53.5-67.1

Similar VAS scores were obtained between the part 1 (aesthetics) scores and the part 2 (preference score) for the Deciduous Canine group. The Patients rated this option slightly more highly than the Parent group (Table 22).

3.7 Descriptive analysis of the aesthetic ranking frequencies

Figures 10, 11, 12 & 13 show the frequencies that the Patient and Parent groups placed each treatment option into preferred aesthetic categories when they were asked to categorize them according to aesthetic preference. Both Patient and Parent groups were now aware of what the image represented in terms of the treatment undertaken.

Figure 10 Ranking scores of Aligned Canines

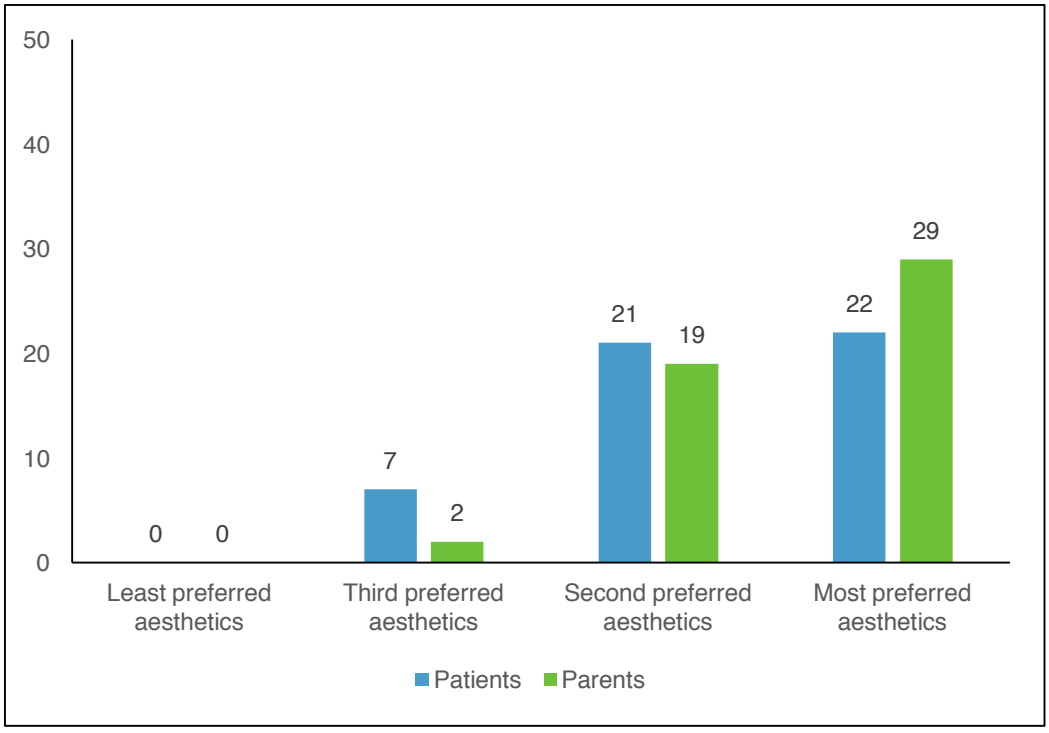


Figure 11 Ranking scores of Substituted Premolars

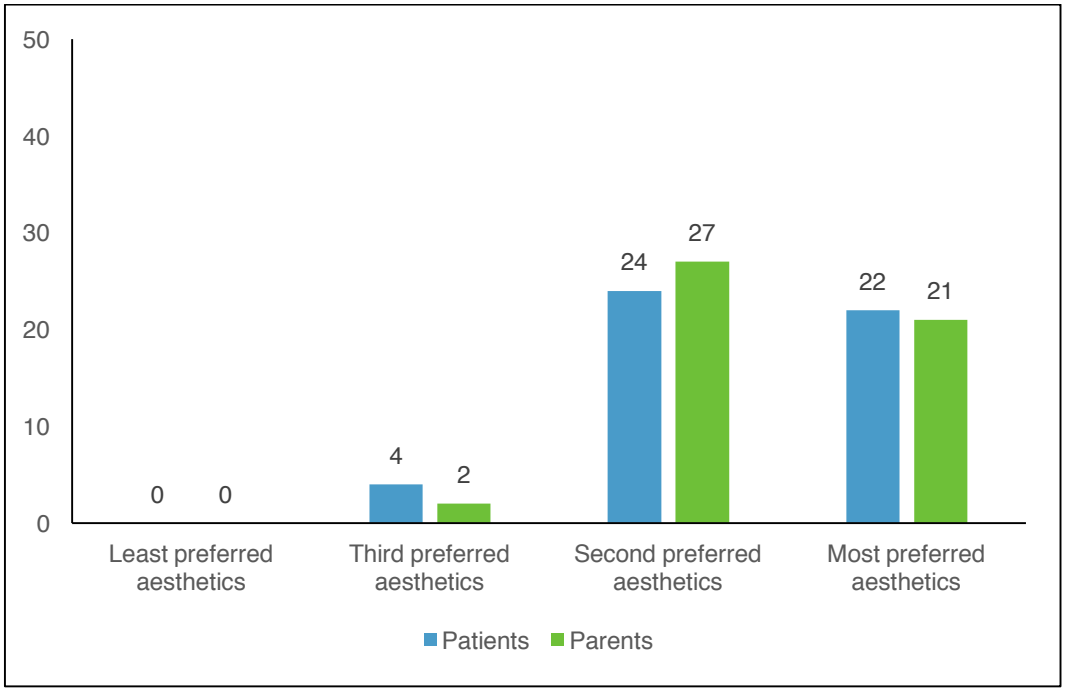


Figure 12 Ranking scores of Gaps

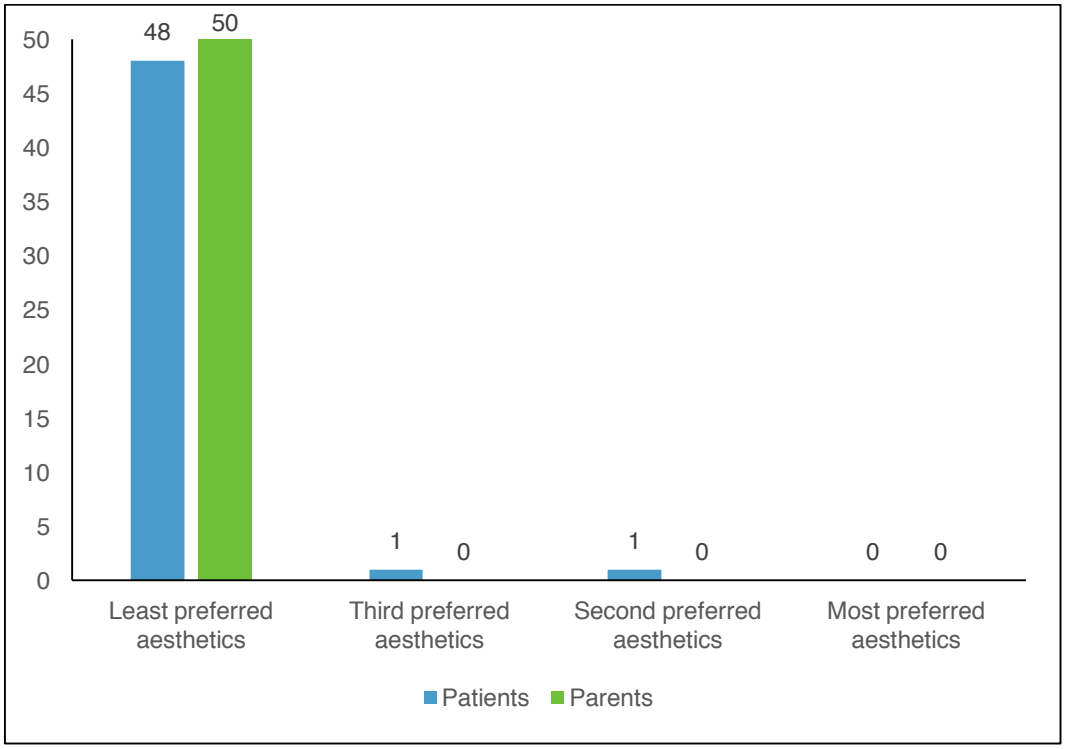
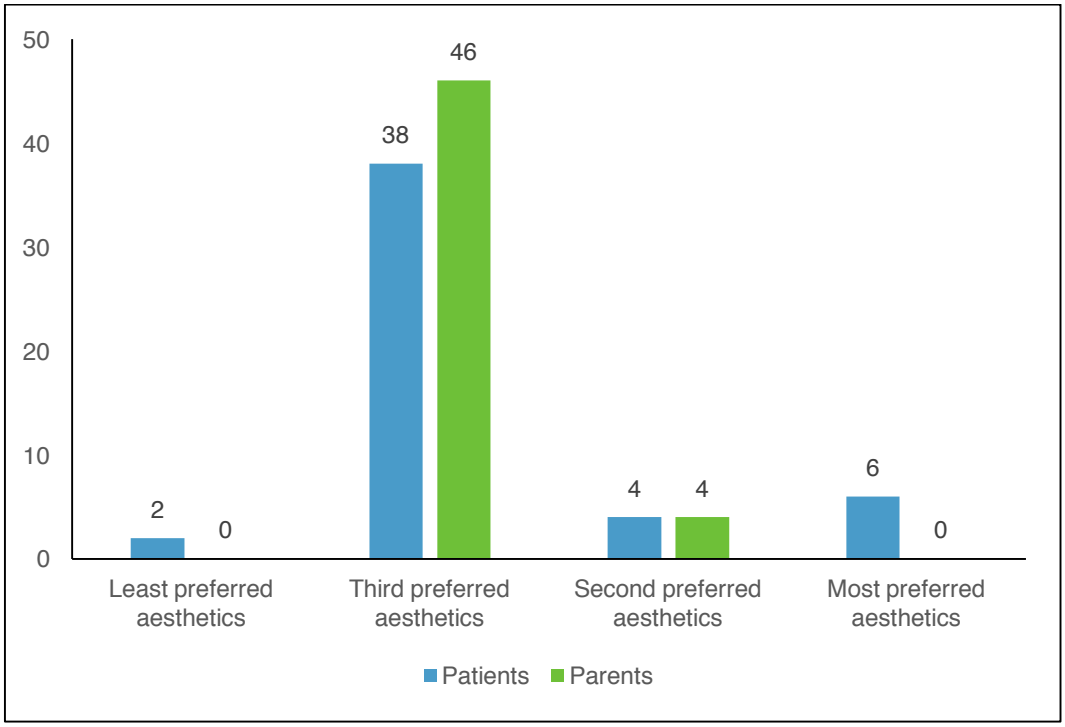


Figure 13 Ranking scores of Deciduous Canines



Similar to the aesthetic VAS scores obtained in Part 1 of the questionnaire there was a clear consensus that the Gaps option was the least preferred and unaesthetic treatment (Figure 12) with the Deciduous Canines ranking third (Figure 13). The frequencies of the Aligned Canines and Substituted Premolars being ranked as most aesthetically preferred was much closer and similar to the mean VAS scores for part 1, although the Aligned Canines image was ranked as being the most preferred aesthetic option more frequently (Figure 10) than the Substituted Premolars (Figure 11).

When the mean VAS scores from part 1 of the questionnaire were transformed into ranked data for the Patient and Parent groups and compared with the ranked scores given at the end of the questionnaire only a handful of individuals were seen to have changed their aesthetic choices.

3.8 Intra-examiner reliability

Intraclass correlation (ICC) was used to determine the reliability of the agreement between the continuous VAS score measurements taken on two separate occasions. The results were interpreted using the values of Landis and Koch (1977) as cited by Cicchetti (1994).

3.6.1 Re-measuring of VAS scores by author at 6 weeks

Table 23 ICC result for re-measured VAS scores (n=20)

Treatment	ICC score	Definition
Aligned Canine VAS score	0.989	Almost perfect agreement
Substituted Premolars VAS score	0.997	Almost perfect agreement
Gaps VAS score	0.989	Almost perfect agreement
Deciduous Canines VAS score	0.965	Almost perfect agreement

3.6.2 Test-retest repeating of questionnaire at 6 weeks by 10% of judges (n =20)

Table 24 ICC result for repeating questionnaire at 6 weeks (n=20)

Treatment	ICC score	Definition
Aligned Canine VAS score	0.712	Substantial agreement
Substituted Premolars VAS score	0.647	Substantial agreement
Gaps VAS score	0.929	Almost perfect agreement
Deciduous Canines VAS score	0.5	Moderate agreement

In line with previous studies the scores derived in Table 23 and 24 indicate that using the VAS scale is valid and reliable.

CHAPTER 4

DISCUSSION AND CONCLUSIONS

Chapter 4 Discussion and Conclusions

4.1 Recruitment

The methodology used in this study regarding recruitment of the four judging groups did not pose any challenges during data collection. The Orthodontist group was recruited at educational meetings which the author attended. These were at the Midland Orthodontic Society group in January 2016, which is attended by both Orthodontic consultants and specialists as well as the national meeting of the British Orthodontic Society Consultants Group (BOS COG) in January 2016. GDPs were also recruited during January 2016 at local Continuing Professional Development (CPD) meetings held for GDPs by the British Dental Association (BDA) and the West Midlands Deanery. All Orthodontists and GDPs who were asked to take part in the study agreed to participate.

The patient and parent groups were consecutively recruited during their routine orthodontic appointments with the author (LS). Five subjects declined to participate in the study, due to time constraints when they attended for their routine appointments. Although the patient and parent VAS scores obtained in the study were similar, steps to prevent collusion were taken by asking the assessors to not converse during questionnaire completion and the author remained present to ensure no discussions took place.

4.2 Repeatability

The data collection to assess the repeatability of the study was slightly difficult. However, this difficulty was overcome by obtaining a computer generated random

sample in advance from the original numbered participants who had completed the questionnaires. The chosen participants were asked after they had completed the questionnaire if they could compete the same questionnaire after six weeks so that the consistency of their answers could be measured. All chosen participants for this part of the study consented to complete the questionnaire on a second occasion six weeks later. The random samples from the Patient and Parent groups were given the second repeated questionnaire when they attended for their next routine orthodontic appointment. The study author (LS) travelled to the work place of the Orthodontists and GDPs random sample groups for them to complete the second repeated questionnaire after 6-weeks of completing the first questionnaire. Only one participant in the Orthodontist group had to be sent the second repeat questionnaire in the post. The author phoned the Orthodontist and repeated the instructions to complete the questionnaire to maintain consistency in data collection.

4.3 Reproducibility

To assess the reproducibility of the study, the classification of reliability quoted by Landis and Koch (1977), cited in Cicchetti (1994) was used. This classification is ideally used for interpreting continuous data using the Intra-class correlation (ICC) statistical test (Table 25).

Table 25 Interpretation of ICC values (Cicchetti, 1994)

Value of ICC	Interpretation
<0	Poor agreement
0.01-0.20	Slight agreement
0.21-0.40	Fair agreement
0.41-0.60	Moderate agreement
0.61-0.80	Substantial agreement
0.81-1.00	Almost perfect agreement

With respect to assessing the intra-examiner reliability (same author re-measuring 10% of VAS scales on two occasions), there was almost perfect agreement. This could be contributed to the author (LS) using digital calipers to measure the VAS scales which probably improved the accuracy of measurements.

With respect to the test-retest reliability (same participant repeating the questionnaire 6 weeks later), the scores obtained ranged from almost perfect agreement for the Gaps VAS score (0.929) to moderate agreement for the Deciduous Canines VAS score (0.5).

These findings tie in with the suggestion by Howells and Shaw (1985) that the VAS score is reliable, as well as being convenient and rapid to use with the benefit that it generates continuous data rather than categorical data. These properties of the VAS score were ideal when selecting the measuring scale for this study. The reliability of

using VAS has more recently been supported by Oliveria et al., 2015. Kaya and Uyar (2016) obtained 'almost perfect agreement' ICC scores for the images rated in their similarly designed study which examined the impact of occlusal plane cant and gingival display on smile attractiveness. However, it was not clear in their study the time differences between the randomly chosen selected participants completing the first questionnaire and the second questionnaire. Ioi et al. (2012) obtained ICC scores of 0.7 or more in their study, but participants were asked to repeat their questionnaire two weeks later, which is a much shorter time period than the six-week period used in this study.

In contrast, Barber, Houghton and Spencer (2015) expressed concerns with the reliability of the VAS score when assessing adolescents, after obtaining poor intra-examiner agreement scores in their study. However, they used a different method of test-retest to that used in the present study by repeating images at the end of the questionnaire, making direct comparisons challenging.

Due to the lack of literature in assessing the perception of different treatments for impacted canine on smile aesthetics, it is difficult to compare the reliability results of the present study to other similar studies, since assessing aesthetics is known to be so subjective and it is known that certain aspects of a smile are likely to show more agreement than others.

4.4 Summary of results for part 1 of the Questionnaire

To answer the first part of the research question which evaluated the post-orthodontic smile aesthetics of patients with impacted maxillary canines as perceived by Orthodontists, GDPs, patients and parents, a two-way mixed between-within subject's ANOVA (split plot ANOVA) statistical test was used to analyse the data.

The null hypothesis was:

There is no difference in the perception of smile aesthetics between the different treatment options available for treating palatally impacted canines as perceived by Orthodontists, GDPs, patients and parents.

The present study demonstrated that when the mean VAS scores were calculated, the Aligned Canines treatment was rated as consistently the most aesthetic, with the Orthodontist group being the most critical in terms of aesthetic perception.

With regards to the statistical analysis it is apparent that:

- There was a significant ($P < 0.001$) main effect for treatment, $F(3,500) = 546.941$
- There was a significant ($P < 0.002$) main effect for group, $F(3\text{-}196) = 5.110$
- There was a significant ($P < 0.002$) interaction between the effect of treatment and group on the VAS scores obtained $F(8,500) = 3.113$

Regarding the interactions:

- Within the Orthodontists and GDPs group there was a statistically significant difference in the mean VAS scores obtained between all four treatment options with the aligned canines being rated as the most aesthetic option. However the difference between the aligned canine and substituted premolars for the GDP group was less than the pre-determined clinically significant difference.
- Within the Patient and Parent group, there was no statistically significant difference in the mean VAS scores obtained between the Aligned Canines and Substituted Premolars group.
- There was a statistically significant difference between the Gaps present and Deciduous Canines treatment options VAS scores when compared to the Aligned Canines and Substituted Premolars, in favour of Aligned Canines and Substituted Premolars being the most aesthetic options.
- There was no statistically significant difference observed between the four groups in relation to how aesthetic they found the Aligned Canine treatment option, with a similar mean VAS score being obtained for this treatment option by all four groups.
- There was a statistically significant difference in how the Orthodontists rated the Substituted Premolars treatment compared to the other groups, with the Orthodontist group rating it as being significantly less aesthetic.
- The Gaps present and Deciduous Canines treatment options were rated as much less aesthetic by the Orthodontists when compared to the Patient group. No other significant differences were found.

The null hypothesis is therefore rejected.

4.5 Summary of results from questionnaire Part 2

The second part of the questionnaire aimed to assess if treatment time influences the preference of treatment options available to treat impacted maxillary canines by patients and parents.

The null hypothesis was:

There is no difference in the preference of treatment options by patients and parents in relation to the time taken for treating a palatally impacted canine tooth.

The present study demonstrated that when just the mean VAS_with time preference scores were observed, the Aligned Canines rated as the most preferred option. However, the Patient group indicated little difference between their mean VAS_with time scores between the Aligned Canines, Substituted Premolars and Deciduous Canines option. Both groups found the Gaps present treatment as the option they would be least likely to choose.

With regards to the statistical analysis it is apparent that:

- There was a statistically significant (P=<0.001) main effect for treatment_with time, F = (2,221) 81.2
- There was a statistically significant (P = <0.044) main effect for group, F = (1,98) 4.1, p = 0.044

- There was a significant interaction (P= >0.05) between the effect of treatment and group of the VAS preference scores obtained, F = (2.263-221.744) 5.13.

Regarding the interactions:

- Within the Patient group there was only a statistically significant difference in the preference between the Gaps treatment and the other options. The Gaps present option being rated as significantly less preferable to the other options.
- Within the Parent group, the Gaps present treatment was being rated as significantly less preferable compared to all the other options. There was a significant difference in the preference of the Aligned Canines and Substituted Premolars over the Deciduous Canines image.
- The Patient group rated the Aligned Canines and Substituted Premolars as less preferable compared to the score given by their Parents.

The null hypothesis is therefore rejected.

4.6 How the findings of this study compare with the literature

Some of the present study's findings can be compared with the findings of other studies, such as Haravi, Rashed and Abachizadeh (2011) and Foulger et al. (2010) which assessed different aspects of smile aesthetics perception by different sample groups. In the present study, it was found that whilst the groups in general were broadly similar when the VAS scores were ranked in order of aesthetics, it was apparent that significant differences existed between the mean scores. This was found particularly between the patient and the dental professional groups and is in agreement with that of Cooper et al. in 2012 who also found significant differences in the aesthetic perceptions between their chosen sample groups, (dentists, technicians and patients).

In the present study it was found that the Orthodontist group was more critical in terms of their aesthetic perceptions: this is in agreement with other studies that have compared dental professionals and orthodontists to patient/parent or laypeople groups (Hussain et al., 2016; Kaya and Uyar, 2016; Correa, Bittencourt and Machado, 2014; Johnston, Burden and Stenvenson, 1999; Kokich, Kayak and Shapiro, 1999). Therefore, treatment decisions, particularly involving aesthetics, should be discussed with the patient and parents since the orthodontist and dental professional's aesthetics perception may be completely different to that of the patient and their parents.

In line with the findings of previous literature (Brisman, 2000; Parekh et al., 2006), we found that there was no difference detected between the average VAS scores given by males and females.

4.7 Limitations of this study

4.7.1 Limitation of use of symmetrical images

One limitation of this study in relation to the validity could be that the images used were all symmetrical, yet in 'real life' only 8% of maxillary impacted canines are bilateral. (Ericson and Kurol, 1986). This is an important factor to take into account for the perception of smile aesthetics, given that Kokich, Kayak and Shapiro (2006) found that asymmetric alterations can be perceived as more unattractive to laypersons as well as dental professionals, with unilateral reduction of papillary height being rated as less attractive than a bilateral reduction. Thus, whilst bilateral substitution of premolars for canines might not be statistically significantly less attractive than alignment of canines in the view of the patient and parent groups in this study. A unilateral substitution with a reduced gingival margin height that is generally associated with a first premolar substitution may be perceived as much less aesthetic when compared to a contralateral regular canine in a patient with a high smile line.

4.7.2 Limitations of images and digital manipulation

In agreement with the conclusions by Correa, Bittencourt and Machado (2014), who also used digitally manipulated images in their study, as the results and conclusions are based on averages, customization of this information in the clinical setting for the patient could be problematic due to the subjectivity of smile attractiveness perceptions. In the present study, an attempt was made to select 'average' treatment results for the images, such as an 'average' sized deciduous canine and a 'average' first premolar in

terms of gingival height and size. Only one image representing each treatment was also used in the questionnaire to reduce the burden on each participant. However, in 'real-life' it is recognized that there will be wide variations between patients regarding these aesthetic factors which could influence treatment decisions made. However, despite limitations in image selection and manipulation it was considered that it would be more beneficial to use manipulated images of real teeth rather than purely computer-simulated images which have been used in some studies such as by Rosa et al. (2013). This is considered as less natural and therefore have questionable 'real-life' validity. Using only 4 images does however limit the generalizability of the study.

In this study a close up image of the teeth and gingiva surrounded by the lips was selected, as used in other similarly designed studies (Foulger et al., 2010). This presents an image where the assessor can easily perceive the overall smile attractiveness, whilst eliminating any other components of facial appearance, and limiting other potential distractions of the viewer from the variable under consideration.

In the pilot study, intra-oral images showing only the teeth and gingiva without the surrounding lip curtain were displayed on the same page as the extra-oral cropped image as these have also been used in the literature (Kokich, Kayak and Shapiro, 1999).

However, many comments were made by patients and parents following completion of the questionnaire in the pilot study regarding these images and their confusion by them. As this perhaps indicated that these images were likely to significantly influence the opinion of the parent and patient groups in a negative way, a decision was made

therefore to only show the close-up extra-oral images when the main study was conducted.

4.7.3 Limitations of the VAS scale

The use of a VAS scale was suggested by Howells and Shaw in 1985 as a convenient and rapid method of assessing dental attractiveness and it was particularly appealing for use in this study as it does not restrict the participant to categorize or to make a forced choice between two options which perhaps the assessor could feel as being otherwise perceptually the same.

However, limitations are that part of the scale might be ignored, or that the scale could be judged unequally by different assessors thus causing a misinterpretation of perception of attractiveness (Parekh et al, 2006 and Ioi, Nakata and Counts, 2010).

Therefore, for this study, although VAS scoring was very acceptable for the first part of the questionnaire which examined the aesthetic scores. The limitation of using VAS, allowing the assessor to adopt a neutral position and give no preference was a negative factor in the second part of the questionnaire where an attempt was made to ascertain preference for choosing treatment (Foulger, et al., 2010). Thus for the Patient group the only difference in preference was seen between the Gaps present and the other options with no significance difference seen between the Aligned Canines, Substituted Premolars and Deciduous Canines treatment option. However, when this is compared to the ranks given to the Deciduous Canines treatment, this was ranked as the third most preferable below the Aligned Canines and Substituted Premolars

option. Barber, Houghton and Spencer (2015) also expressed concerns regarding the ability of an adolescent group of patients to fully grasp the concept of the VAS scale.

Phillips, Tullochs and Dann (1992) recommended that, when surveys employed assessors of different backgrounds, a ranking system rather than VAS scores should be used. Whilst many studies looking at smile aesthetics from the perception of different peer groups have adopted a ranking approach to their data collection (Cooper et al., 2012; Foulger et al., 2010; Hussain et al., 2016) the limitations of an assessor having to make a forced choice and the importance of not being able to detect if there is 'no difference' in the aesthetics between two treatment options should be borne in mind.

4.8 Conclusions

Within the few limitations of this study, the following conclusions can be drawn with regards to the perception of smile aesthetics related to potential treatment options for impacted maxillary canines:

- The aesthetic perception of orthodontists is more critical than that of patients and parents and possibly even GDPs.
- Orthodontists should therefore factor in and not unduly influence the aesthetic opinions of patients and parents at the treatment planning stage.
- There is a particularly large discrepancy between the aesthetic perception of orthodontists and their adolescent patients.

- With regards to a symmetrical result, there appears to be no difference in the aesthetic perception of aligned canines and substituted premolars in the view of patients and parents and also GDPs as the difference in VAS score was clinically insignificant.
- Gaps present gave consistently the worst aesthetic result and should be avoided.

With regards to the preference of treatment options when patients and parents were made aware of the time taken for each option:

- The treatment option of gaps, even with the knowledge that prosthetic replacement is possible was rated as the least preferable treatment option
- The patients were less sure than their parents regarding their preference of treatment choice between aligned canines, substituted premolars and deciduous canines treatment options, indicating perhaps lack of concept regarding the question or appreciation regarding the factor of treatment duration.
- There was no significant difference between the preference for aligned canine and substituted premolar, despite the patient and parent groups now being aware that the substituted premolars would take less time on average.

4.9 Suggestions for further research

Simms, in 1977 (p.246), suggested that;

> "longer term evaluation of the ability of the first premolars to function as canines is necessary before truly definitive conclusions can be drawn as to the ultimate long-term effect of substitution."

Therefore, although the present study has provided greater insight into the probability there is likely to be little difference in terms of the average smile aesthetics between an aligned canine and substituted premolar in symmetrical clinical situations in the opinion of the patients (arguably the most important party) and their parents, there are other potential factors that need to be considered such as the possibility of early loss of the first premolars, increased risk of caries, cusp fracture or a reduced chewing efficiency. These are all factors that may jeopardize this option as a life-long successful treatment and which have not been investigated in the literature.

Other areas of interest on this topic, include examining the smile aesthetics perceptions by different ethnic groups. In this study we did not factor in for ethnicity, as some studies have shown little difference (Cons and Jenny, 1994; Otuyemi et al., 1998) however, there is some evidence suggesting that smile perception may vary between different ethnic groups, (Kiyak, 1981) particularly in regards to the tolerance of gaps present and this could be important concept to take into account if such a difference does exist, particularly in areas where a multicultural society exists such as the population of the West Midlands.

CHAPTER 5

APPENDICES AND REFERENCES

Chapter 5 Appendices and References

Appendices

Appendix 1. Information sheet Patient group

UNIVERSITY OF BIRMINGHAM

University Hospitals of North Midlands NHS
NHS Trust

Royal Stoke University Hospital
Orthodontic Department
Newcastle Road
Stoke-on-Trent
Staffordshire
ST4 6QG

Tel:
Email:

PATIENT'S INFORMATION SHEET: Version 2/9.1.16

Title: Smile aesthetics perception amongst dental professionals, patients and parents following treatment for impacted maxillary canines.

PART 1: The project

We are asking if you would take part in a research project that is looking at if different types of brace treatment can affect the smile.

Before you decide if you want to join in, it's important to understand why the research is being done and what it will involve for you. So please consider this leaflet carefully.

Why have I been invited to take part?
You have been asked to take part because you are having brace treatment at the moment.

Do I have to take part?
No. It is up to you. If you do I will ask you to sign a form saying you are happy to take part. You will be given a copy of this information sheet and your signed form to keep. You are free to stop taking part at any time during the research without giving a reason. If you decide to stop or if you don't want to take part, this will not affect the treatment you are receiving.

What will happen to me if I take part?
If you agree to take part you will be asked to fill out a short questionnaire. This should take about 10 minutes. No extra appointments will be needed.

Contact details
If you have any questions you can ask me: Leonie Seager.

Thank you for reading so far – if you are still interested, please turn over and read Part 2:

PART 2: More information

What happens following completion of the study?
Ideally you will answer the questions after you are seen on the clinic today and you might be asked to complete the questionnaire for a second time in around 6 weeks time. After this we will not need to contact you again, however you would be able to speak to us at any time regarding the study if you wish.

What if there is a problem or something goes wrong?
If you have any problems these will be seen too immediately. If you are worried about the way you have been treated then you may contact the study team. If you wish to complain then you can contact us on the numbers below.

Confidentiality
You will not need to provide any personal details. We will not give anyone the information you have provided.

Who is organising this research?
This research is organised and supported by The University of Birmingham and Royal Stoke University Hospital.

Who has reviewed the study?
Before any research goes ahead it has to be checked by a Research Ethics Committee. They make sure that the research is fair. This study has been checked and have been told that we can ask you to complete the questionnaire.

Questions & Complaints:
If you have any questions you can ask:
Leonie Seager (the person giving you this sheet) or Mr Shah (Consultant Orthodontist)
If you want to complain you can speak to: Mr J Shah
Tel:

Thank you for reading this

Appendix 2. Information sheet for Parent group

UNIVERSITY OF BIRMINGHAM

University Hospitals of North Midlands NHS
NHS Trust

Royal Stoke University Hospital
Orthodontic Department
Newcastle Road
Stoke-on-Trent
Staffordshire
ST4 6QG

Tel:
Email:

PARENT/GUARDIAN INFORMATION SHEET: Version 3/9.1.16

We would like to invite you to take part in a research study. Before you decide you need to understand why the research is being done and what it would involve for you. Please take time to read the following information carefully. Talk to others about the study if you wish. (Part 1 tells you the purpose of this study and what will happen to you if you take part. Part 2 gives you more detailed information about the conduct of the study).

Title: Smile aesthetics perception amongst dental professionals, patients and parents following treatment for impacted maxillary canines.

PART 1: The project

Why are we doing this research?
Many children present with impacted canine teeth, and there are often several treatment options usually available. We currently do not know if there is any difference regarding the aesthetics of the smile when these treatment options are compared.

Why have we asked your child to participate?
We are inviting you and your child to take part in this study because your child is currently undergoing brace treatment. Participation is entirely voluntary and your child's treatment will not be affected if you decide not to participate.

What is involved?
Once you have verbally agreed to participate we will obtain written consent from you and your child. You will then both be asked to complete a questionnaire. I will be present if you have any queries.
No additional appointments are required and answering the questionnaires will take a **maximum of 10 minutes**. It is important that you do not discuss the questionnaire with your child whilst you are both completing it. At no point will any treatment be withheld. You may withdraw either yourself or your child from the study at any time without consequence to the quality of care your child will receive in this department.

Contact Details:
For further information about the study or for any concerns please contact:
Mrs Leonie Seager or Mr J Shah Tel:

P.T.O

Alternatively you may contact the orthodontic department on the usual number.

Part 2: Additional information

What happens following completion of the study?
Ideally we would like you to complete the questionnaire straight after your appointment. The study team will not need to contact you again, unless we need you to complete the questionnaire for a second time in 6 weeks.

What if there is a problem or something goes wrong?
If you have any problems these will be seen to immediately. If you are worried about the treatment received or the way you have been treated then you may contact the study team or speak to the consultants at any time.

Confidentiality
All of the information that is collected regarding the participants, during the course of the research, will be kept strictly confidential. You will not be asked to provide any personal details. Information that has been provided will be anonymous so you and your child cannot be identified from it.

Who has reviewed the study?
All research in the NHS is looked at by independent group of people, called a Research Ethics Committee to protect your safety, rights, wellbeing and dignity. This group have approved this piece of research.

Organisation and funding
This study is being supported by the University of Birmingham and the Royal Stoke University Hospital.

Complaints
If you require further advice or have concerns, independent of the research team, then you may contact the Patient Advice and Liaison Service in the first instance. They can give advice, provide information on NHS services, listen to your concerns and help to sort out problems on your behalf.
Your PALS representatives are: Stoke-on-Trent, North Staffordshire and South Staffordshire Team.
Tel: 0800 783 2865

Thank you for reading this – please ask if you have any questions.

Appendix 3. Information sheet for GDP and Orthodontist group

UNIVERSITY OF BIRMINGHAM

University Hospitals of North Midlands NHS
NHS Trust

Royal Stoke University Hospital
Orthodontic Department
Newcastle Road
Stoke-on-Trent
Staffordshire
ST4 6QG

Tel:
Email:

DENTAL PROFESSIONALS INFORMATION SHEET: Version 2/9.1.16

We would like to invite you to take part in a research study. Before you decide you need to understand why the research is being done and what it would involve for you. Please take time to read the following information carefully. Talk to others about the study if you wish. (Part 1 tells you the purpose of this study and what will happen to you if you take part. Part 2 gives you more detailed information about the conduct of the study).

Title: Smile aesthetics perception amongst dental professionals, patients and parents following treatment for impacted maxillary canines.

PART 1: The project

Why are we doing this research?
Many children present with impacted canine teeth and several different treatment options are usually available to the patient. The profession currently does not have any evidence to support whether there is any difference regarding smile aesthetics following treatment for impacted maxillary canine treatment, particularly from the perception of different peer-groups.

Why have we asked you to participate?
We are inviting you to take part in this study because we would like to be able to compare the perceptions of different demographic groups when answering this research question. Participation is entirely voluntary.

What is involved?
If you are happy to participate in this research we will ask for you to give written consent.
You will then be asked to complete a questionnaire during which I will be present should you have any queries. Answering the questionnaires will take a **maximum of 5 minutes** and extensive instructions are available to you on the first sheet of the questionnaire.

Contact Details:
For further information about the study or for any concerns please contact:
Mrs Leonie Seager or Mr J Shah Tel:

Alternatively you may contact the orthodontic department on the usual number.

P.T.O

Part 2: Additional information

What happens following completion of the study?
10% of the study participants will be contacted and asked to complete the questionnaire for a second time in 6 weeks time. Unless you are one of these participants the study team will not need to contact you again, however you can contact us at any time to speak to us regarding the study if you wish.

Confidentiality
All of the information that is collected in the questionnaire will be kept strictly confidential. You will not be asked to provide any personal details. Any information that you have provided us with will be anonymised so you cannot be identified from it.

Who has reviewed the study?
The Research Ethics Committee have been contacted and approval has been granted for this study.

Organisation and funding
This study is being supported by the University of Birmingham and The Royal Stoke University Hospital.

Thank you for reading this – please ask if you have any questions.

Appendix 4. Consent/assent forms

UNIVERSITY OF BIRMINGHAM

University Hospitals of North Midlands NHS
NHS Trust

Royal Stoke University Hospital
Orthodontic Department
Newcastle Road
Stoke-on-Trent
Staffordshire
ST4 6QG

Tel:
Email:

CONSENT/ASSENT FORM PATIENT/PARENT GROUP: Version 3/9.1.16

Title of Project: **Smile aesthetics perception amongst dental professionals, patients and parents following treatment for impacted maxillary canines.**

Name of Researcher: Mrs Leonie Seager / Mr Jinesh Shah / Professor Burke

Please tick box

1. I confirm that I have read the information sheet dated 9.1.16 (version 3) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐
2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my medical care or legal rights being affected. ☐
3. *(Parent/guardian only)* I consent to my child completing the questionnaire and taking part in the study ☐
4. I agree to take part in the above study. ☐

Name of Participant	Date	Signature
Name of Person taking consent	Date	Signature

When completed, 1 for patient; 1 for researcher site file; 1 (original) to be kept in medical notes

UNIVERSITY OF BIRMINGHAM

University Hospitals of North Midlands NHS
NHS Trust

Royal Stoke University Hospital
Orthodontic Department
Newcastle Road
Stoke-on-Trent
Staffordshire
ST4 6QG

Tel:
Email:

CONSENT FORM GDP & ORTHODONTIST GROUP: Version 2/9.1.16

Title of Project: Smile aesthetics perception amongst dental professionals, patients and parents following treatment for impacted maxillary canines.

Name of Researcher: Mrs Leonie Seager / Mr Jinesh Shah

Please tick box

1. I confirm that I have read the information sheet dated 9.1.16 (version 2) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐
2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my medical care or legal rights being affected. ☐
3. I agree to take part in the study ☐

Name of Participant	Date	Signature
Name of Person taking consent	Date	Signature

Appendix 5. Invitation letter and consent form for cases

UNIVERSITY OF BIRMINGHAM

University Hospitals of North Midlands NHS
NHS Trust

Royal Stoke University Hospital
Orthodontic Department
Newcastle Road
Stoke-on-Trent
Staffordshire
ST4 6QG

Tel:
Email:

Invitation letter to take part in research study: Smile aesthetics perception amongst dental professionals, patients and parents following treatment for impacted maxillary canines: Version 2/18.8.15

Dear ,

I am a registrar in Orthodontics and I am undertaking a project investigating how different groups of people respond to what a smile looks like after different forms of orthodontic treatment to correct canine (eye teeth) problems.

I am asking you to be involved by agreeing to photographs of your smile to be used in my study because you have had orthodontic treatment to correct canine (eye teeth) problems.

The photos would have identifying features either cropped or edited out. Once the photos have been inputted into the questionnaire it will be impossible for anyone to trace the photos back to your identity. I also have a sample of the photographs available to show you as examples.

You do not have to take part if you do not wish to do so and your participation or otherwise will not affect the treatment you receive.

This project is being supervised by Mr J Shah, Consultant in Orthodontics. If you would like to know more about it, please feel free to ask either myself or Mr Shah any questions.

Thank you for your help.

Yours sincerely

Leonie Seager

Specialist Registrar in Orthodontics

UNIVERSITY OF BIRMINGHAM

University Hospitals of North Midlands NHS
NHS Trust

Royal Stoke University Hospital
Orthodontic Department
Newcastle Road
Stoke-on-Trent
Staffordshire
ST4 6QG

Tel:
Email:

CONSENT/ASSENT FORM: USE OF PHOTOGRAPHS IN STUDY: Version 2/18.8.15

Title of Project: Smile aesthetics perception amongst dental professionals, patients and parents following treatment for impacted maxillary canines.

Name of Researcher: Mrs Leonie Seager / Mr Jinesh Shah

	Please initial box
1. I confirm that I have read the invitation letter (date……version……) for the above study. I have had the opportunity to consider the information and ask questions.	☐
2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my medical care or legal rights being affected.	☐
3. I consent to the use of my own or my child's (if the subject is less than 16 years old) post-orthodontic clinical photographs in the study questionnaire.	☐
4. I understand that relevant sections of my medical notes and data collected during the study may be looked at by individuals from regulatory authorities or from the NHS Trust, where it is relevant to my taking part in this research. I give permission for these individuals to have access to my/my childs records.	☐

Name	Date	Signature
_____	_____	_____

When completed, 1 for patient; 1 for researcher site file; 1 (original) to be kept in medical notes

Appendix 6. Questionnaire for Patient group

University Hospitals of North Midlands NHS Trust

UNIVERSITY OF BIRMINGHAM

"Smile aesthetics perception amongst dental professionals, patients and parents following treatment for impacted maxillary canines"

QUESTIONNAIRE
(Patient Group)

4.1.16 Version 3

1

UNIVERSITY OF BIRMINGHAM

University Hospitals of North Midlands NHS
NHS Trust

Thank you for taking the time to take part in this study

Please complete the following information

- Age (yrs & months) ……
- Gender *(please circle)* M F
- First part of post-code (i.e. SY1) ……

Questionnaire Instructions

This questionnaire is in two parts.

Part 1: Each case will be presented on a single page. Please mark on the line where your instinctive opinion sits regarding how attractive you think this smile looks.

Part 2: Each case will be presented on a single page. Please mark on the line likely you would be to choose that treatment option taking into account the additional information you have been given. On the final page of the questionnaire you will then view all the images together and be asked to rank the images in order of preference.

Please do not discuss the questionnaire with others whilst you are completing it.

Please do not return to view any previous images or change your mark.

If you have any questions please just ask.

2

PART 1

CASE 1

Very unattractive — Very attractive

3

PART 1

CASE 2

Very unattractive — Very attractive

4

PART 1

CASE 3

Very unattractive — Very attractive

5

PART 1

CASE 4

Very unattractive — Very attractive

6

PART 2

CASE 1

In this case the impacted adult upper 'fang' (canine) tooth has been aligned – the average treatment time is 30-36 months.

How likely would you be to choose this treatment option for yourself?

Not at all likely ——— Very likely

7

PART 2

CASE 2

In this case the impacted adult upper 'fang' (canine) tooth has been extracted. The average treatment time is likely to be 24-30 months.

How likely would you be to choose this treatment option for yourself?

Not al all likely ——— Very likely

8

PART 2

CASE 3

In this case the patient has a retained "baby" canine tooth and the impacted "adult" canine tooth was extracted – the average time for this treatment can vary from no orthodontic treatment to 18-24 months of orthodontic treatment.

How likely would you be to choose this treatment option for yourself?

Not at all likely ——— Very likely

9

PART 2

CASE 4

In this case the patient has decided to accept a gap where they have lost the 'baby' canine tooth, which will be replaced by either a denture or a bridge. The impacted adult impacted canine tooth has been extracted. The average time for this treatment can vary from no orthodontic treatment to 18-24 months of orthodontic treatment.

How likely would you be to choose this treatment option for yourself?

Not at all likely — Very likely

10

Please now rank the 4 images in order of your preference for treatment of impacted canine teeth.

Mark 1 as your most preferred aesthetic result to 4 being your least preferred aesthetic result.

11

Appendix 7. Questionnaire for Parent group

University Hospitals of North Midlands NHS Trust

UNIVERSITY OF BIRMINGHAM

"Smile aesthetics perception amongst dental professionals, patients and parents following treatment for impacted maxillary canines"

QUESTIONNAIRE
(Parent Group)

4.1.16 Version 3

1

UNIVERSITY OF BIRMINGHAM

University Hospitals of North Midlands NHS
NHS Trust

Thank you for taking the time to take part in this study

Please complete the following information

- Age (yrs & months) .....
- Gender *(please circle)* M F
- Occupation .....
- First part of post-code (i.e. SY1) .....

Questionnaire Instructions

This questionnaire is in two parts.

Part 1: Each case will be presented on a single page. Please mark on the line where your instinctive opinion sits regarding how attractive you think this smile looks.

Part 2: Each case will be presented on a single page. Please mark on the line likely you would be to choose that treatment option taking into account the additional information you have been given. On the final page of the questionnaire you will then view all the images together and be asked to rank the images in order of preference.

Please do not discuss the questionnaire with others whilst you are completing it.

Please do not return to view any previous images or change your mark.

If you have any questions please just ask.

2

PART 1

CASE 1

Very unattractive — Very attractive

3

PART 1

CASE 2

Very unattractive — Very attractive

4

PART 1

CASE 3

Very unattractive — Very attractive

5

PART 1

CASE 4

Very unattractive — Very attractive

6

PART 2

CASE 1

In this case the impacted adult upper 'fang' (canine) tooth has been aligned – the average treatment time is 30-36 months.

How likely would you be to choose this treatment option for your child?

Not at all likely ——— Very likely

7

PART 2

CASE 2

In this case the impacted adult upper 'fang' (canine) tooth has been extracted. The average treatment time is likely to be 24-30 months.

How likely would you be to choose this treatment option for your child?

Not al all likely ——— Very likely

8

PART 2

CASE 3

In this case the patient has a retained "baby" canine tooth and the impacted "adult" canine tooth was extracted – the average time for this treatment can vary from no orthodontic treatment to 18-24 months of orthodontic treatment.

How likely would you be to choose this treatment option for your child?

Not at all likely ——— Very likely

9

PART 2

CASE 4

In this case the patient has decided to accept a gap where they have lost the 'baby' canine tooth, which will be replaced by either a denture or a bridge. The impacted adult impacted canine tooth has been extracted. The average time for this treatment can vary from no orthodontic treatment to 18-24 months of orthodontic treatment.

How likely would you be to choose this treatment option for your child?

Not at all likely — Very likely

10

Please now rank the 4 images in order of your preference for treatment of impacted canine teeth.

Mark 1 as your most preferred aesthetic result to 4 being your least preferred aesthetic result.

11

Appendix 8. Questionnaire for GDP and Orthodontists

UNIVERSITY OF BIRMINGHAM

University Hospitals of North Midlands NHS
NHS Trust

Thank you for taking the time to take part in this study

Please complete the following information

Demographic Information to be completed by participant

- Age .....
- Gender *(please circle)* M F
- Occupation .....
- Post-code (i.e SY1) .....
- Primary Dental Qualification .....
- Specialist Qualification(s) .....
- Any other qualifications .....

QUESTIONNAIRE INSTRUCTIONS

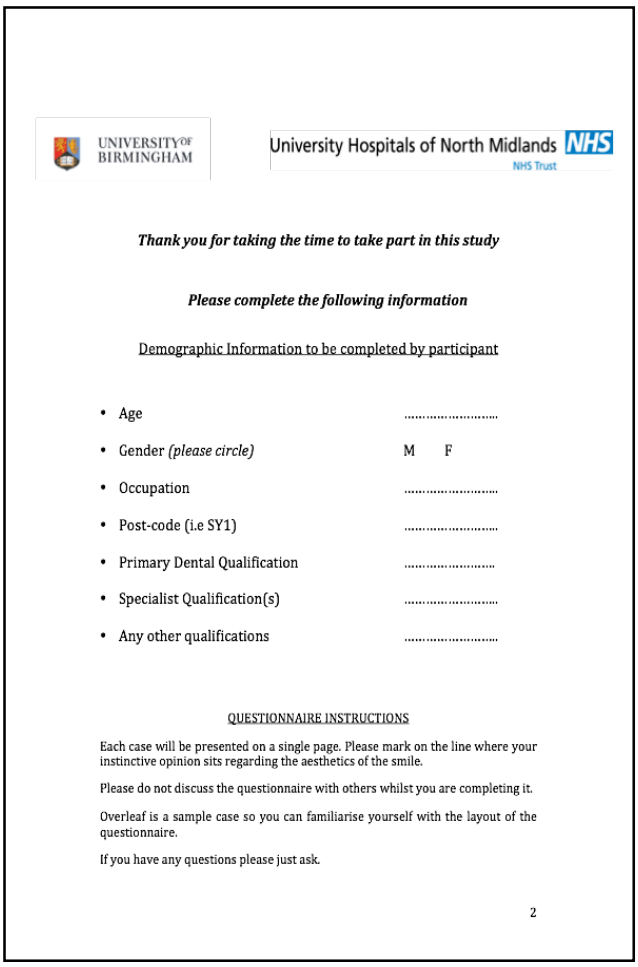
Each case will be presented on a single page. Please mark on the line where your instinctive opinion sits regarding the aesthetics of the smile.

Please do not discuss the questionnaire with others whilst you are completing it.

Overleaf is a sample case so you can familiarise yourself with the layout of the questionnaire.

If you have any questions please just ask.

2



UNIVERSITY OF BIRMINGHAM

University Hospitals of North Midlands NHS
NHS Trust

Thank you for taking the time to take part in this study

Please complete the following information

Demographic Information to be completed by participant

- Age .....
- Gender *(please circle)* M F
- Occupation .....
- Post-code (i.e SY1) .....
- Primary Dental Qualification .....
- Specialist Qualification(s) .....
- Any other qualifications .....

QUESTIONNAIRE INSTRUCTIONS

Each case will be presented on a single page. Please mark on the line where your instinctive opinion sits regarding the aesthetics of the smile.

Please do not discuss the questionnaire with others whilst you are completing it.

Overleaf is a sample case so you can familiarise yourself with the layout of the questionnaire.

If you have any questions please just ask.

2

PART 1

CASE 1

Very unattractive — Very attractive

3

PART 1

CASE 2

Very unattractive — Very attractive

4

PART 1

CASE 3

Very unattractive — Very attractive

5

PART 1

CASE 4

Very unattractive — Very attractive

6

Appendix 9. Pilot Data

Group

1 = Orthodontists

2 = GDPs

3 = Patients

4 = Parents

VAS Treat 1: Aligned Canines

VAS Treat 2: Substituted Premolars

VAS Treat 3: Gaps

VAS Treat 4: Deciduous Canines

Part 1

ID	Group	VAS Treat 1	VAS Treat 2	VAS Treat 3	VAS Treat 4
1	1	91	93	32	60
2	1	98	97	45	80
3	1	88	49	6	28
4	1	96	48	18	39
5	1	95	78	39	51
Means Group 1		***93.6***	***73***	***28***	***51.6***
6	2	71	75	14	50
7	2	84	87	59	90
8	2	90	92	74	70
9	2	95	96	43	86
10	2	95	94	44	69
Means Group 2		***87***	***88.8***	***46.8***	***73***
11	3	36	41	7	50
12	3	63	53	43	54
13	3	72	74	42	50
14	3	100	99	94	99
15	3	72	63	43	74

ID	Group	VAS Treat 1	VAS Treat 2	VAS Treat 3	VAS Treat 4
Means Group 3		***68.6***	***66***	***45.8***	***65.4***
16	4	100	98	65	96
17	4	98	100	63	96
18	4	93	95	5	49
19	4	90	92	67	88
20	4	77	75	47	54
Means Group 4		***91.6***	***92***	***49.4***	***76.6***

Part 2

ID	Group	VAS_with time Treat 1	VAS_with time Treat 2	VAS_with time Treat 3	VAS_with time Treat 4
11	3	65	54	72	13
12	3	44	49	35	29
13	3	93	93	50	8
14	3	76	80	81	74
15	3	100	100	72	76
Mean Group 3		***75.6***	***75.2***	***62***	***40***
16	4	100	100	72	80
17	4	84	94	87	58
18	4	63	92	100	17
19	4	95	83	89	33
20	4	66	81	65	90
Mean Group 4		***81.6***	***90***	***82.6***	***55.6***

Appendix 10. Demographics data

Data codes

Gender

0 = male

1 = female

Occupation

0 = employed

1 = not employed

2 = not applicable

Group

1 = Orthodontists

2 = GDPs

3 = Patients

4 = Parents

Dental qualification

0 = not applicable

1 = BDS (GDP)

2 = Specialist Orthodontist

3 = Consultant Orthodontist

ID	Age	Gender	Group	Postcode	Occupation	Dental Qualification
1	30	0	1	B18	2	2
2	41	1	1	B75	2	2
3	75	0	1	ST5	2	3
4	41	1	1	B75	2	3
5	42	1	1	B17	2	3
6	60	0	1	ST18	2	2
7	38	1	1	B15	2	3
8	32	1	1	B16	2	2
9	37	0	1	SY5	2	3
10	46	0	1	CV35	2	3
11	37	1	1	B93	2	1
12	31	1	1	B5	2	2
13	30	0	1	B18	2	2
14	32	1	1	B13	2	2
15	39	0	1	B34	2	2
16	51	1	1	ST17	2	2
17	50	0	1	B91	2	3
18	39	1	1	CV35	2	2
19	51	0	1	B13	2	3
20	39	0	1	B15	2	3
21	48	0	1	BA7	2	3
22	47	1	1	B5	2	2
23	42	1	1	B48	2	3
24	37	1	1	B28	2	3
25	55	0	1	B4	2	3
26	45	0	1	CW11	2	3
27	54	0	1	SY1	2	2
28	65	1	1	B13	2	2
29	47	1	1	BD5	2	3
30	32	0	1	M32	2	2
31	32	1	1	NE3	2	2

ID	Age	Gender	Group	Postcode	Occupation	Dental Qualification
32	45	0	1	BT37	2	3
33	33	0	1	NE3	2	3
34	51	0	1	NR18	2	3
35	53	0	1	SE1	2	3
36	35	1	1	SE1	2	2
37	29	0	1	N4	2	2
38	67	0	1	DE13	2	3
39	59	1	1	BT47	2	3
40	39	1	1	BN3	2	3
41	35	0	1	S10	2	3
42	66	0	1	CF62	2	3
43	59	0	1	GU20	2	3
44	50	1	1	OX2	2	3
45	59	0	1	TS21	2	3
46	38	1	1	B93	2	3
47	38	1	1	W1G	2	3
48	65	0	1	CH3	2	3
49	55	0	1	WA4	2	3
50	49	1	1	S10	2	3
51	57	1	2	CH4	2	1
52	37	1	2	TF10	2	1
53	34	1	2	WS11	2	1
54	44	1	2	SY3	2	1
55	37	1	2	TF10	2	1
56	23	1	2	B15	2	1
57	28	1	2	SY1	2	1
58	51	1	2	SY11	2	1
59	60	0	2	TF2	2	1
60	34	1	2	TF2	2	1
61	51	0	2	SY5	2	1
62	25	1	2	TF2	2	1

ID	Age	Gender	Group	Postcode	Occupation	Dental Qualification
63	26	1	2	DY2	2	1
64	32	1	2	TF4	2	1
65	31	1	2	SW18	2	1
66	31	0	2	LE5	2	1
67	30	1	2	LE18	2	1
68	28	0	2	BS6	2	1
69	30	1	2	RM12	2	1
70	26	1	2	HA8	2	1
71	32	1	2	SY3	2	1
72	40	0	2	ST5	2	1
73	29	0	2	DE14	2	1
74	23	1	2	ST5	2	1
75	27	0	2	B13	2	1
76	50	0	2	WS11	2	1
77	39	0	2	WS12	2	1
78	26	0	2	B73	2	1
79	29	0	2	ST5	2	1
80	24	0	2	B17	2	1
81	25	0	2	B17	2	1
82	24	0	2	B73	2	1
83	41	1	2	WS11	2	1
84	23	1	2	B44	2	1
85	38	0	2	WS2	2	1
86	40	1	2	ST5	2	1
87	36	1	2	B34	2	1
88	24	1	2	HA8	2	1
89	23	0	2	WS4	2	1
90	23	0	2	B23	2	1
91	35	0	2	DE14	2	1
92	26	1	2	B16	2	1
93	23	1	2	B16	2	1

ID	Age	Gender	Group	Postcode	Occupation	Dental Qualification
94	24	1	2	B70	2	1
95	25	1	2	B14	2	1
96	28	1	2	B16	2	1
97	57	0	2	B17	2	1
98	27	1	2	B18	2	1
99	26	1	2	B74	2	1
100	50	0	2	WS11	2	1
101	17	0	3	ST6	2	0
102	16	1	3	ST3	2	0
103	13	1	3	ST5	2	0
104	14	1	3	ST5	2	0
105	17	0	3	ST5	2	0
106	12	1	3	ST5	2	0
107	13	0	3	ST4	2	0
108	15	1	3	ST2	2	0
109	11	1	3	TF9	2	0
110	15	0	3	ST4	2	0
111	12	1	3	ST10	2	0
112	16	1	3	ST2	2	0
113	15	0	3	ST5	2	0
114	15	1	3	ST4	2	0
115	13	0	3	ST5	2	0
116	13	1	3	ST9	2	0
117	14	0	3	ST7	2	0
118	16	1	3	ST4	2	0
119	15	1	3	ST4	2	0
120	15	1	3	ST3	2	0
121	12	1	3	ST5	2	0
122	15	1	3	Cw3	2	0
123	16	0	3	Cw2	2	0
124	15	1	3	ST17	2	0

ID	Age	Gender	Group	Postcode	Occupation	Dental Qualification
125	14	0	3	ST3	2	0
126	11	1	3	ST3	2	0
127	16	1	3	St5	2	0
128	11	1	3	ST6	2	0
129	15	1	3	SK10	2	0
130	14	0	3	ST8	2	0
131	13	1	3	SK10	2	0
132	15	0	3	ST2	2	0
133	15	0	3	ST7	2	0
134	12	0	3	ST5	2	0
135	15	0	3	B67	2	0
136	11	1	3	B14	2	0
137	14	1	3	B66	2	0
138	15	0	3	B31	2	0
139	14	1	3	B45	2	0
140	17	1	3	ST4	2	0
141	11	1	3	WV9	2	0
142	11	1	3	ST5	2	0
143	12	0	3	CW2	2	0
144	13	1	3	ST3	2	0
145	17	1	3	ST5	2	0
146	11	1	3	ST9	2	0
147	14	0	3	ST13	2	0
148	13	1	3	ST5	2	0
149	14	1	3	ST5	2	0
150	14	0	3	ST10	2	0
151	47	1	4	ST5	1	0
152	41	1	4	ST6	1	0
153	51	1	4	ST3	1	0
154	51	1	4	ST5	1	0
155	36	1	4	ST4	0	0

ID	Age	Gender	Group	Postcode	Occupation	Dental Qualification
156	34	1	4	ST2	1	0
157	43	1	4	TF9	1	0
158	34	1	4	ST4	1	0
159	43	1	4	ST5	1	0
160	53	0	4	ST10	1	0
161	45	1	4	ST4	1	0
162	36	0	4	ST5	1	0
163	45	1	4	ST5	1	0
164	44	1	4	ST9	1	0
165	43	1	4	ST7	1	0
166	54	0	4	ST4	1	0
167	48	1	4	ST5	1	0
168	37	1	4	ST3	1	0
169	40	0	4	CW3	1	0
170	32	1	4	ST5	0	0
171	50	0	4	ST3	1	0
172	53	1	4	ST17	1	0
173	40	0	4	ST3	1	0
174	68	0	4	ST6	0	0
175	48	1	4	ST5	0	0
176	43	1	4	ST5	0	0
177	55	0	4	ST7	1	0
178	42	1	4	ST20	0	0
179	62	1	4	ST13	1	0
180	51	0	4	ST3	1	0
181	40	1	4	ST7	1	0
182	50	0	4	SK10	1	0
183	48	1	4	ST8	1	0
184	38	1	4	ST7	1	0
185	48	1	4	ST7	1	0
186	31	1	4	ST5	1	0

ID	Age	Gender	Group	Postcode	Occupation	Dental Qualification
187	34	1	4	B67	1	0
188	35	1	4	B14	1	0
189	54	0	4	B6	1	0
190	46	1	4	B31	0	0
191	44	1	4	B45	1	0
192	44	0	4	ST3	1	0
193	43	1	4	CW2	1	0
194	31	1	4	ST5	1	0
195	36	0	4	WV9	1	0
196	45	1	4	ST5	0	0
197	45	1	4	ST4	0	0
198	44	1	4	ST5	1	0
199	48	0	4	ST9	1	0
200	36	1	4	ST13	1	0

Appendix 11. Part 1 Questionnaire VAS data

Data codes

VAS Treat 1: Aligned canines

VAS Treat 2: Substituted premolars

VAS Treat 3: Gaps

VAS Treat 4: Deciduous Canines

ID	Group	VAS Treat 1	VAS Treat 2	VAS Treat 3	VAS Treat 4
1	1	71	68	23	26
2	1	88	73	32	53
3	1	85	73	23	68
4	1	76	59	27	66
5	1	54	38	29	51
6	1	97	97	96	96
7	1	79	77	23	69
8	1	95	74	35	59
9	1	79	71	15	69
10	1	85	77	32	69
11	1	98	57	8	84
12	1	48	58	8	35
13	1	94	84	19	18
14	1	64	61	19	37
15	1	100	83	45	86
16	1	85	56	35	47
17	1	77	63	39	48
18	1	82	61	41	50
19	1	71	72	43	68
20	1	63	19	3	10

ID	Group	VAS Treat 1	VAS Treat 2	VAS Treat 3	VAS Treat 4
21	1	85	70	43	52
22	1	85	82	52	48
23	1	89	62	16	30
24	1	78	85	55	76
25	1	93	67	37	64
26	1	95	69	37	65
27	1	100	76	19	36
28	1	65	61	29	45
29	1	85	72	28	65
30	1	81	46	22	38
31	1	64	73	40	36
32	1	83	73	33	51
33	1	94	75	17	59
34	1	67	40	17	33
35	1	60	5	10	42
36	1	32	30	6	30
37	1	93	95	17	49
38	1	75	66	19	36
39	1	94	86	20	50
40	1	81	86	35	54
41	1	81	47	22	41
42	1	75	72	14	28
43	1	93	92	37	77
44	1	75	93	30	30
45	1	82	77	15	32
46	1	90	35	7	39
47	1	84	76	3	49
48	1	98	61	20	36
49	1	87	47	15	40

ID	Group	VAS Treat 1	VAS Treat 2	VAS Treat 3	VAS Treat 4
50	1	91	50	5	27
51	2	92	91	2	97
52	2	93	68	46	59
53	2	84	97	30	72
54	2	72	73	33	58
55	2	71	79	41	66
56	2	96	97	50	77
57	2	97	93	21	47
58	2	95	79	42	78
59	2	92	90	7	6
60	2	94	72	14	47
61	2	91	89	25	47
62	2	74	35	18	34
63	2	85	85	8	32
64	2	94	93	26	44
65	2	95	78	32	63
66	2	69	30	11	39
67	2	67	68	29	67
68	2	92	82	49	87
69	2	91	88	24	84
70	2	91	72	11	53
71	2	76	59	31	44
72	2	96	98	52	70
73	2	93	94	25	68
74	2	66	65	42	74
75	2	74	63	31	72
76	2	82	85	43	78
77	2	95	97	37	74
78	2	78	78	32	70

ID	Group	VAS Treat 1	VAS Treat 2	VAS Treat 3	VAS Treat 4
79	2	68	49	14	29
80	2	99	92	24	69
81	2	98	99	25	86
82	2	85	72	27	70
83	2	65	66	50	62
84	2	68	70	41	59
85	2	95	78	18	55
86	2	58	62	18	48
87	2	88	78	40	67
88	2	66	72	45	81
89	2	32	52	17	52
90	2	94	76	17	54
91	2	87	64	35	73
92	2	67	37	13	32
93	2	89	84	26	47
94	2	89	75	20	63
95	2	88	55	13	37
96	2	87	95	31	78
97	2	97	98	28	62
98	2	75	83	43	48
99	2	74	56	43	42
100	2	86	90	44	62
101	3	62	20	58	79
102	3	94	98	62	86
103	3	72	80	3	100
104	3	92	90	73	77
105	3	75	61	37	57
106	3	86	73	12	68
107	3	78	80	46	47

ID	Group	VAS Treat 1	VAS Treat 2	VAS Treat 3	VAS Treat 4
108	3	84	84	38	59
109	3	73	72	32	45
110	3	77	78	59	89
111	3	97	82	33	80
112	3	92	90	47	75
113	3	100	94	52	43
114	3	75	98	18	49
115	3	64	87	29	83
116	3	67	72	35	57
117	3	85	90	29	32
118	3	99	99	61	95
119	3	94	68	27	27
120	3	100	100	50	54
121	3	55	47	21	52
122	3	45	50	28	50
123	3	92	79	60	68
124	3	100	100	77	100
125	3	71	75	35	49
126	3	25	45	0	18
127	3	44	40	13	41
128	3	68	83	16	46
129	3	99	100	49	83
130	3	100	92	49	80
131	3	90	57	42	73
132	3	47	26	15	69
133	3	69	59	33	93
134	3	100	100	10	67
135	3	75	91	49	57
136	3	100	100	80	100

ID	Group	VAS Treat 1	VAS Treat 2	VAS Treat 3	VAS Treat 4
137	3	84	66	36	37
138	3	63	73	42	50
139	3	68	62	45	70
140	3	100	78	57	51
141	3	95	97	5	76
142	3	92	78	21	74
143	3	83	94	25	84
144	3	81	75	33	75
145	3	81	65	6	64
146	3	85	65	35	45
147	3	53	51	5	69
148	3	100	100	19	100
149	3	100	69	25	25
150	3	100	98	69	92
151	4	100	100	46	100
152	4	96	79	47	77
153	4	73	63	19	59
154	4	96	91	40	49
155	4	88	79	47	53
156	4	75	76	59	73
157	4	96	87	37	74
158	4	93	83	36	31
159	4	63	68	36	27
160	4	87	88	26	64
161	4	95	97	2	62
162	4	85	72	21	49
163	4	81	75	51	69
164	4	71	75	36	49
165	4	72	82	48	88

ID	Group	VAS Treat 1	VAS Treat 2	VAS Treat 3	VAS Treat 4
166	4	68	77	20	19
167	4	97	81	42	53
168	4	100	100	55	96
169	4	58	63	27	70
170	4	88	90	67	83
171	4	65	67	21	36
172	4	73	78	12	40
173	4	91	71	37	28
174	4	65	53	2	11
175	4	100	100	0	48
176	4	95	97	15	85
177	4	75	63	39	57
178	4	45	57	28	54
179	4	99	100	44	90
180	4	86	72	27	35
181	4	87	78	35	25
182	4	98	96	27	78
183	4	95	80	22	28
184	4	78	76	30	59
185	4	84	81	45	42
186	4	73	77	61	59
187	4	99	85	50	95
188	4	97	99	89	100
189	4	84	86	29	79
190	4	75	81	0	54
191	4	90	80	37	42
192	4	81	78	23	48
193	4	86	84	28	48
194	4	100	100	77	99

ID	Group	VAS Treat 1	VAS Treat 2	VAS Treat 3	VAS Treat 4
195	4	91	93	28	45
196	4	80	64	16	72
197	4	93	93	40	86
198	4	100	99	7	74
199	4	95	92	56	49
200	4	31	26	23	60

Appendix 12. Part 2 questionnaire VAS_withtime data

Data codes

VAS Treat with time 1: Aligned Canines

VAS Treat with time 2: Substituted Premolars

VAS Treat with time 3: Gaps

VAS Treat with time 4: Deciduous Canines

ID	Group	VAS_with time 1	VAS_with time 2	VAS_with time 3	VAS_with time 4
101	3	79	55	1	48
102	3	86	84	30	76
103	3	76	10	0	56
104	3	30	31	34	42
105	3	77	36	13	36
106	3	71	42	10	58
107	3	66	48	45	60
108	3	86	76	40	65
109	3	68	76	20	63
110	3	79	70	69	91
111	3	55	68	32	72
112	3	83	76	23	52
113	3	70	64	67	51
114	3	99	99	0	60
115	3	72	89	20	79
116	3	62	32	30	34
117	3	42	57	86	65
118	3	46	51	57	67
119	3	46	50	6	22
120	3	99	100	0	100

ID	Group	VAS_with time 1	VAS_with time 2	VAS_with time 3	VAS_with time 4
121	3	53	44	24	31
122	3	58	68	52	30
123	3	65	62	71	70
124	3	67	62	14	73
125	3	55	35	0	57
126	3	34	62	0	54
127	3	76	80	44	64
128	3	36	31	65	46
129	3	100	79	45	91
130	3	83	90	41	91
131	3	31	25	5	22
132	3	87	87	11	85
133	3	92	95	97	97
134	3	100	100	39	100
135	3	48	61	52	65
136	3	50	80	84	85
137	3	37	63	47	75
138	3	69	38	28	53
139	3	10	67	23	20
140	3	91	54	25	53
141	3	58	54	87	88
142	3	74	77	12	73
143	3	93	56	2	90
144	3	71	56	55	85
145	3	69	97	3	47
146	3	89	69	16	28
147	3	74	50	0	48
148	3	60	37	17	39

ID	Group	VAS_with time 1	VAS_with time 2	VAS_with time 3	VAS_with time 4
149	3	3	30	76	46
150	3	47	50	0	98
151	4	100	99	95	75
152	4	26	44	19	26
153	4	94	86	20	83
154	4	87	84	10	72
155	4	77	32	48	30
156	4	75	68	28	76
157	4	92	65	18	42
158	4	96	87	34	38
159	4	93	50	1	55
160	4	83	81	26	47
161	4	98	95	0	99
162	4	82	83	10	61
163	4	72	77	42	70
164	4	20	30	27	53
165	4	72	31	7	18
166	4	88	97	92	95
167	4	96	68	0	7
168	4	100	97	50	98
169	4	80	79	48	71
170	4	85	92	32	95
171	4	79	60	37	63
172	4	53	91	3	28
173	4	12	73	9	34
174	4	93	71	1	68
175	4	100	100	0	0
176	4	96	93	93	95

ID	Group	VAS_with time 1	VAS_with time 2	VAS_with time 3	VAS_with time 4
177	4	72	72	24	35
178	4	95	74	6	81
179	4	100	100	85	99
180	4	99	71	8	42
181	4	79	73	83	49
182	4	46	46	28	61
183	4	82	86	21	80
184	4	80	84	60	76
185	4	90	64	10	46
186	4	99	98	21	62
187	4	100	100	50	91
188	4	95	93	93	95
189	4	85	95	0	70
190	4	58	83	6	5
191	4	77	50	29	69
192	4	80	82	13	62
193	4	80	23	6	75
194	4	98	99	60	97
195	4	95	95	15	72
196	4	94	57	5	64
197	4	90	85	34	65
198	4	100	76	3	44
199	4	93	64	80	47
200	4	54	25	88	32

Appendix 13. Ranked data

Data Codes

Treatment

1 = Aligned Canines

2 = Substituted Premolars

3 = Gaps

4 = Deciduous Canines

Rank

1 = least preferred aesthetically

2 = third preferred aesthetically

3 = second preferred aesthetically

4 = most preferred aesthetically

ID	GROUP	TREATMENT	RANK
1	3	1	4
1	3	2	2
1	3	3	1
1	3	4	3
2	3	1	3
2	3	2	4
2	3	3	1
2	3	4	2
3	3	1	3
3	3	2	4
3	3	3	1
3	3	4	2
4	3	1	4
4	3	2	3
4	3	3	1
4	3	4	2
5	3	1	4
5	3	2	3
5	3	3	1
5	3	4	2
6	3	1	3

ID	GROUP	TREATMENT	RANK
6	3	2	4
6	3	3	1
6	3	4	2
7	3	1	4
7	3	2	3
7	3	3	2
7	3	4	1
8	3	1	4
8	3	2	3
8	3	3	1
8	3	4	2
9	3	1	3
9	3	2	4
9	3	3	1
9	3	4	2
10	3	1	3
10	3	2	2
10	3	3	1
10	3	4	4
11	3	1	4
11	3	2	3
11	3	3	1
11	3	4	2
12	3	1	2
12	3	2	4
12	3	3	3
12	3	4	1
13	3	1	2
13	3	2	3
13	3	3	1
13	3	4	4

ID	GROUP	TREATMENT	RANK
14	3	1	4
14	3	2	3
14	3	3	1
14	3	4	2
15	3	1	3
15	3	2	4
15	3	3	1
15	3	4	2
16	3	1	3
16	3	2	4
16	3	3	1
16	3	4	2
17	3	1	3
17	3	2	4
17	3	3	1
17	3	4	2
18	3	1	4
18	3	2	3
18	3	3	1
18	3	4	2
19	3	1	3
19	3	2	4
19	3	3	1
19	3	4	2
20	3	1	4
20	3	2	3
20	3	3	1
20	3	4	2
21	3	1	3
21	3	2	4
21	3	3	1

ID	GROUP	TREATMENT	RANK
21	3	4	2
22	3	1	4
22	3	2	3
22	3	3	1
22	3	4	2
23	3	1	3
23	3	2	4
23	3	3	1
23	3	4	2
24	3	1	3
24	3	2	2
24	3	3	1
24	3	4	4
25	3	1	2
25	3	2	3
25	3	3	1
25	3	4	4
26	3	1	2
26	3	2	4
26	3	3	1
26	3	4	3
27	3	1	4
27	3	2	3
27	3	3	1
27	3	4	2
28	3	1	3
28	3	2	4
28	3	3	1
28	3	4	2
29	3	1	3
29	3	2	4

ID	GROUP	TREATMENT	RANK
29	3	3	1
29	3	4	2
30	3	1	4
30	3	2	3
30	3	3	1
30	3	4	2
31	3	1	4
31	3	2	3
31	3	3	1
31	3	4	2
32	3	1	4
32	3	2	3
32	3	3	1
32	3	4	2
33	3	1	2
33	3	2	4
33	3	3	1
33	3	4	3
34	3	1	3
34	3	2	4
34	3	3	1
34	3	4	2
35	3	1	2
35	3	2	3
35	3	3	1
35	3	4	4
36	3	1	3
36	3	2	4
36	3	3	1
36	3	4	2
37	3	1	4

ID	GROUP	TREATMENT	RANK
37	3	2	3
37	3	3	1
37	3	4	2
38	3	1	2
38	3	2	3
38	3	3	1
38	3	4	4
39	3	1	3
39	3	2	4
39	3	3	1
39	3	4	2
40	3	1	4
40	3	2	3
40	3	3	1
40	3	4	2
41	3	1	4
41	3	2	2
41	3	3	1
41	3	4	3
42	3	1	3
42	3	2	4
42	3	3	1
42	3	4	2
43	3	1	4
43	3	2	3
43	3	3	1
43	3	4	2
44	3	1	3
44	3	2	4
44	3	3	1
44	3	4	2

ID	GROUP	TREATMENT	RANK
45	3	1	4
45	3	2	3
45	3	3	1
45	3	4	2
46	3	1	3
46	3	2	4
46	3	3	1
46	3	4	2
47	3	1	4
47	3	2	3
47	3	3	1
47	3	4	2
48	3	1	4
48	3	2	3
48	3	3	1
48	3	4	2
49	3	1	4
49	3	2	3
49	3	3	1
49	3	4	2
50	3	1	3
50	3	2	4
50	3	3	1
50	3	4	2
1	4	1	3
1	4	2	4
1	4	3	1
1	4	4	2
2	4	1	4
2	4	2	3
2	4	3	1

ID	GROUP	TREATMENT	RANK
2	4	4	2
3	4	1	3
3	4	2	4
3	4	3	1
3	4	4	2
4	4	1	3
4	4	2	4
4	4	3	1
4	4	4	2
5	4	1	4
5	4	2	3
5	4	3	1
5	4	4	2
6	4	1	4
6	4	2	3
6	4	3	1
6	4	4	2
7	4	1	3
7	4	2	4
7	4	3	1
7	4	4	2
8	4	1	4
8	4	2	3
8	4	3	1
8	4	4	2
9	4	1	3
9	4	2	4
9	4	3	1
9	4	4	2
10	4	1	4
10	4	2	3

ID	GROUP	TREATMENT	RANK
10	4	3	1
10	4	4	2
11	4	1	4
11	4	2	3
11	4	3	1
11	4	4	2
12	4	1	4
12	4	2	3
12	4	3	1
12	4	4	2
13	4	1	4
13	4	2	3
13	4	3	1
13	4	4	2
14	4	1	4
14	4	2	3
14	4	3	1
14	4	4	2
15	4	1	3
15	4	2	4
15	4	3	1
15	4	4	2
16	4	1	3
16	4	2	4
16	4	3	1
16	4	4	2
17	4	1	4
17	4	2	3
17	4	3	1
17	4	4	2
18	4	1	3

ID	GROUP	TREATMENT	RANK
18	4	2	4
18	4	3	1
18	4	4	2
19	4	1	4
19	4	2	3
19	4	3	1
19	4	4	2
20	4	1	4
20	4	2	3
20	4	3	1
20	4	4	2
21	4	1	3
21	4	2	4
21	4	3	1
21	4	4	2
22	4	1	3
22	4	2	4
22	4	3	1
22	4	4	2
23	4	1	3
23	4	2	4
23	4	3	1
23	4	4	2
24	4	1	3
24	4	2	4
24	4	3	1
24	4	4	2
25	4	1	3
25	4	2	4
25	4	3	1
25	4	4	2

ID	GROUP	TREATMENT	RANK
26	4	1	4
26	4	2	3
26	4	3	1
26	4	4	2
27	4	1	4
27	4	2	3
27	4	3	1
27	4	4	2
28	4	1	3
28	4	2	4
28	4	3	1
28	4	4	2
29	4	1	3
29	4	2	4
29	4	3	1
29	4	4	2
30	4	1	4
30	4	2	3
30	4	3	1
30	4	4	2
31	4	1	4
31	4	2	3
31	4	3	1
31	4	4	2
32	4	1	4
32	4	2	3
32	4	3	1
32	4	4	2
33	4	1	3
33	4	2	4
33	4	3	1

ID	GROUP	TREATMENT	RANK
33	4	4	2
34	4	1	4
34	4	2	3
34	4	3	1
34	4	4	2
35	4	1	4
35	4	2	3
35	4	3	1
35	4	4	2
36	4	1	4
36	4	2	3
36	4	3	1
36	4	4	2
37	4	1	4
37	4	2	2
37	4	3	1
37	4	4	2
38	4	1	3
38	4	2	4
38	4	3	1
38	4	4	3
39	4	1	3
39	4	2	4
39	4	3	1
39	4	4	2
40	4	1	4
40	4	2	3
40	4	3	1
40	4	4	2
41	4	1	3
41	4	2	4

ID	GROUP	TREATMENT	RANK
41	4	3	1
41	4	4	2
42	4	1	4
42	4	2	3
42	4	3	1
42	4	4	2
43	4	1	4
43	4	2	2
43	4	3	1
43	4	4	2
44	4	1	4
44	4	2	3
44	4	3	1
44	4	4	3
45	4	1	4
45	4	2	3
45	4	3	1
45	4	4	2
46	4	1	4
46	4	2	3
46	4	3	1
46	4	4	2
47	4	1	4
47	4	2	3
47	4	3	1
47	4	4	2
48	4	1	4
48	4	2	3
48	4	3	1
48	4	4	2
49	4	1	2

ID	GROUP	TREATMENT	RANK
49	4	2	4
49	4	3	1
49	4	4	3
50	4	1	2
50	4	2	4
50	4	3	1
50	4	4	3

Appendix 14. Test-Retest data (questionnaire repeated)

ID		VAS Treat 1	VAS Treat 2	VAS Treat 3	Treatment 4
9		79	71	15	69
	6 weeks later	81	66	11	41
1		71	68	23	26
	6 weeks later	81	50	21	33
38		75	66	19	36
	6 weeks later	85	65	16	48
14		64	61	19	37
	6 weeks later	67	63	23	36
24		78	85	55	76
	6 weeks later	83	78	46	65
69		91	88	24	84
	6 weeks later	91	89	21	81
70		76	59	31	44
	6 weeks later	85	63	30	49
68		92	82	49	87
	6 weeks later	85	77	52	75
61		76	59	31	44
	6 weeks later	71	59	28	38
1		92	91	2	97
	6 weeks later	93	91	5	77
142		92	78	21	74
	6 weeks later	70	56	4	53
125		71	75	35	49
	6 weeks later	71	87	27	78
110		77	78	59	89
	6 weeks later	64	65	45	62
118		99	99	61	95

ID		VAS Treat 1	VAS Treat 2	VAS Treat 3	Treatment 4
	6 weeks later	91	82	45	62
140		100	78	57	51
	6 weeks later	80	94	53	43
192		81	78	23	48
	6 weeks later	80	75	15	55
197		93	93	40	86
	6 weeks later	83	80	37	77
158		93	83	36	31
	6 weeks later	90	93	43	84
190		75	81	0	54
	6 weeks later	76	62	0	44
192		81	78	23	48
	6 weeks later	80	75	15	55

Appendix 15. Re-measuring reliability data (questionnaires re-measured)

ID		VAS Treat 1	VAS Treat 2	VAS Treat 3	VAS Treat 4
19	second	72	72	43	68
	first	71	72	43	68
21	second	85	70	43	52
	first	85	70	43	52
20	second	63	19	3	10
	first	63	19	3	10
18	second	82	61	41	50
	first	82	61	41	50
5	second	54	38	29	50
	first	54	38	29	51
103	second	72	80	3	100
	first	72	80	3	100
136	second	100	100	81	100
	first	100	100	80	100
120	second	100	100	50	53
	first	100	100	50	54
	second	44	40	13	41
	first	44	40	13	41
133	second	69	58	33	93
	first	69	59	33	93
156	second	88	79	47	53
	first	88	79	47	53
163	second	82	76	52	69
	first	81	75	51	69
152	second	96	78	47	77
	first	96	79	47	77
179	second	99	100	44	90
	first	99	100	44	90

ID		VAS Treat 1	VAS Treat 2	VAS Treat 3	VAS Treat 4
168	second	99	100	55	96
	first	100	100	55	96
97	second	97	99	28	68
	first	97	98	28	67
75	second	74	63	31	72
	first	74	63	31	72
89	second	32	52	18	52
	first	32	52	17	52
81	second	98	99	26	86
	first	98	99	25	86
67	second	67	68	29	68
	first	67	68	29	67

REFERENCES

Ahmad, I. (2005a) Anterior dental aesthetics: Facial perspective. **British Dental Journal**, 199(1): 15-21

Ahmad, I. (2005b) Anterior dental aesthetics: Dentofacial perspective. **British Dental Journal**, 199(2): 81-88

Ahmad, I. (2005c) Anterior dental aesthetics: Dental Perspective. **British Dental Journal**, 199(3):135-141

Ahmad, I. (2005d) Anterior dental aesthetics: Gingival perspective. **British Dental Journal**, 199(4); 195-202

Ali Fayyad, M. Jamani, K. and Aqrabawi, J. (2006) Geometric and mathematical proportions and their relations to maxillary anterior teeth. **Journal of Contemporary Dental Practice**, 5:62-70

Altman, J. Arnold, H. and Spector, P. (1979) Substituting maxillary first premolars for maxillary impacted canines in cases requiring the extraction of dental units as part of orthodontic correction. **American Journal of Orthodontics,** 75(6): 618-629

Anderson, J. Behrents, R. McKinney, T. and Buschang, P. (2005) Tooth shape preferences in an esthetic smile. **American Journal of Orthodontics and Dentofacial Orthopaedics**, 128(4): 458-65

Baccetti, T. (1998). A controlled study of associated dental anomalies. **Angle Orthodontist** 68(3):267-74

Baccetti, T. Leonardi, M. and Armi, P. (2008) A randomized clinical study of two interceptive approaches to palatally displaced canines. **European Journal of Orthodontics**, 30(4); 381-385

Baccetti, T. Singler, L. and McNamara, J. (2011) An RCT on treatment of palatally displaced canines with RME and/or a transpalatal arch. **European Journal of Orthodontics**, 33(6); 601-607

Baldwin, D. (1980) Appearance and aesthetics in oral health. **Community Dentistry and Oral Epidemiology**, 8(5):244-256

Barber, S. Houghton, N. and Spencer, J. (2015) Limitations of a method used for adolescent assessment of smile aesthetics, **European J Orthodontics***,* 37(2): 135-41

Bazargani, F. Magnuson, A. Dolati, A. and Lennartsson, B. (2012) Palatally displaced maxillary canines: factors influencing duration and cost of treatment. **European Journal of Orthodontics,** 35(3):310-316

Bazargani, F. Magnuson, A. and Lennartsson, B. (2014) Effect of interceptive extraction of deciduous canine on palatally displaced maxillary canine: a prospective randomized controlled study. **Angle Orthodontist**, 84(1):3-10

Becker, A. (1995) Palatal canine displacement: Guidance theory or an anomaly of genetic origin? A letter to the editor. **Angle Orthodontist**, 65(2); 95-98

Becker, A. and Chaushu, S. (2003) Success rate and duration of orthodontic treatment for adult patients with palatally impacted maxillary canines. **American Journal of Orthodontics and Dentofacial Orthopaedics** 124(5); 509-514

Becker, A. and Chaushu, S. (2005) Long-term follow-up of severely resorbed maxillary incisors after resolution of an etiologically associated impacted canine. **American Journal of Orthodontics and Dentofacial Orthopaedics**, 127(6):650-654

Becker, A. and Chaushu, S. (2015) Etiology of maxillary canine impaction: A review. **American Journal of Orthodontics and Dentofacial Orthopaedics**,148(4):557-67

Becker, A. Smith, P. Behar, R. (1981) The incidence of anomalous maxillary lateral incisors in relation to palatally displaced cuspids. **Angle Orthodontist**, 51(1): 24-9

Becker, A. Zogakis, I. Luchian, I and Chaushu, S. (2016) Surgical exposure of impacted canines: Open or closed surgery? **Seminars in Orthodontics**, 22:27-33.

Bishara, S. (1992) Impacted maxillary canines: A review. **American Journal of Orthodontics and Dentofacial Orthopaedics***,* 101(2);159-71

Bowling, A. (1997) **Questionnaire Design. In: Research Methods in Health**. Buckingham: Open University Press.

Brisman, A. (1980) Esthetics: A comparison of dentists' and patients' concepts. **The Journal of the American Dental Association**, 100;345-352

British Orthodontic Society (2015) **Consent in orthodontics advice sheet**. London: BOS

Bukhary, S. Gill, D. Tredwin, C. and Moles, D. (2007) The influence of varying maxillary lateral incisor dimensions on perceived smile aesthetics. **British Dental Journal**, 203(12):687-93

Camilleri, S. Lewis, C. and McDonald, F. (2008) Ectopic maxillary canines: segregation analysis and a twin study. **Journal of Dental Research**, 87(6):580-3

Chen, P. Yu, S. and Zhu, G. (2012) The psychosocial impacts of implantation on the dental aesthetics of missing anterior teeth patients. **British Dental Journal**, 213:E20

Cicchetti, D. (1994) Guidelines, criteria, and rules of thumb for evaluating normed and standardized assessment in instruments of psychology. **Psychological Assessment**, 6(4): 284-290

Clifford, M. Walster, E. (1973) The effect of physical attractiveness on teacher expectations. **Sociology of education**, 46(2):248-258

Cobourne M and DiBiase A (2015) **Handbook of orthodontics**. 2nd Ed. London:Elsevier.

Cons, N. and Jenny, J. (1994) Comparing perceptions of dental aesthetics in the USA with those in eleven ethnic groups. **International Dental Journal**, 44(5):489–494

Cooper, G. Tredwin, C. Cooper, N. Petrie, A. and Gill, D. (2012) The influence of maxillary central incisor height-to-width ratio on perceived smile aesthetics. **British Dental Journal**, 212(12):589-599

Correa, B. Bittencourt, V, and Machado, A. (2014) Influence of maxillary canine gingival margin asymmetries on the perception of smile aesthetics among orthodontists and laypersons. **American Journal of Orthodontics and Dentofacial Orthopaedics**, 145(1);55-63

Cotrim, E. Vasconcelos, J. Haddad, A. and Reis, A. (2015) Perception of adults' smile aesthetics among orthodontists, clinicians and laypeople. **Dental Press Journal of Orthodontics**, 20(1):40-44

Cunningham, S. Hunt, N. and Feinmann, C. (1996) Perceptions of outcomes following orthognathic surgery. **British Journal of Oral and Maxillofacial Surgery**, 34(3);210-213

D'Amico, R. Bjerklin, K., Kurol, J. and Falahat, B. (2003) Long-term results of orthodontic treatment of impacted maxillary canines. **Angle Orthodontist**, 73(3):231-8

De-Marchi, L. Pini, N. Ramos, A. and Pascotto, R. (2014) Smile attractiveness of patients treated for congenitally missing maxillary lateral incisors as rated by dentists, laypersons and the patients themselves. **The Journal of Prosthetic Dentistry**, 112(3);540-546

Eli, L. Bar-Tat, Y. and Kostovetzki, I. (2001) At first glance: social meanings of dental appearance. **Journal of Public Health Dentistry**, 61(3);150-154

Ericson, S. and Kurol, J. (1986) Radiographic assessment of maxillary canine eruption in children with clinical signs of eruption disturbance. **European Journal of Orthodontics**, 8(3):133-140

Ericson, S. and Kurol, J. (1987) Radiographic examination of ectopically erupting maxillary canines. **American Journal of Orthodontics and Dentofacial Orthopedics**, 91(6):483-92

Ericson, S. and Kurol, J. (1988) Resorption of maxillary lateral incisors caused by ectopic eruption of the canines. A clinical and radiographic analysis of predisposing factors. **American Journal of Orthodontics and Dentofacial Orthopedics**, 94(6);503-513

Ericson, S. and Kurol, J. (2000) Resorption of incisors after ectopic eruption of maxillary canines. A CT study. **Angle Orthodontist**, 70(6);415-423.

Field, A. (2013) **Discovering statistics using IBM SPSS statistics**. 4th ed. London: SAGE.

Foulger, T. Tredwin, C. Gill, D. and Moles, R. (2010) The influence of varying maxillary incisal edge embrasure space and interproximal contact area dimensions on perceived smile aesthetics. **British Dental Journal,** 209(3), E4.

Graber, L. and Lucker, G. (1980) Dental esthetic self-evaluation and satisfaction. **American Journal of Orthodontics**, 77(2):163-173

Hägg, U. and Taranger, J. (1986) Timing of tooth emergence. A prospective longitudinal study of Swedish urban children from birth to 18 years. **Swedish Dental Journal**, 10(5): 195-206

Hasanreisoglu, U. Berksun, S. Aras, K. and Aslan, I. (2005) an analysis of maxillary anterior teeth: facial and dental proportions. **The Journal of Prosthetic Dentistry**, 94(6);530-538

Heinlein, W. (1980) Anterior teeth: esthetics and function. **The Journal of Prosthetic Dentistry**, 44(4):389-393

Heravi, F. Rashed, R. and Abachizadeh, H. (2011) Esthetic preferences for the shape of anterior teeth in a posed smile. **American Journal of Orthodontics and Dentofacial Orthopedics**, 139(6):806-14

Ho, K. and Liao, Y. (2011) Predictors of surgical-orthodontic treatment duration of unilateral impacted maxillary central incisors. **Orthodontics and Craniofacial Research**, 14(3): 175-180

Howells, D. and Shaw, W. (1985) The validity and reliability of ratings of dental and facial attractiveness for epidemiologic use. **American Journal of Orthodontics**, 88(5);402-408

Husain, J. Burden, D. McSherry, P. Morris, D. and Allen, M. (2012) National Clinical guidelines for management of the palatally ectopic maxillary canine. **British Dental Journal,** 213(4); 171-176

Hussain, A. Louca, C. Leung, A. and Sharma, P. (2016) The influence of varying maxillary incisor shape on perceived smile aesthetics. **Journal of Dentistry**, 50;12-20

Huston, TL. (1973) Ambiguity of acceptance, social desirability, and dating choice. **Journal of Experimental Social Psychology**, 9:32-42

Ioi, H. Kang, S. Shimomura, T. Kim, S. Park, S. Son, W and Takahashi, I. (2012) Effects of buccal corridors on smile esthetics in Japanese and Korean orthodontists and orthodontic patients. **American Journal of Orthodontics and Dentofacial Orthopedics**, 142(4); 459-465

Ioi, H. Nakata, S. and Counts, AL. (2009) Effects of buccal corridors on smile aesthetics in Japanese. **Angle Orthodontist** 79(4):628-633

Ioi, H. Nakata, S. and Counts, AL. (2010) Influence of gingival display on smile aesthetics in Japanese. European Journal of Orthodontics, 32(6):633–637

Irameneerat, S. Cunningham, S. and Horrocks, S. (1998) The effect of two alternative methods of canine exposure upon subsequent duration of orthodontic treatment. **International Journal of Pediatric Dentistry**, 8(2):123-129

Jansen, G. Branco, N. Fernandes, T. Sathler, D. and Lauris, J. (2011) Influence of orthodontic treatment, midline position, buccal corridor and smile arc on smile attractiveness. A systematic Review. **Angle Orthodontist**. 81(1):153-161

Jenny, J. (1986) Visibility and prestige of occupations and the importance of dental treatment. **Journal of the Canadian Dental Association,** 52:987-989

Johnston, C. Burden, D. and Stevenson, M. (1999) The influence of dental to facial midline discrepancies on dental attractiveness ratings. **European Journal of Orthodontics**, 21(5):517-522

Kaya, B. and Uyar, R. (2013) Influence on smile attractiveness of the smile arc in conjunction with gingival display. **American Journal of Orthodontics and Dentofacial Orthopedics**, 144 (4):541-547

Kaya, B. and Uyar, R. (2016) The impact of occlusal plane cant along with gingival display on smile attractiveness. **Orthodontics and Craniofacial Research**, 19(2): 93-101

Kiyak, H (1981) Comparison of esthetic values among Caucasians and Pacific-Asians. **Community Dentistry and Oral Epidemiology**, 9(5): 219–223

Kokich, V. Kiyak, H. and Shapiro, P. (1999) Comparing the perception of dentists and lay people to altered dental esthetics. **Journal of Esthetic Dentistry**, 11(6):311-324

Landis, J. and Koch, G. (1977) The measurement of observer agreement for categorical data. **Biometrics**, 33:159-174

Langlois, J. Kalakanis, L. Ruberstein, A. Larson, A. Hallam, M. and Smoot, M. (2000) Maxims or myths of beauty? A meta-analytic and theoretical review. **Psychological Bulletin**, 126(3);390-423

Lappin, M. (1951) Practical management of the impacted maxillary canine. **American Journal of Orthodontics**, 37(10):769-778

Levin, E. (1978) Dental esthetics and the golden proportion. **The Journal of Prosthetic Dentistry**, 40(3):244-252

Lukez, A. Pavlic, A. Trinajstic, M, and Spalj, S. (2015) The unique contribution of smile aesthetics to psychosocial well-being. **Journal of Oral Rehabilitation**, 42(4), 275-281

Mavreas, D. and Athanasiou, E. (2008) Factors affecting the duration of orthodontic treatment: a systematic review. **European Journal of Orthodontics**, 30(4);386-395

Mirabella, D. Giunta, G. and Lombardo, L .(2013) Substitution of impacted canines by maxillary first premolars: a valid alternative to traditional orthodontic treatment. **American Journal of Orthodontics and Dentofacial Orthopedics**, 143(1):125-133

Miralles, R. (2015) Canine-guide occlusion and group function occlusion are equally acceptable when restoring the dentition. **The Journal of Prosthetic Dentistry**,114(2): 193-204

Moore, T. Southard, K. Casko, J. Qian, F. and Southard, T. (2005) Buccal corridors and smile esthetics. **American Journal of Orthodontics and Dentofacial Orthopedics**, 127(2):296-304

Morley, J. and Eubank, J. (2001) Macroesthetic elements of smile design. **Journal of the American Dental Association**, 132(1):39-45

Mossey, P. Campbell, H. and Luffingham, J. (1994) The palatal canine and the adjacent lateral incisor; a study of a West Scotland population. **British Journal of Orthodontics**, 21:169-74

Mukatash, G. Al-Rousan, M and Al-Sakarna, B. (2010) Needs and demands of prosthetic treatment among two groups of individuals. **Indian J Dent Res**, 21(4):564-7.

Naoumova, J. Kurol, J. and Kjellberg, H. (2015) Extraction of the deciduous canine as an interruptive treatment in children with palatal displaced canines - part I: shall we extract the deciduous canine or not? **European Journal of Orthodontics**, 37(2): 209-218

Newton, J. Probhu, N. and Robinson, P. (2003) The impact of dental appearance on the appraisal of personal characteristics. **The International Journal of Prosthodontics**, 16(4):429-434

Oliveira, P. Da Motta, A. Guerra, C. and Mucha, J. (2015) Comparison of two scales for evaluation of smile and dental attractiveness. **Dental Press Journal of Orthodontics**, 20(2):42-8

Ong, E. Brown, R. and Richmond, S. (2006) Peer assessment of dental attractiveness. **American Journal of Orthodontics and Dentofacial Orthopedics**, 130(2):163-9

Otuyemi, O. Ogunyinka, A. Dossuma, O. Cons, N. Jenny, J. Kohout, F. and Jakobsen, J. (1998) Perception of dental aesthetics in the United States and Nigeria. **Community Dentistry and Oral Epidemiolgy**, 26: 418–420

Parekh, S. Fields, H. Beck, M. and Rosentiel, S. (2006) Attractiveness of variations in the smile arc and buccal corridor space as judged by orthodontists and laymen. **Angle Orthodontist**, 76(4):557-563

Parkin, N. Benson, P. Thind, B. Shah, A. (2008) Open versus closed surgical exposure of canine teeth that are displaced in the roof of the mouth. **Cochrane Database of Systematic Reviews**, Issue 4. Art No: CD006966. DOI:10.1002/14651858. CD006966.pub.2. [accessed 10 August 2016].

Parkin, N. Freeman, J. Deery, C. and Benson, P. (2015) Esthetic judgements of palatally displaced canines 3 months postdebond after surgical exposure with either a closed or an open technique. **American Journal of Orthodontics and Dentofacial Orthopedics**, 147(2):173-81

Parkin N, Furness, S. Shah, A. Thind, B. Marshman, Z. Glenroy, G, Dyer, F. and Benson, P. (2012) Extraction of primary (baby) teeth for unerupted palatally displaced permanent canine teeth in children. Cochrane Database Systematic Review, Issue 2. Art No: CD004621. DOI: 1-.1002/14651858.CD004621.pub3. [accessed 10 August 2016].

Peck, S. Peck, L. and Kataja, M. (1994) The palatally displaced canine as a dental anomaly of genetic origin. **Angle Orthodontist**, 64(4):249-56

Petrie, A. Bulman, J. and Osborn, J. (2002) Further statistics in dentistry. Part 4: Clinical trials 2. **British Dental Journal**, 193(10):557-561

Phillips, C. Tulloch, C. and Dann, C. (1992) Rating of facial attractiveness. **Community Dental and Oral Epidemiology**, 20(4):214-220

Pjutursson, B. Tan, W. Tan, K. Brägger, U. Zwahlen, M. and Lang, N. (2008) A systematic review of the survival and complication rates of resin-bonded bridges after an observation period of at least 5 years. **Clinical Oral Implants Research**, 19(2):131-141

Power, S. and Short, M. (1993) An investigation into the response of palatally displaced canines to the removal of deciduous canines and an assessment of factors contributing to favourable eruption. **British Journal of Orthodontics**, 20; 215-23

Preston, J. (1993) The Golden Proportion revisited. **Journal of Esthetic Dentistry,** 5(6):247-251

Raynor, W. Barber, S. and Spencer, R. (2015) The effect of canine characteristics and symmetry on perceived smile attractiveness when canines are substituted for lateral incisors. **Journal of Orthodontics**, 42:22-32

Robertsson, S. Mohlin, B. and Thilander, B. (2010) Aesthetic evaluation in subjects treated due to congenitally missing maxillary laterals. A comparison of perception in patients, parents and dentists. **Swedish Dental Journal**, 34:177-86

Robinson, S. and Chan, M. (2009) New teeth from old: treatment options for retained primary teeth. **British Dental Journal,** 207(7): 315-320

Rosa, M. Olimpo, A. Fastuca, R. and Caprioglio, A. (2013) Perceptions of dental professions and laypeople to altered dental aesthetics in cases with congentially missing maxillary lateral incisors. **Progress in orthodontics**, 14(1): 1-7

Rosenstiel, S. Ward, D. and Rashid, G. (2000) Dentists' preferences of anterior tooth proportion - A web-based study. **Journal of Prosthodontics**, 9(3):122-136

Rufenacht, C.R.(1990) **Fundamentals of Esthetics**. Berlin: Quintessence.

Sarver, D.M. (2001) The importance of incisor positioning in the esthetic smile: The smile arc. **American Journal of Orthodontics and Dentofacial Orthopedics**, 120(2):98-111

Sarver, D.M. (2004) Principles of cosmetic dentistry in orthodontics: Part 1. Shape and proportionality of anterior teeth. **American Journal of Dentofacial Orthopedics**, 126 (6):749-753

Schwartz, H. (1987) Anterior guidance and aesthetics in prosthodontics. **Dental Clinics of North America**, 31: 323-332

Shafer, W. Hine, M. and Levy, B. (1963) **A textbook of oral pathology**. 2nd ed. Philadelphia: WB Saunders.

Sharma, P. and Sharma, P. (2012) Dental Smile esthetics: The assessment and creation of the ideal smile. **Seminars in Orthodontics**, 18:193-201

Shaw, W. Rees, G. Dawe, M. and Charles C.R. (1985) The influence of dentofacial appearance on the social attractiveness of young adults. **American Journal of Orthodontics and Dentofacial Orthopedics**, 87(1):21-26

Shaw W. (1981) Factors influencing the desire for orthodontic treatment. **European Journal of Orthodontics**, 3(3):151-62

Sheats, R. McGorray, S. Musmar, Q. Wheeler, T. and King, G (1998) Prevalence of orthodontic asymmetries. **Seminars in Orthodontics**, 4(3):128-145

Silva, B. Jiménez-Castellanos, E. Martinez-de-Fuentes, R. Greenberg, J. and Chu, S. (2013) Laypersons' perception of facial and dental asymmetries. **The International Journal of Periodontics and Restorative Dentistry**, 33(6):162-71

Simms, R. (1977) Management of orthodontic treatment when first premolars are substituted for canines. **Angle Orthodontist**, 47(4):239-247

Skidmore, K. Brook, K. Thompson, W. and Harding, W. (2006) Factors influencing treatment time in orthodontic patients. **American Journal of Orthodontics and Dentofacial Orthopedics**, 129(2):230-238

Stanley, H. Collett, W. and Hazard, J. (1999) Retention of a maxillary primary canine: fifty years above and beyond the call of duty. **ASDC Journal of Dentistry for Children**, 63(2): 120-30

Sterrett, J. Oliver, T. Robinson, F. Fortson, W. Knaak, B. and Russell, C. (1999) Width/length ratios of normal clinical crowns of the maxillary anterior dentition in man. **Journal of Clinical Periodontology**, 26(3):153-157

Stewart, J. Heo, G. Glover, K. Williamson, P. Lam, E. and Major, P. (2001) Factors that relate to treatment duration for patients with palatally impacted maxillary canines. **American Journal of Orthodontics and Dentofacial Orthopedics**, 119(3): 216-225

Stivaros, N. and Mandall, N. (2000) Radiographic factors affecting the management of impacted upper permanent canines. **Journal of Orthodontics**, 27(2): 169-73

Szarmach, I. Szarmach, J. and Waskiel, D. (2006) Complications in the course of surgical-orthodontic treatment of impacted maxillary canines. **Advances in Medical Science,** 51 Suppl 1:217-220

Thomas, J. Hayes, C. and Zawaideh, S. (2003) The effect of axial midline angulation on dental esthetics. **Angle Orthodontist**, 73(4):359-364

Thornton, L. (1990) Anterior guidance: group function/canine guidance. A literature review. **The Journal of Prosthetic Dentistry**, 64(4):479-482

Van Der Geld, P. Oosterveld, P. Van Heck, G. and Kuijpers-Jagtman, A. (2007) Smile attractiveness: self-perception and influence on personality. **Angle Orthodontist**, 77(5):759-765

Ward, D. (2007) A study of dentists' preferred maxillary anterior tooth width proportions: Comparing the recurring aesthetic dental proportion to other mathematical and naturally occurring proportions. **Journal of Esthetic and Restorative Dentistry**, 19(6);324-339

Ward, D. (2001) Proportional smile design using the RED proportion. **Dental Clinics of North America**, 45;143-54

Wei, Y. Wang, X. Zhang, Q. Blatz, M. Jian, Y. and Zhoa, K. (2016) Clinical performance of anterior resin-bonded fixed dental prostheses with different framework designs: A systematic review and meta-analysis. **Journal of Dentistry**, 47: 1-7

Woloshyn, H. Artun, J. Kennedy, D. and Joondeph, D. (1994), Pulpal and periodontal reactions to orthodontic alignment of palatally impacted canines. **Angle Orthodontist**, 64(4):257-264

Xu, H. Han, X. Wang, Y. Shu, R. Jing, Y. Tian, Y. Andrews, W. Andrews, L. and Bai, D. (2015) Effect of buccolingual inclinations of maxillary canines and premolars on perceived smile attractiveness. **American Journal of Orthodontics and Dentofacial Orthopedics**, 147(2):182-9

Zachrisson, B. (2003) Premolar extractions and smile aesthetics. **American Journal of Orthodontics and Dentofacial Orthopedics**, 124(6); 11A-12A.