# ORTHODONTICALLY POSITIONED IMPACTED MAXILLARY CANINES: A POST-TREATMENT SURVEY

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TABLE OF CONTENTS


| | PAGE |
|---|---|
| INTRODUCTION . . . . . | 4 |
| REVIEW OF THE LITERATURE . . . . . | 6 |
| MATERIALS AND METHODS . . . . . | 21 |
| RESULTS . . . . . | 27 |
| DISCUSSION . . . . . | 32 |
| SUMMARY AND CONCLUSIONS . . . . . | 36 |
| BIBLIOGRAPHY . . . . . | 39 |
| FIGURES 1 - 11 | |

# INTRODUCTION

Proper management of the impacted maxillary canine is one of the most perplexing problems the dental practitioner has to face. This oral anomaly has implications in almost every field of dentistry. A multi-disciplinary approach utilizing the composite skills of the general practitioner, pedodontist, radiologist, oral surgeon, endodontist, orthodontist, and prosthodontist is often needed to provide thorough diagnosis, treatment, and follow-up.

The incidence of impacted maxillary canines is such that its correction often represents a significant part of the care provided in many orthodontic practices. In 1929 Rohrer[1] examined radiographs of 3000 cases and found the incidence to be 2%. Rayne[2] examined 12,000 cases in 1969 and proposed an incidence of 1.5% with unerupted maxillary canines. A survey in 1976[3] of the records and radiographs of 7,100 consecutive cases admitted at the School of Dentistry in Belfast showed the unerupted maxillary canine to be present in 2.5% of the cases radiographed.

The orthodontist has several avenues of treatment at his disposal in dealing with this difficult clinical problem. In certain situations, it may be in the patient's best interest to remove the impacted maxillary canines and utilize the first premolars in their place[4,5]. A combination of surgical exposure of the canine with or without some form

of ligation or attachment to the tooth in combination with orthodontic traction is the most commonly used method of treatment[6,7,8]. Autogenous transplantation of impacted maxillary canines has been reported in several European Dental Journals[9,10,11]. This technique can be undertaken at any age, but is more applicable to the older age group where orthodontic treatment needs to be reduced to the minimum for esthetic and social reasons.

The post-treatment condition of the canines should be paramount in the orthodontist's mind as the treatment plan is formulated and predictions of the result are made. Criteria such as periodontal condition of the supporting structures, vitality of the teeth involved, physical condition of the previously impacted canines, and functional contribution to the dental arches should be considered in determining if the procedure will be successful or not.

The purpose of this paper is to evaluate several cases of maxillary impacted canines after surgical exposure and orthodontic treatment has been completed. This is being done to determine if the final condition of these impacted maxillary canines, based on the above criteria, justifies the surgical and subsequently prolonged orthodontic treatment.

## REVIEW OF THE LITERATURE

The abnormality that occurs when a tooth has not erupted and is retained in the maxilla or mandible is called dental impaction and the retained tooth, an impacted tooth. The impaction may be bony or submucous, unilateral or bilateral, and it may have reference to deciduous, permanent, or supernumerary teeth[12]. This paper was limited to a discussion of impacted permanent canines, and in particular to those of the maxilla.

Records in early dental literature indicate the recognition of impacted canines. In 1803 Hunter, as quoted by Rayne[2] in 1969, stated that the canine was often irregular because it erupted late in the series, and its place was taken by the adjacent teeth. He felt that early loss of deciduous teeth and crowding of the permanent successors may displace a canine buccally.

Edward H. Angle[13] wrote in 1907 that the impaction of the canine is the most common of that of any of the teeth, since its eruption is subsequent to that of both its mesial and distal associates. He stated that later, if efforts toward eruption occur and there is no space, the canine must necessarily be deflected itself or force other teeth into malposition. So-called "third dentitions" were mentioned as being probable instances of tardy eruption of some permanent teeth.

The etiology of impacted teeth has long been a controversial subject. Several theories have been advanced as to the underlying cause of the impacted maxillary cuspid.

Dewel[14] (1949) wrote that possibly the original cause of the cuspid impaction lies in the extent of eruption required of these teeth. Opportunity for deflection from a normal course increases in proportion to the distance a tooth must travel from its point of origin to full occlusion. He pointed out that to reach full occlusion the cuspid travels the longest and most round-about course of any of the permanent teeth. Dewel also mentioned the dense and thick fibrous mucosa of the palate, dense palatal bone, and the fact that most cuspid roots are normally more advanced than other permanent teeth upon eruption as possible causative factors in maxillary canine impaction.

Delayed exfoliation of the deciduous canine as an etiological factor in the production of this condition was stated in Lappin's[15] 1951 paper. When, for some reason, the resorptive forces do not attack the deciduous cuspid root, it often deflects the permanent cuspid and prevents it from erupting. Since these impacted cuspids are most often deflected lingually, it is entirely possible that the normal eruption of the impacted cuspid may be retarded because of the character and density of the palatal tissue. Lappin[15], in agreement with Dewel[14], believed that the firm and fibrous lingual tissue may serve as an obstacle to normal eruption, and thus produce an impaction.

The presence of supernumerary teeth may also be considered in regard to contributing to impacted maxillary canines[12,15,16,17]. However, the presence of a supernumerary tooth in the upper canine area is so

rare that this cause alone cannot be considered as having great importance.

Fastlight[12] (1954) wrote of leaning habits, dentigerous cysts, and the premature extraction of deciduous canines and molars as possible contributing factors. He felt the reduction of space produced by the premature extraction of the first deciduous molar causes the permanent premolar to be displaced to a forward position, consequently reducing the area belonging to the canine, which in turn, may be thus deviated toward the labial or the palatine region.

According to Rayne[2] (1969) predisposing causes of misplaced canines are said to be crowding and local pathological conditions. Crowding may be exaggerated by a narrow maxilla and/or retroclination of the maxillary incisors. Bass[18], in 1967, wrote that a high proportion of patients with impacted canines had partial anodontia, even when missing lateral incisors were excluded. He suggested that an abnormality of the dental lamina might be blamed for the impactions as well as the anodontia.

Bishara[8] (1976) reported several primary causes in a summary paper that were not previously mentioned. These include: trauma to the primary tooth bud, rotation of tooth buds, premature root closure, and canine eruption into the cleft area in some cleft-palate individuals. Secondary causes mentioned by Bishara were abnormal muscle pressure, febrile disease, endocrine disturbances, and vitamin D deficiency.

Several authors made reference to the possibility of heredity playing an important role in the etiology of impacted maxillary canines[2,12,15,17]. However, nothing more than an occasional familial

example was presented to support this hypothesis.

In view of the large number of possibilities for affecting canine eruption and position it would seem that the incidence might be somewhat higher than previously mentioned. The fact that a canine may erupt normally in the face of some of these factors, and conversely, failure of eruption may occur where no predisposing cause can be found, should be kept in mind.

There is general agreement that impacted canines are more common in the maxilla than mandible, more often positioned lingual than labial, and occur with greater frequency in females than males[1,2,12,14,15,16,17]. A large disparity does exist in reports of the lingual-labial position of maxillary impacted canines. Johnston[16] indicated a finding of fifty to one lingual vs. labial cuspid positioning, while Fastlight[12] wrote of the lingual position of the canines being three times greater than the labial position.

Although the etiology of maxillary impacted cuspids may be obscure, the orthodontist is still faced with the fact there is an impacted tooth (or teeth) present. The question then becomes whether it is possible and practical to recover these teeth and if so, by what procedure can you accomplish this treatment.

Roentgenography is of primary importance for the diagnosis of the impacted teeth and for their accurate localization. Excellent periapical films are essential and may need to be supplemented with an occlusal film to localize further the unerupted tooth or teeth[17]. Fastlight[12] is not in agreement with most authors on this subject. He feels that the customary intraoral x-ray films are not sufficient

to locate the cuspids and that occlusal roentgenograms are essential for surgical intervention.

Stafne[19] suggested a practical procedure for establishing whether a canine is located in the palatal area or whether it is labial to the adjacent teeth. This can be determined with periapical x-ray films by noting the impacted canines change in position, in relation to the roots of the erupted teeth as the direction of the (x-ray) beam of radiation is changed. In the event that the image of the canine moves posteriorly (distally) as the beam is moved in that direction, it is situated on the palatal surface. If its image moves forward (mesially) its location is on the labial surface. He also states that if it remains in the same position it is situated in direct alignment with the roots of the erupted teeth.

In cases of impacted canines with unusual morphology or ones that are positioned in a bizarre manner, more sophisticated roentgenographic techniques may have to be used. Steward[20] (1963) recommended five exposures to locate a particularly high cuspid with a recurved apex: periapical, vertex occlusal, posterior-anterior of the jaws, rotated oblique lateral of the jaws, and a lateral exposure of the sinuses.

Sperry[21] ( 1978) examined human skulls in the mixed dentition with impacted maxillary canines using several radiographic procedures. The results were analyzed and verified by direct skull examination of the position of the unerupted tooth relative to the adjacent structures. He proposed that the diagnostic records to locate maxillary canines include image shift periapical films, a cephalometric or profile film, and optional records of a panographic film and an occlusal film.

Once the maxillary impacted cuspid has been properly diagnosed and located, the decision of what method(s) to use for treating the situation comes to fore. Historically, this has involved a surgical procedure to expose the canine followed by, in many cases, orthodontic forces applied to the canine in order to properly position it in the dental arch. The specific techniques of the surgical intervention and orthodontic traction are quite varied, leading to several methods to handle this difficult problem.

In the early 1900's impacted teeth were surgically exposed to aid in their eruption. A small portion of mucoperiosteum which overlays the most accessible surface of the impacted tooth was removed and this space usually stuffed with an iodoform pack. The wound was then repeatedly packed until healing was accomplished. Success of this technique was sporadic due to tissue necrosis, secondary infection, and scar tissue formation which would render the operation unsuccessful.

During this period several techniques utilizing pins or inlays placed in the exposed impacted canine were in vogue. These were controversial at best with problems of access during placement and consequent destruction of tooth material during placement as the major complaints of the operators[14,15].

In 1938 Strock[22] described a technique using a celluloid crown form placed over the impacted canine following surgical uncovering. The crown is held in place with surgical dressing cream and is utilized to facilitate eruption and to prevent the tissue from healing over the exposure sight. This surgical cream was obtundant and slightly antiseptic. He felt this helped to eliminate the infection and tissue problems of

previously used techniques.

Dewel[14] observed that impacted maxillary canines can and do erupt with no mechanical assistance other than the usual surgical dissection of the overlying tissues. He advocates not only uncovering the impacted canine, but also enlarging the bony crypt surrounding the crown so that an excess of space is provided. In this manner a channel slightly larger than the diameter of the crown will be created which will facilitate the downward movement of the tooth. However, he does say that some form of orthodontic attachment may be necessary in a limited number of cases.

A similar opinion was expressed by Lappin[15] in a 1951 paper on practical management of impacted maxillary cuspids. He advocated surgical exposure of the offending tooth (teeth) and then waiting up to one year prior to orthodontic intervention. He expressed the feeling that:

> "Many ingenious appliances have been designed to bring these impacted cuspids into the mouth when the identical results could have been obtained by proper surgical exposure and then just waiting for Mother Nature to do the rest--a great savings in time, expense, and in convenience to the patient."

Fastlight[12] presented a technique utilizing a lingual arch to hold a surgical dressing in place over the exposed canine. A cast gold cap was cemented on the impacted canine and the tooth moved into position by a force from the lingual arch if the canine is positioned labially. A similar method of treatment is proposed by Johnston[16] utilizing cast gold onlay(s) and the Johnson twin arch technique.

Lewis[17] (1971) also reported good success with the use of gold castings cemented on impacted canines. He proposed the preparation of a channel to the alveolar ridge through the palatal tissue and palatal bone when

the canine is surgically exposed. With this method the impacted tooth does not have to be dragged through this mass of resistant tissue and there is no tissue pile-up ahead of the canine resulting in less resistance to movement. The combined factors of little or no trauma to the impacted tooth during exposure and the lessened resistance during movement are given as the two chief reasons for success of this technique.

Kettle (1958), as quoted by Howard[23], advocated a method of traction that would be indicated if resorption of the incisors had occurred. A screw is inserted into the crown of the impacted canine and distal traction exerted. He also replaced the tissue flap after insertion of the screw which made it possible to treat the difficult high labially positioned canines.

In 1967 Helmore[24] reviewed the results of 213 patients with maxillary impacted canines. He found that ninety per cent could be treated satisfactorily with exposure, stimulation, and packing. Positive traction was required only for labially unerupted teeth, for those in unfavorable position, or those where treatment had been too long deferred. A circumferential wire loop placed around the cervical region was successful in cases where needed. Results of treatment were assessed by having orthodontists classify the results as good, fair, or failure.

Another method to facilitate the eruption of the more severely buccally displaced maxillary canines was suggested by Howard[23] in 1970. Following a surgical flap procedure to expose the impacted canine, a cavity is prepared in the tooth to receive a preformed cast gold inlay with a small hook in it. This to be placed equidistant between cusp tip and cemento enamel junction and within the distal third of the labial

surface. Traction is then instituted from the orthodontic appliance to the hook on the inlay. When the tooth is moved into its proper position in the arch, the hook is removed and the inlay finished properly or the inlay may be replaced by a more esthetic restoration.

In 1971 Clark[25] reported success in 2000 cases by utilization of free physiologic eruption of impacted canines. He utilized a celluloid crown technique similar to Strock[22] and in addition luxated the tooth about 1 - 2 mm away from its bone impingement (or the roots of the upper anterior teeth). This was thought to be a very important step in allowing the free eruption of the impacted canine. He also suggested a surgical technique to prevent lingual drifting of the palatally impacted maxillary canines when orthodontic retention is discontinued. This drift can be eliminated by cutting a crescent, half-moon piece of tissue from the lingual aspect of the moved canine down to the bone.

Thilander et al[26] reported on the effect of surgical exposure only with no previous or subsequent orthodontic treatment involved, as a method to facilitate the eruption of impacted teeth. They surgically exposed 240 maxillary impacted cuspids and followed them up from two to seven years later ($\overline{X}$ = 3.8 years). Results showed 45.8% of the surgically exposed maxillary cuspids had properly erupted, while 31.7% showed no tendency to erupt, and that the remaining teeth had only partly erupted despite several years of observation. It should be noted that in this paper the term "properly erupted" means that the entire crown had erupted, but not that the tooth was in the dental arch or occlusion. This term was

thus used in cases of a completely erupted palatally or buccally situated maxillary cuspid, that required later orthodontic treatment.

A direct bonding technique to aid in the management of maxillary impacted canines was presented by Gensoir and Strauss[27] in 1974. They recommended a minimum surgical exposure of the most easily accessible portion of the crown of the canine. A conservative approach is urged to achieve a final result of about 2 mm of visible crown. The conventional technique of acid-etch composite placement was then followed to attach a small button or bracket to the exposed surface of the impacted canine. The direct bonding technique offers a new and convenient method of treating impacted canines without the usual problems associated with extensive surgical exposures and the older techniques of management.

Heydt[6] proposed packing the follicular space with baseplate gutta-percha and keeping the crown open to the oral cavity with surgical WonderPak as an effective method of making the tooth erupt into the oral cavity. The impacted canine will migrate away from the site of pressure of the gutta-percha allowing some control over the eruption direction of the tooth. When the necessary eruption was accomplished he would place preformed bands over the teeth and proceed to guide them into proper position with orthodontic traction. He favors the preformed bands over direct bonding to attachments because of the access requirement of each procedure. Well-exposed surfaces are more critical for successful bonding than for the application of a preformed band which can be introduced without discomfort below the surface of the soft tissues.

In 1976 Stangle[28] wrote of a technique to treat maxillary impacted canines cases using segmental arch wires. He developed this procedure to help reduce the severity of several unfavorable reactions previously observed with other techniques: 1) apical resorption of maxillary central and lateral incisors, 2) gingival irritation and recession of the maxillary first premolars, and 3) severe gingival recession of the maxillary canines. With this technique the mesiodistal space for the impacted maxillary canines was greatly increased and was believed to help to avoid possible "brushing" of the maxillary incisor apices against the impacted canines during traction therapy.

Bishara[8] and colleagues, in explaining surgical exposure of impacted canines concluded that the prognosis for successful exposure of the canine and guidance to its proper position is often guarded. They advise that in those cases requiring a maxillary premolar extraction, it is desirable to delay this procedure until the prognosis is certain. Other authors[4,5] support this alternative type of treatment within the anatomical differences of the teeth being considered.

Ligation of the maxillary impacted cuspids with wire is an often mentioned method of providing an attachment to the tooth from which traction may be applied[6,16,17]. Ziegler[7] describes a method using a modified type of ligation chain that enables the oral surgeon to lasso the tooth with ease. It also affords the orthodontist large, successively placed eyelets to which he can utilize to keep continuous heavy force on the impacted canine.

McKay[2] writes of an attempt to assess the role of various types of surgery used in a series of 2572 cases. Results indicate that impacted

canines which are treated by adequate surgical exposure at the optimum age of approximately 13 years respond well. Later, when the root is fully formed, the eruptive power is greatly diminished and the procedure is seldom successful after 17 years of age. He also feels that there is a place in treatment for surgical repositioning--swinging the tooth around its apex, provided that the position after surgery will be less than 4 mm short of the occlusal plane. If it is shown that the position would be outside this limit, surgical alignment would be the treatment choice.

Becker[29] describes a "new" method for applying traction to maxillary impacted canines displaced palatally. He utilizes a removable maxillary lingual arch to provide traction to the impacted canines. The traction is applied in a lingually downward direction to prevent interference with the neighboring teeth. This method is proposed as a possible adjunct to almost any of the established techniques.

Jacoby[30] (1979) has recently developed the "ballista spring" system for impacted maxillary canines. In this system the impacted tooth is retracted by a spring that accumulates a continuous force from being twisted on its long axis. Anchorage is provided by a palatal bar and soldering the first premolar and molar bands to this appliance on the lingual surface. The "ballista spring" is inserted in the molar tubes and the vertical part is carefully raised and ligated to the bonded hook on the canine by an elastomeric thread. The force exerted on the tooth is vertical and is supposedly well controlled and easily modified.

The etiology and general management of impacted cuspids has been well reviewed by several authors. However, one aspect of this problem

which has received only superficial attention in the literature, concerns the results of the surgical exposure and subsequent orthodontic treatment of these teeth. In particular, the significance to the periodontal health of the supporting structures, has aroused little comment. The incidence of periodontal problems following surgical exposure of impacted teeth would indicate that examination of this issue would warrant further examination.

In 1973 Hansson and Linder-Aronson[31] investigated the periodontal conditions in cases of impacted maxillary canines. They evaluated 18 patients who had undergone treatment for unilateral palatal impaction of a maxillary canine. The contralateral canine, which had erupted unaided, served as a control. Their results showed significant differences between the treated and untreated maxillary canines in the same patient with respect to the depth of the mesio-lingual gingival pockets. This was attributed to insufficient cleansing while treatment was in progress. The overall slight differences between the treated and untreated canines indicate that on the average the orthodontic treatment altered the periodontal conditions to only a limited extent.

Wisth et al[32] made a study of two surgical methods in combined surgical-exposure-orthodontic correction of impacted maxillary canines. In one group the teeth were exposed in the mouth after removal of the bone and soft tissue covering of the crown--"the radical exposure group". In the other group the bone covering the crown was removed, then the mucoperiosteal flap was sutured--"the moderate exposure group". The loss of fiber attachment on the palatal was greater after radical surgical exposure, and also more variable. This may indicate that the risk of

permanent damage of the marginal periodontal tissue is greater when this method is used. They concluded that the moderate surgical procedure causes the least periodontal damage.

A conservative surgical flap approach was discussed by Heaney and Atherton[33] in 1976. They found that to expose an impacted canine into unkeratinized alveolar mucosa results in periodontal pathology characterized by absence of a functional zone of attached gingivae. Increased clinical crown length was also noted. These changes in turn resulted in an increase in severity of chronic periodontal inflammation.

Although the severity of these changes can be minimized by using a flap procedure, they were often disappointed in the final result. For these reasons therefore, they feel that the use of surgical exposure techniques in the management in impacted maxillary canines should be avoided wherever possible.

Wisth et al[34] also evaluated separately the 34 patients with unilateral maxillary impacted canines that had the radical surgical exposure in their previously mentioned study. The contralateral canines which had erupted unaided served as controls during the study. Measurements showed that the distal pocket on the treated teeth was significantly deeper than on the control teeth. The treated canines displayed more loss of periodontal support on the buccal and palatal surfaces than did the untreated teeth. They showed that radiographically, there was more alveolar bone loss on the mesial surfaces of the corrected than on the control teeth. To summarize, the periodontal health of the canines that were exposed with radical surgery was not equal to that of the untreated contralateral teeth.

Vanarsdall and Corn[35] discuss a surgical exposure technique that helps to protect the attached gingivae in the area of the impacted maxillary canine. Prevention of soft-tissue recession and radicular bone loss of the unerupted teeth are mentioned as being results of their technique. The paper calls for more attention to be placed on the manipulation of the soft tissues by the oral surgeon. More research is needed in the area so that a better understanding of soft-tissue reactions to tooth movement can be achieved.

In 1978 Odenrick and Modeer[36] did a similar study of two different surgical techniques similar to those described by Wisth et al[32]. The referred to the surgical techniques as the partially exposed and the radically exposed groups. The mean age of the patients was 17.9 years and all patients were past the period of orthodontic retention. The periodontal status was examined with respect to gingival recession and hyperplasia of the free gingival margin on the labial and lingual surfaces. It was determined that by using the partial surgical technique a comparatively better periodontal health was achieved. These findings were in agreement with Wisth et al in their previous paper in 1976.

Shiloah and Kopczyk[37] reported on a maxillary impacted canine case and the need for soft-tissue considerations. As reported in previous articles, they felt that it was essential that the path of eruption be directed through the attached gingiva, in order to preclude the development of a mucogingival defect. This can be obtained by retaining the existing band of attached gingivae with the surgical flap procedure.

# MATERIALS AND METHODS

The material comprised 30 patients (6 males and 24 females) who had undergone treatment for their impacted maxillary canines. Treatment involved surgical exposure and in some instances attachment to the canine by various means, followed by subsequent orthodontic positioning by the affected teeth.

There were 8 bilateral and 22 unilateral surgical exposures of various types in this sample. The patients examined were from 6 private orthodontic practices and the orthodontic department of the University of Oregon Health Sciences Center, School of Dentistry. The type of surgical procedure varied as per the office involved, with the common factor being that each patient had at least one maxillary impacted canine surgically exposed (Fig. 1). Standard edgewise mechanics were utilized in each patient for the positioning of the canine following its eruption into an accessible position.

All of the patients were examined at least two years after removal of the fixed appliances. The mean age at the time of examination was 21 years 8 months. At the time of surgical exposure, the age of the patients varied between 11 years 10 months and 22 years 3 months with a mean of 14 years 6 months. The duration of the orthodontic treatment varied between one year and four years four months with a mean of two years one month.

Each patient was evaluated for several criteria as outlined in Fig. 2. They were examined for occurrence of plaque, the state of the gingivae, depth of the gingival pockets, gingival recession, attached gingivae, mobility, color-shade, vitality, and function. It was also attempted to study root resorption of the canines from intraoral radiographs.

All of the measurements and evaluations were done on the patients prior to determining which tooth (teeth) had been impacted whenever this was possible. This was done to encourage the operator to be as objective as possible.

The occurrence of plaque and the health of the gingivae were registered for the labial, lingual, mesial, and distal aspects of the maxillary canines with the aid of indexes described by Silness and Loe[38,39].

Criteria for the palque index system (Silness and Loe 1964)[38]

0 = No plaque

1 = A film of plaque adhering to the free gingival margin and adjacent area of the tooth. The plaque may be seen in situ only after application of disclosing solution or by using the probe on the tooth surface.

2 = Moderate accumulation of soft deposits within the gingival pocket, or on the tooth and gingival margin, which can be seen with the naked eye.

3 = Abundance of soft matter within the gingival pocket and/or on the tooth and gingival margin.

Criteria for the gingival index system (Loe and Silness 1963)[39]

0 = Absence of inflammation

1 = Mild inflammation--slight change in color and little change in texture.

2 = Moderate inflammation--moderate glazing, redness, edema, and hypertrophy. Bleeding on pressure.

3 = Severe inflammation--marked redness and hypertrophy. Tendency to spontaneous bleeding. Ulceration.

Gingival recession was measured on the labial and lingual surfaces of both maxillary canines. There was considered to be recession present when the gingival margin was apical to the cemento-enamel junction.

The attached gingivae on the labial surface of the maxillary canines and also the most immediate tooth to its distal was measured. This was measured from the gingival groove to the mucogingival line of the vestibular fornix as described by Schluger[40] (1978).

The depths of the gingival pockets were measured with a graduated periodontal probe according to Schluger[40], from the border of the free marginal gingiva to the floor of the pocket. The depths of these pockets were measured at six points for each tooth; three on the labial and three on the lingual side. A Marquis periodontal probe which is designed to facilitate reading pocket depth with marked bands 3 mm in width was utilized in these measurements.

Clinical mobility was evaluated on each of the maxillary canines. This was done by exerting pressure with two rigid instruments on the tooth and measuring the movement of the crown. A mobility index outlined by Miller[41] was used to classify the findings.

Criteria for the mobility index (Miller)[41]

1. The first distinguishable sign of movement greater than normal.
2. Movement of the tooth which allows the crown to move 1 mm from its normal position in any direction.
3. Movement of the tooth which allows the crown to move more than 1 mm from its normal position in any direction. Teeth which may be rotated or depressed in their alveoli are classified also mobility number 3.

An attempt was made to group the canines into three categoris as the color or shade of the tooth was evaluated. Good or excellent was meant for those canines that blended in well with the rest of the arch and were esthetically pleasing and harmonious. The group that was not as pleasing to the eye was categorized as a comment group. In each of these instances an attempt was made to describe why the tooth did not match or blend as well, i.e., slightly too much cervical yellow, etc. The teeth in the third group were those that were objectionable esthetically and were not considered esthetically acceptable. These teeth were labeled as being poor.

Vitality of the canines and their adjacent teeth were determined by menas of a digital automatic pulp tester. When the probe makes contact with a tooth the instrument turns on automatically. This is accomplished by a transistorized circuit which senses the current flow from the probe mantle via the dentist's hand, which is in contact with the patient, through the tooth back to the tip of the probe. The automatic turn on feature prevents testing unless a good electrical contact has been established. This eliminates the possibility of false diagnosis due to poor

electrical contact. It also eliminates the possibility of jolting a patient by suddenly establishing good electrical contact after initially having begun pulp testing with a poor contact between the probe and the tooth. The readout for this instrument is on a relative scale between zero and 80. The normal response ranges are: 10-40 incisors, 20-50 bicuspids, and 30-70 molars.

The functional aspect of the canines was also evaluated. Angle[42] classification of the canines and first molars was determined as well as the method of disocclusion of the mandible with lateral excursive movements. This was included in the survey to see if there was any tendancy for the previously impacted canines to relapse away from the plane of occlusion.

Intraoral radiographs were taken of the maxillary canines when it was possible. The purpose of this was to evaluate the incidence of root resorption of the canines. The original intent was to compare the original periapical radiographs with these that had been taken following treatment. However, several factors have made this impossible to fulfill. It was not possible to obtain the preoperative radiographs as routinely as had been expected. Individual office policies and different methods of record keeping contributed to this problem. Three of the offices used for examination did not have x-ray machines with periapical capacities. Other factors were x-ray developing problems, operator error, and the wishes of three patients who did not wish any additional x-rays taken.

It was possible to obtain diagnostic periapical radiographs of 17 patients that were examined. These x-rays were evaluated as having no resorption, moderate resorption, or severe resorption of the treated canines. These were used to compare the surgically exposed impacted tooth

to the non-surgical contralateral tooth wherever possible in making the decision.

# RESULTS

## Oral Hygiene Index

An oral hygiene evaluation did not show any statistically significant differences between the surgically exposed canines and their freely erupted contralaterals in the 22 unilateral impaction cases (Fig. 3). The mean plaque index for all teeth examined was .67. The proximal values were highest followed by lingual and labial, respectively, in all patients.

The statistical evaluation of the material included testing of the means. A t-test for repeated measures was used and evaluated at a .05 level of confidence and 21 degrees of freedom[43].

## Gingival Index

In the same 22 patients, the gingival index means for the two types of treatment (surgical and non-surgical) were tested in a similar manner. This showed a significant difference between the means for the distal aspect of these canines (Fig. 4). The mean gingival index for all the teeth examined was .53.

There was no replicate recording of measurement error with these two indices attempted. Wisth et al[34] reported on double determinations of recordings that showed a coincidence of 87% for the plaque scores

and 93% for the gingival scores. Their error was never more than one score unit in this study.

## Periodontal Probing

A comparison of periodontal pocket depth did not show any significant differences of the mean depths in the two previously mentioned groups (Fig. 5). In fact, one half of the measurements demonstrated deeper periodontal pockets with the freely erupting canines. The eight cases with bilateral surgical procedures were also evaluated for mean differences (Fig. 6). Nothing of significance was noted in this group either.

The accuracy and reproducibility (measurement error) in measuring pocket depth was investigated by Glavind and Loe[44]. They statistically analyzed the difference between duplicate measurements of 1,530 teeth in 63 Danish men. This was calculated from the following equation: $S.E.Meas. = \sqrt{\frac{D^2}{2N}}$ where D is the difference between the duplicate measurements and N is the number of double measurements. They found the method error for single measurements to be $\pm$ 0.36 mm and for mean pocket depth to be $\pm$ 0.11 mm.

## Gingival Recession

The results of the examination with respect to gingival recession showed six teeth in the unilateral group and two in the bilateral group exhibiting this condition (Fig. 7). There was no significant difference in mean recession measurements between the two groups of canines in the unilateral patients. This also held true for comparisons between right

and left canines in the bilateral group (Fig. 8).

Attached Gingivae

The amount of attached gingiva varied from a mean of 1.36 mm for 22 surgically exposed canines to 2.14 mm for their freely erupting contralaterals. T-testing showed this to be significant at a .01 level of confidence (Fig. 9).

Mobility

There was a significant difference between the mean values for mobility of the canines in the unilateral group using the t-test at a .02 level of confidence and 21 degrees of freedom. The same comparison of the canines in the bilateral group did not exhibit a significant difference (Fig. 10).

Color-Shade

All of the surgically exposed canines were evaluated for their color-shade. A total of 29 of the 38 teeth examined were found to be in the good or excellent category. There was no noticable difference between these teeth and the rest of the teeth in the arch. The other nine were judged to be in the comment group. These teeth were slightly more yellow or darker in color than the contralateral canine or other teeth in the arch depending on a unilateral or bilateral surgical exposure. No canines were placed in the clinically unacceptable or poor grouping.

## Vitality

The mean vitality reading for all surgically exposed canines, excluding two teeth which were judged to be devital, was 41.2. Surgically exposed canines in the unilateral group showed a mean of 42.9 while the freely erupting contralaterals showed 41.7. No significant differences were found between the two groups (Fig. 11). The one devital cuspid in this unilateral group was not included in the mean computation or the t-testing.

## Function

An Angle Class I canine relationship was found on 27 of the 38 teeth surgically exposed in this study. All but two of these teeth were functioning in canine rise upon lateral movement and disarticulation. The remaining canines in this group were positioned in Class II, Class III, or end-to-end situations and were functioning in various forms of group function in lateral excursions. There were no instances noted of the canine relapsing apically away from the plane of occlusion.

## Root Resorption

The radiographs of 23 surgically exposed canines from 17 patients were evaluated for root resorption or apical shortening. A total of 20 teeth showed no noticeable root resorption, while three teeth had moderate root resorption. There were no cases that exhibited severe root resorption. Examination of eleven freely erupting canines by radiograph found nine teeth with no resorption, two with moderate

resorption, and none with severe root resorption.

The coefficients of variation and their standard errors were computed for the oral hygiene index, gingival index, periodontal probing, gingival recession, attached gingiva, mobility, and vitality determinations.

# DISCUSSION

The comparison of the oral hygiene index scores of the surgically exposed canines and their freely erupting contralaterals showed that the conditions were similar. There was no statistically significant difference between means of the two groups when they were t-tested (Fig. 3).

However, it is not unlikely that the oral hygiene, and thus the plaque index, may have varied during the treatment period. This would especially have been so during the time while the surgically exposed teeth were in a partially exposed position where accessibility for cleansing was poor[34]. On the other hand, the freely erupted teeth were subjected to banding and increased plaque retention for a longer period of time than the surgically exposed canines. This makes it very difficult to establish whether or to what extent oral hygiene conditions during treatment may have influenced the periodontal condition differently on the two sides.

The distal value of the mean gingival index was significantly higher in the surgically exposed group of canines (Fig. 4). This was contrary to other investigators who have reported no significant mean differences between similarly treated canines[31,34]. It is possible that this value could be the result of surgical exposure techniques on the impacted canines, be related to various methods of traction to bring the tooth into the arch, or even be connected to space closure distal to the canine.

However, it would seem more likely to look to the method error and keep in mind the relatively small sample size with several different methods of surgery having been utilized.

If this finding were substantiated by future investigation, it would be wise to specifically instruct patients to meticulously clean in the distal area to minimze the occurrence of periodontal disease.

Periodontal probing of the two groups did not reveal any mean differences that were significant (Fig. 5). These slight differences between the surgically exposed canines and their freely erupting contralaterals indicate that in these cases evaluated, the treatment altered the periodontal conditions to only a limited extent.

The reliability of periodontal probing has been shown by other investigators[44]. They feel that from a quantitative point of view, clincial measurement of pocket depth is a fairly accurate procedure. The accuracy of single measurements as expressed by the method error was reported as less than $\pm$ .05 mm.

The gingival recession measurements and subsequent t-testing of the means did not show any significant differences (Fig. 8). Other investigators have suggested a correlation between initial position of the impacted tooth and the surface which showed gingival recession[36]. This was not undertaken in this paper due to the unavailability of the initial records of the patients examined.

Attached gingiva measurements were significantly different when the means were t-tested (Fig. 9). This procedure is one that would tend towards a larger measurement error. It was previously mentioned that measurement error in periodontal probing was nearly 0.5 mm. The

location of the mucogingival line may often not be readily discernible to the operator and would enhance method error in determining the amount of attached gingivae present. Another factor is that attached gingiva may vary in width from one individual to another and from one site to another[45]. It is felt that these factors should be considered in assessing the importance of the statistically significant differences of attached gingivae of the two groups.

Mobility was also shown to exhibit significant mean differences in the surgically exposed and freely erupting groups (Fig. 10). This extremely subjective evaluation does not lend itself to accurately reproducible data needed for tight statistical analysis. The small differences shown may be statistically significant but would be of little clincial significance.

There were no conclusions to be drawn from the color-shade evaluation. This was investigated with the possibility of equating length of time in the oral cavity, specific surgical exposure procedure, or orthodontic traction method to this characteristic. However, the method of measurement was not specific enough to apply towards a statistical evaluation.

The mean differences in vitality readings for the two groups of canines were very small. This would be in agreement with other investigators in that nearly all teeth retain their vitality after an initial recovery period[17,46]. It is worthwhile to note that two devital canines were discovered that had been surgically exposed.

Positioning of the canines was evaluated and the findings were not unusual. Most of the canines were in a Class I position and no incidences

of apical relapse were noted.

The radiographic evaluation of root resorption met with limited success. Several previously mentioned extraneous factors led to a small sample size. There was some incidence of root resorption in both groups. However, nothing was found form which valid conclusions could be drawn.

## SUMMARY AND CONCLUSIONS

The purpose of this paper was to evaluate the overall condition of previously impacted maxillary canines following surgical exposure and orthodontic positioning. This was done to determine if an alternative treatment method to bringing impacted canines into the arch should be considered.

This study was performed on 30 patients (24 females and 6 males) who had undergone surgical exposure of at least one impacted canine and subsequently orthodontic treatment. In 22 of the cases, the freely erupting contralateral canine served as a control. The mean age of the subjects at the time of examination was 21 years 8 months.

Each patient was evaluated for ten criteria. The following conclusions were drawn from these examinations:

1) Oral hygiene differences are very small between surgically exposed and freely erupting cuspids.
2) Periodontal health does not differ significantly between these two groups, with the exception of the distal surface of the canines, which may or may not be the result of method error.
3) Periodontal pocket depth and gingival recession showed no differences in the two groups.

4) Attached gingiva and mobility were shown by t-testing to be statistically significant in their mean differences of the two groups. The clinical significance was, however, not substantiated.

5) Color-shade, vitality, function, and root resorption were inconclusive as to their contribution to significant group differences.

6) All testing parameters were characterized by extremely high ratios between their variations and means (coefficient of variation). Because time did not permit extensive measurement error testing it may well be that the broad range of variation is not a true representation of real difference.

7) It is extremely difficult to utilize patients from orthodontists in private practice in a study of this type. The disparity in record keeping, treatment methods, facilities, and attitude towards research make this a nearly insurmountable hurdle.

The minor differences exhibited between surgically exposed canines and their freely erupting contralaterals indicate that on the average the surgical uncovering followed by orthodontic positioning altered the overall condition of these canines only to a limited extent.

The treatment of choice for impacted maxillary canines will continue to be surgical exposure followed by orthodontic positioning until better evidence is presented to the contrary.

Further studies are necessary to evaluate this problem in a more definitive manner.

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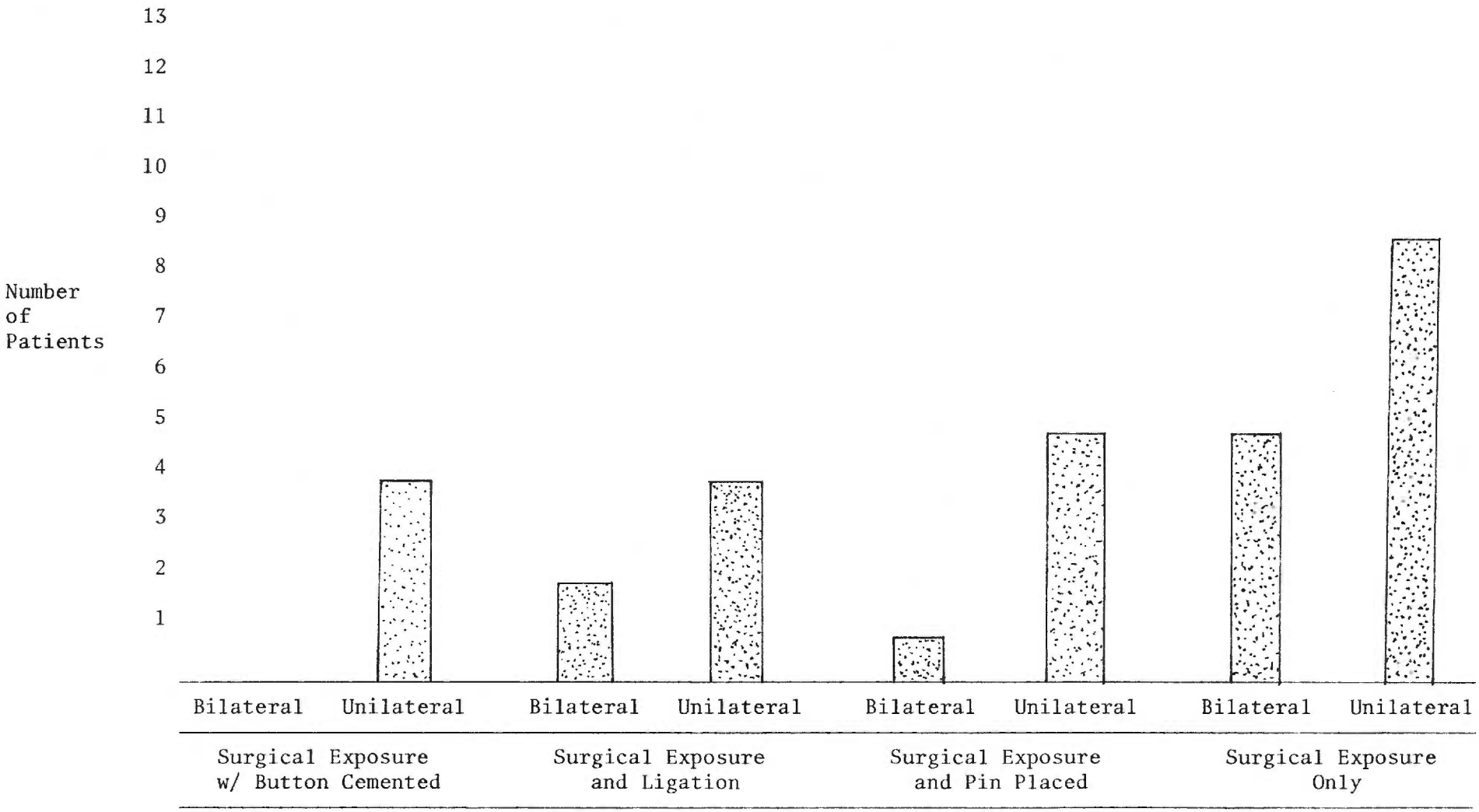


Fig. 1: Various Treatment Methods Used - 30 Patients

Fig. 2

# IMPACTED CUSPID PROJECT

ame _____ Sex _____ Age _____ Office _____ Date _____

ge At Surgery(s) _____ _____
Ortho Start _____
Ortho Complete _____

urgical Procedure

rtho Procedure

ral Hygiene ndex

Right L D M Ling

L Left M D Ling

ingival ndex

erio Cond.

Recession

R: Labial ___ Ling ___

L: Labial ___ Ling ___

Attached Gingivae

R L

Probe

Tooth # ___ Lab ___ D M Ling

Tooth # ___ Lab ___ D M Ling

obility

Right 0 1 2 3

Left 0 1 2 3

olor-Shade

Right

Left

itality

Right Tooth _____ _____ _____ _____ _____ _____

Left Tooth _____ _____ _____ _____ _____ _____

unction

Right - Cuspid _____
Molar _____
Lat. Excursion _____

Left - Cuspid _____
Molar _____
Lat. Excursion _____

oot Resorption Radiographs)

omments-Misc.

22 Unilateral Cases

| | Surgical | | | | | Freely Erupted | | | | | t |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\bar{X}$ | SD | SEM | CV | $CV_{SE}$ | $\bar{X}$ | SD | SEM | CV | $CV_{SE}$ | test |
| Labial | .41 | .50 | .11 | 121.9 | 18.8 | .31 | .48 | .10 | 154.8 | 23.9 | .81 |
| Lingual | .64 | .66 | .14 | 103.1 | 15.9 | .59 | .67 | .14 | 113.6 | 17.5 | .37 |
| Mesial | .73 | .46 | .10 | 63.0 | 9.7 | .86 | .47 | .10 | 54.7 | 8.4 | -1.00 |
| Distal | .91 | .43 | .09 | 47.2 | 7.3 | .82 | .39 | .08 | 47.6 | 7.3 | .81 |

$\alpha = .05$

DOF = 21

8 Bilateral Cases

| Right | Labial | Lingual | Mesial | Distal | Left | Labial | Lingual | Mesial | Distal |
|---|---|---|---|---|---|---|---|---|---|
| $\bar{X}$ | .37 | .50 | 1.00 | 1.12 | $\bar{X}$ | .37 | .87 | 1.00 | .89 |

Fig. 3: Oral Hygiene Index Statistical Analysis

22 Unilateral Cases

| | Surgical | | | | | Freely Erupted | | | | | t |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\bar{X}$ | SD | SEM | CV | $CV_{SE}$ | $\bar{X}$ | SD | SEM | CV | $CV_{SE}$ | test |
| Labial | .50 | .51 | .11 | 102.0 | 15.7 | .27 | .46 | .10 | 170.4 | 26.3 | 2.02 |
| Lingual | .50 | .60 | .13 | 120.0 | 18.5 | .50 | .60 | .13 | 120.0 | 18.5 | 0 |
| Mesial | .46 | .51 | .11 | 110.9 | 17.1 | .32 | .48 | .10 | 150.0 | 23.1 | 1.37 |
| Distal | .73 | .46 | .10 | 63.0 | 9.7 | .46 | .51 | .11 | 110.9 | 17.1 | 2.81* |

$\alpha = .05$

DOF = 21

8 Bilateral Cases

| Right | Labial | Lingual | Mesial | Distal | Left | Labial | Lingual | Mesial | Distal |
|---|---|---|---|---|---|---|---|---|---|
| $\bar{X}$ | .50 | .62 | .75 | 1.00 | $\bar{X}$ | .62 | .75 | .87 | .75 |

* Significant at $\alpha = .05$ and 21 DOF

Fig. 4: Gingival Index Statistical Analysis

22 Unilateral Cases

| | Surgical | | | | | Freely Erupted | | | | | t |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\bar{X}$ | SD | SEM | CV | $CV_{SE}$ | $\bar{X}$ | SD | SEM | CV | $CV_{SE}$ | test |
| Distal | 2.59 | .59 | .13 | 22.8 | 3.5 | 2.73 | .70 | .15 | 25.6 | 3.9 | -.83 |
| Labial | 1.55 | .67 | .14 | 43.2 | 6.7 | 1.41 | .59 | .13 | 41.8 | 6.4 | 1.0 |
| Mesial | 2.64 | .73 | .15 | 27.7 | 4.3 | 2.45 | .60 | .13 | 24.5 | 3.8 | 1.28 |
| Mesial | 2.73 | .83 | .18 | 30.4 | 4.7 | 2.95 | .49 | .10 | 16.6 | 2.6 | -1.23 |
| Lingual | 2.45 | .74 | .16 | 30.2 | 4.7 | 2.59 | .67 | .14 | 25.8 | 4.0 | -.83 |
| Distal | 3.18 | .50 | .11 | 15.7 | 2.4 | 3.18 | .50 | .11 | 15.7 | 2.4 | 0 |

$\alpha = .05$

DOF = 21

Fig. 5: Periodontal Probe Statistical Analysis. Unilateral Impacted Canines.

8 Bilateral Cases

| | Right Side | | | | | Left Side | | | | | t |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\bar{X}$ | SD | SEM | CV | $CV_{SE}$ | $\bar{X}$ | SD | SEM | CV | $CV_{SE}$ | test |
| Distal | 2.63 | .74 | .26 | 28.1 | 4.3 | 3.13 | .64 | .23 | 20.4 | 3.2 | -1.53 |
| Labial | 1.50 | .76 | .27 | 50.7 | 7.8 | 1.75 | 1.04 | .37 | 59.4 | 9.2 | -1.0 |
| Mesial | 2.63 | .52 | .18 | 19.8 | 3.0 | 3.00 | .53 | .19 | 17.7 | 2.7 | -1.43 |
| Mesial | 3.00 | .53 | .19 | 17.7 | 2.7 | 2.75 | .46 | .16 | 16.7 | 2.6 | 1.53 |
| Lingual | 2.00 | .76 | .27 | 38.0 | 5.9 | 2.38 | .52 | .18 | 21.8 | 3.4 | -1.43 |
| Distal | 3.12 | .64 | .23 | 20.5 | 3.1 | 2.88 | .35 | .12 | 12.1 | 1.9 | 1.00 |
| | | | | | | | | | | | DOF = 7 |

Fig. 6: Periodontal Probe Statistical Analysis. Bilateral Impacted Canines.

| | Number of Canines Exhibiting Recession | | | |
|---|---|---|---|---|
| | Unilateral Group N = 22 Patients | | Bilateral Group N = 8 Patients | |
| | Surgical | Freely Erupted | Right | Left |
| Labial | 4 | 3 | 1 | 1 |
| Lingual | 0 | 1 | 1 | 1 |

Fig. 7: Occurrence of Gingival Recession in 30 Patients

22 Unilateral Cases

| | Surgical | | | | | Freely Erupted | | | | | t |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\bar{X}$ | SD | SEM | CV | $CV_{SE}$ | $\bar{X}$ | SD | SEM | CV | $CV_{SE}$ | test |
| Labial | .23 | .53 | .11 | 230.4 | 35.6 | .18 | .50 | .11 | 277.8 | 42.9 | .44 |
| Lingual | 0 | 0 | 0 | 0 | 0 | .05 | .21 | .05 | 420.0 | 64.8 | -1.0 |
| | | | | | | | | | | | DOF = 21 |

8 Bilateral Cases

| | Surgical | | | | | Freely Erupted | | | | | t |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\bar{X}$ | SD | SEM | CV | $CV_{SE}$ | $\bar{X}$ | SD | SEM | CV | $CV_{SE}$ | test |
| Labial | .13 | .35 | .12 | 269.0 | 71.9 | .13 | .35 | .12 | 269.2 | 79.2 | 0 |
| Lingual | .25 | .71 | .25 | 284.0 | 75.9 | .13 | .35 | .12 | 269.2 | 79.2 | 1.0 |
| | | | | | | | | | | | DOF = 7 |

Fig. 8: Gingival Recession Statistical Analysis. Amount of Recession in mm.

22 Unilateral Cases

| Surgical | | | | | Freely Erupting | | | | |
|---|---|---|---|---|---|---|---|---|---|
| $\overline{X}$ | SD | SEM | CV | $CV_{SE}$ | $\overline{X}$ | SD | SEM | CV | $CV_{SE}$ |
| 1.36 | 1.40 | .30 | 102.9 | 15.5 | 2.14 | 1.42 | .30 | 66.4 | 10.0 |

t-test

$t = 3.40^*$

* Significant at $\alpha = .01$ and 21 DOF

Fig. 9: Attached Gingiva Statistical Analysis

22 Unilateral Cases

| Surgical | | | | | Freely Erupted | | | | | t |
|---|---|---|---|---|---|---|---|---|---|---|
| $\bar{X}$ | SD | SEM | CV | $CV_{SE}$ | $\bar{X}$ | SD | SEM | CV | $CV_{SE}$ | test |
| .32 | .48 | .10 | 150 | 23.1 | .05 | .21 | .05 | 420 | 64.8 | 2.81* |

8 Bilateral Cases

| Right Side | | | | | Left Side | | | | | t |
|---|---|---|---|---|---|---|---|---|---|---|
| $\bar{X}$ | SD | SEM | CV | $CV_{SE}$ | $\bar{X}$ | SD | SEM | CV | $CV_{SE}$ | test |
| .25 | .46 | .16 | 184 | 49.1 | .13 | .35 | .12 | 269.2 | 71.9 | 1.00 |

* Significant at $\alpha$ = .02 and 21 DOF

Fig. 10: Mobility Statistical Analysis

21 Unilateral Cases

| Surgical | | | | | Freely Erupting | | | | | t |
|---|---|---|---|---|---|---|---|---|---|---|
| $\bar{X}$ | SD | SEM | CV | $CV_{SE}$ | $\bar{X}$ | SD | SEM | CV | $CV_{SE}$ | test |
| 42.90 | 7.29 | 1.59 | 17.0 | 2.6 | 41.70 | 7.61 | 1.66 | 18.2 | 2.8 | t = .58 |
| | | | | | | | | | | N = 21 |

Fig. 11: Vitality Statistical Analysis