The Philippine Journal of Orthodontics
Vol. 10 No. 1 August 2011

The *Philippine Journal of Orthodontics* is the official journal of the Association of Philippine Orthodontics (APO) and the Philippine Board of Orthodontics (PBO) and is published for its members and subscribers by Dot-To-Dot Enterprise.

It is dedicated to the continuing professional advancement of the orthodontists by publishing original articles related clinical orthodontic reports.

Manuscripts, prepared in accordance with The Information for Authors should be submitted to the editors, or Dr. Martin Reyes c/o PBO Secretariat Tel/Fax 890-6048.

Printed in the Philippines by Dot-To-Dot Enterprise, Fairview, Quezon City, M.M., Philippines

Effect of Low-Dose Systemic Doxycycline Administration During Orthodontically Induced Root and Alveolar Bone Resorption in Guinea Pigs

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Root resorption is a common, iatrogenic phenomenon associated with orthodontic treatment. In the midst of several tetracyclines, which restrain metalloproteinases' action, preventing collagenolysis, it was demonstrated that Doxycycline (DC) decreases the quantity of osteoclasts and inhibit root resorption and alveolar bone loss. The purpose of this study was to histologically quantify and evaluate the effects on the tissues involved in orthodontic tooth movement of incisors. Observations were made while systemic administration of low-dose Doxycycline was performed via ALZET mini-osmotic pumps. Its effect on the rate of tooth movement was also determined.

Twenty-two guinea pigs were randomly distributed into treatment groups. Animals scheduled for antibiotic treatment received low dose 20mg/ml Doxycycline by means of a mini-osmotic pump implanted subcutaneously on the back slightly posterior to the scapulae. Under the conditions of this experiment, animals treated with low dose Doxycycline exhibited a significant decrease in the mean amount of active tooth movement, which suggests the potential inhibiting role of Doxycycline in mediating bone resorption. It was confirmed in this study that this could initially lead to significantly slower tooth movement in the initial days of the experimental procedure but would keep pace with the attained amount of movement in the non-treated Doxycycline-Orthodontic group.

Introduction

Root resorption has been regarded as a side effect of the cellular activity related with the removal of necrotic tissue in an over-compressed periodontal ligament (PDL).[1] This can begin in the early leveling stages of orthodontic management. It is evident in individuals where applied forces are strong and of extended duration, delivered to the tooth in unfavorable directions, or when the tooth is not capable to withstand normal forces due to a weakened periodontal support system.[2] Most studies agree that the root resorption process ceases once the active treatment is terminated.

Permanent teeth have the potential to clinically undergo significant external root resorption when affected by several stimuli. They may show microscopic amounts of root resorption that are clinically insignificant and radiographically undetected. This resorptive potential varies in persons and between different teeth in the same person. Tooth structure, alveolar bone structure at various locations, and types of movement may explain these variations. The magnitude of orthodontic force, duration and type of force can also influence the severity of root resorption. All types of tooth movement can cause root resorption.[3] The intrusion of teeth causes about four times more root resorption than extrusion.[4] It seems that intrusion is the most detrimental among the different types of tooth movement.

Several pharmacological agents have been examined on its modifying effect during root resorption such as L-thyroxine, bisphosphonates and Prednisolone, Prostaglandin E_2 and tetracyclines. Tetracyclines have been used for adjunctive treatment of periodontal disease. These are broad-spectrum antibiotics and their chemically adjusted analogues have been used, as well. Successive studies by Golub and co-workers, which describe anti-inflammatory properties of tetracyclines unrelated to their antimicrobial effect, were published.[5] Facts support that tetracyclines restrain metalloproteinases' action. Examples of metalloproteinases are collagenase and gelatinase, which can prevent collagenolysis. Collagenolysis is the digestion or dissolution of collagen. A very essential step in the pathogenesis of a variety of diseases such as periodontal disease, rheumatoid arthritis and osteoarthritis, is the destruction of collagen, which is the principal structural protein of the body's connective tissues.[6]

In the midst of several tetracyclines, Grevstad in 1993 and with Boe in 1995 have demonstrated that Doxycycline (DC) decreases the quantity of osteoclasts and inhibit root resorption and alveolar bone loss subsequent to mucoperiosteal flap surgery in rats. In clinical trials of Caton in 2000, there has been a substantial reduction of collagenase activity in the gingiva and the gingival crevicular fluid upon treatment with tetracycline and analogues including low-dose DC.[7] Furthermore, loss of attachment in adults with periodontitis has been prevented. Ciancio in 1998 found that the results of clinical trials in patients with adult periodontitis indicate that the adjunctive use of sub-antimicrobial dose doxycycline 20mg BID is an effective and well-tolerated regimen which can significantly improve several indices of periodontal health, in which there was an increase in clinical attachment levels, with decreased probing pocket depths and reduced bleeding on probing.[8] Published findings suggest that administration of tetracycline particularly Doxycycline might have an advantageous effect while orthodontic tooth movement is taking place. Treatment with this antibiotic reduces the amount of root resorption. The recommended dose of Doxycycline, when the drug is prescribed to combat infection, is 100mg or 50mg two times per day; the former regimen is prescribed for the first 24 hours as a loading dose and the latter is administered daily thereafter as the maintenance dose.[9] This dosage, however, has been reported to have untoward effects: gastrointestinal, photosensitivity, hepatic toxicity, and renal toxicity. Studies have already been published showing the beneficial effects when low-dose systemic administration of Doxycycline has been carried out in orthodontically induced molar root resorption in rats. No appraisal has been yet made on orthodontically induced resorption in incisors, as these are the teeth most affected by root resorption,[10] due to the extent of its movement caused by malocclusion, function, and esthetics. Their root structure and relationship to bone and periodontal membrane tend to transfer the forces chiefly to the apex.

The purpose of this study is to histologically quantify and evaluate the effects on the tissues involved in orthodontic tooth movement of incisors, emphasizing on root resorption, when systemic administration of low-dose semi-synthetic tetracycline, Doxycycline is performed. Its effects on the rate of tooth movement will also be determined.

Materials and Methods

Selection of animal subjects

The material comprised 24 male guinea pigs, 10-12 weeks old, weighing 410-680g. To evaluate the accuracy and precision of the appliance and pump placement, pretesting was conducted on 2 guinea pigs. The data from the two animals that were gathered in the pretesting were not included in the results of the study. Males were chosen to eliminate hormonal changes associated to the female reproductive cycle. Guinea pigs were selected mainly because their periodontal structures and incisors can be operated successfully by orthodontic mechanotherapy. The organization of their hard and soft tissues is similar in man except that guinea pigs' teeth erupt continuously. At 6 weeks of age, fusion of their interpremaxillary suture occurs, thereby, separation of the maxillary incisors takes place predominantly by orthodontic tooth movement. Thus, the risk of orthopedic separation between the two halves of the premaxilla is least likely to occur.

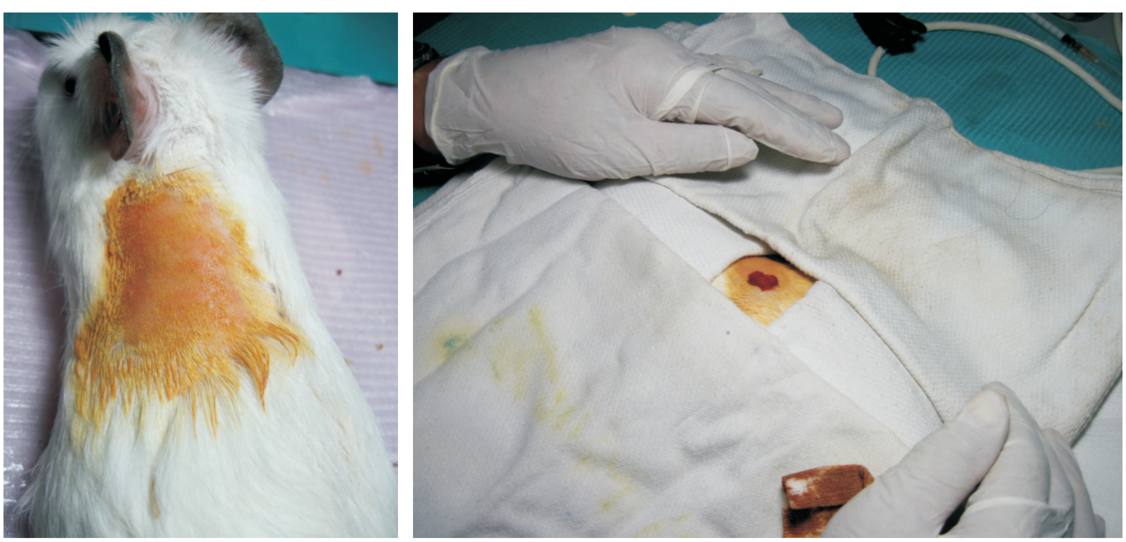

Figure 1. Surgically prepared back and aseptic technique to expose the surgical site

Drug Regimen

Animals scheduled for antibiotic treatment received 20mg/ml Doxycycline Hyclate by means of a mini-osmotic pump (Alzet® Mini-osmotic pump, Model 2002, Alza Corporation, Palo, Alto, California, USA) implanted subcutaneously on the back slightly posterior to the scapulae. Anesthesia was attained by means of intramuscular injections of Zoletil 50, 50-75mg/kg bodyweight. Animals in the doxy-ortho group had the mini-osmotic pump implanted at least 1 day before appliance insertion in order to establish a steady Doxycycline serum level by the time of force application. Doxycycline was released at a mean pumping rate of 0.5 (±0.1) µl/hour during the entire experimental period, which equals administration of 0.24 mg DC/day (1.2mg DC/kg bodyweight/day). Animal weight was daily monitored, from the day of appliance insertion and before death. The Institutional Animal Care and Use Committee (IACUC) approved the methodology with Protocol No. 2010-012.

Installation of the Mini-osmotic pump

To prepare the guinea pigs' back for surgical procedure, it was shaved using a disposable blade. All instruments and drapes used for the procedure were sterilized in an autoclave. Povidone Iodine solution was applied on the desired area. An incision using surgical blade #15 was made adjacent to the site chosen for the pump placement such as slightly posterior to the scapulae.

A hemostat was inserted into the incision and a tunnel was spread underneath the skin to create a pocket for the pump. The filled pump was then inserted, delivery port first. The incision was closed using suturing thread. The pump remained in place no longer than 1 and ½ times its operating duration. It was not reused.

Orthodontic appliance

The appliance used consists of a single 0.016" titanium molybdenum alloy wire (TMA, AVM Ormco) formed into a helical torsion spring with 4 turns of coil, 2mm in diameter, and arms 12mm in length.

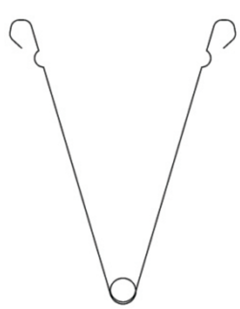

Figure 2. Diagram of the orthodontic appliance

The material possesses half the force and twice the working range of stainless steel. It is capable of delivering light and continuous expansile force. In fabricating the appliance, a vertical step was placed in one arm 1mm anterior to the coil, which allowed both arms to lie parallel. Horizontal V-bends were placed in the arms 12mm anterior to the coil to prevent labial displacement of the appliance. Horizontal bends 90° outward and 3mm anterior to the V-bends, which then was bent into a loop, served as a means for attaching the appliance to the entire width of the incisors up to its gingival third.

Measurement of Force

Prior to appliance insertion, the compression force exerted by each spring was determined with a measuring device (Tinius Olsen, Universal Testing Machine Low Capacity) from UP Diliman - Civil Engineering Construction Materials and Structures Laboratory. With both arms touching, the springs were capable of exerting a reciprocal lateral force of 50g or 0.110 pound. Arms when passive were 45º relative to each other and 12mm distant at their ends. The researcher fabricated all the springs.

Technique for positioning the appliance

Animals were intramuscularly anesthetized with 2mg/kg of Zoletil®, Tiletamine Hydrochloride (Virbac Laboratories). An undercut of about 0.5mm was placed between the maxillary incisors at the gingival papilla using low speed handpiece (Compact-8) and a #1 round carbide bur. The undercut served to

Figure 3. Actual orthodontic appliance using 0.16" titanium molybdenum alloy wire

allow the appliance to remain in place during the bonding procedure and to withstand occluso-gingival displacement. To prevent occlusal interference with the appliance, the incisal edges of the mandibular incisors were reduced using a fissure bur. Labial surfaces of the maxillary incisors were isolated and etched within 60 seconds using 37% phosphoric acid (J. Etch USA). A rubber module, in which a dental floss was inserted, served as a separator to create space between the two incisors. Then, a celluloid strip was placed in between to prevent distribution of bonding agent on unwanted areas and to ensure complete separation of the teeth. After applying the bonding agent (Right-On Dental Bond, Fildent, USA), drying the area with air using an air bulb and curing for 20 seconds (Fortress Light Cure Unit), the helical end of the spring was positioned passively against the palate.

Each loop of the arm was inserted through the interproximal contact, then made to retain in its position with light cured flowable composite (Bisco, AElite Flo, Low Modulus Microhybrid Composite, Schaumburg, USA), while the strip is still in place. Adhesive was applied until the labial and palatal wires were completely embedded in the bonding material, after which it was cured with light. Layers were added to compensate for the possible wear of adhesive due to the animals' continuous gnawing habit.

Recording Tooth Separation

No measurable space existed between the maxillary incisors before appliance placement. Measurements with a digital caliper

Figure 4. Appliance positioned passively against the palate

(Carrera Precision) with .01 graduations were recorded at the interproximal undercuts accurate to 0.01mm. Distance was recorded at 1, 3, 5, 7, 9, 11, 13 and 15 days after appliance activation. The same investigator performed all measurements. Appliance condition was checked every visit.

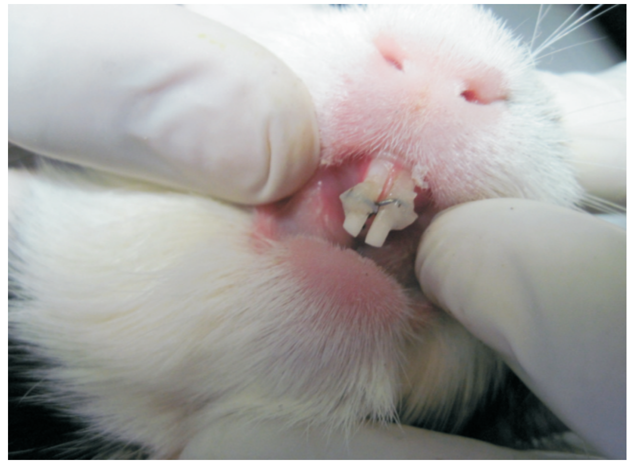

Figure 5. Appliance in place

Statistical Analysis

Non-Parametric tests (Mann Whitney and Kruskal Wallis) tests were used to test the significance between the groups.

Results

Animal subjects

A total of 24 guinea pigs was utilized in this study. There were 10 guinea pigs in the control group: five for the Non-Doxy control and five for the Doxy Control; while 12 animals comprised the experimental group: six for the Non-Doxy Ortho and another 6 animals for the Doxy Ortho group. Two guinea pigs were used separately for pre-testing of the mini-osmotic pump and appliance placement; and an observation period of 15 days was allowed.

In the Non-Doxy Control Group, all animals were included in the results of the study. For the Non-Doxy Ortho group, there were two guinea pigs whose appliance were detached at day 7, while another animal had dislodged appliance at day 11, reason for their exclusion from the results on the indicated day. For the Doxy Control group, only 1 guinea pig had its mini-osmotic pump removed at day 11. It was worthy to note that the pump of 2 animals in this group was intact and their skin showed no evidence of scar, On the other hand, wound was present in the surgical site of 2 other guinea pigs, while their pumps were left intact. Lastly, for the Doxy Ortho group, 1 animal had its appliance detached at day 5. The Doxycycline pumps of 2 guinea pigs remained intact until Day 5 and their surgically implanted pumps were out at day 7. The fabricated spring of 1 guinea pig was detached at day 11. Finally, the appliance attachment of 1 animal, which belonged to the same group, was removed at day 7, as well as its pump was out at day 13. Only 1 guinea pig had its pump and appliance intact until the end of the experimental period.

Nonparametric test (Kruskal-Wallis test) was used to determine whether or not significant differences occurred at different time intervals among the mean weight changes of the experimental and control groups. Post-anesthesia weight loss occurred in all groups except for the Non-Doxy control group, which gradually increased its weight. Among all the period of measurements done, there was a significant difference ($P>0.05$) in the mean weight change observed at day 5 ($P=0.010$) due to the transient loss in weight following anesthesia and appliance placement.

Figure 6 shows a graphical comparison of the mean tooth movement between the two groups. At day 1, the maxillary incisors of the Non-Doxy Ortho group had considerable distance compared to the Doxy Ortho group. It had an even increase of tooth separation from day 5 to day 9. A sudden increase of mean distance was noted at day 11, which steadily continued until day 15. Doxy Ortho group had dissimilar graphical pattern of mean tooth separation compared to the Non-Doxy Ortho group. The mean distance traveled by the maxillary incisors was significantly lower than the first group from day 5 to day 7. There was a minimal increase of active tooth movement from day 5 to 7 followed by an abrupt increase in mean amount of movement from day 7 to day 9. The measurement recorded at day 9 was significantly higher than the measurement demonstrated in Non-Doxy Ortho group. This increase was followed by a sharp decline of mean active tooth movement from day 9 to day 11. During the remaining days of observation period, there was a uniform increase of mean active tooth movement from day 11 to day 15. Mean amount of active tooth movement recorded at day 13 and day 15 was not statistically significant. At the end of the observation period, the mean distance quantified at day 15 was equal for both groups. There was no significant difference in the measurements obtained between the two groups.

Descriptive statistics of mean separation of teeth is illustrated in Table 1. Nonparametric test (Mann-Whitney test) was performed to determine whether or not statistically significant differences in rate of maxillary incisor separation occurred between measurement points of the two experimental groups. Prior to appliance

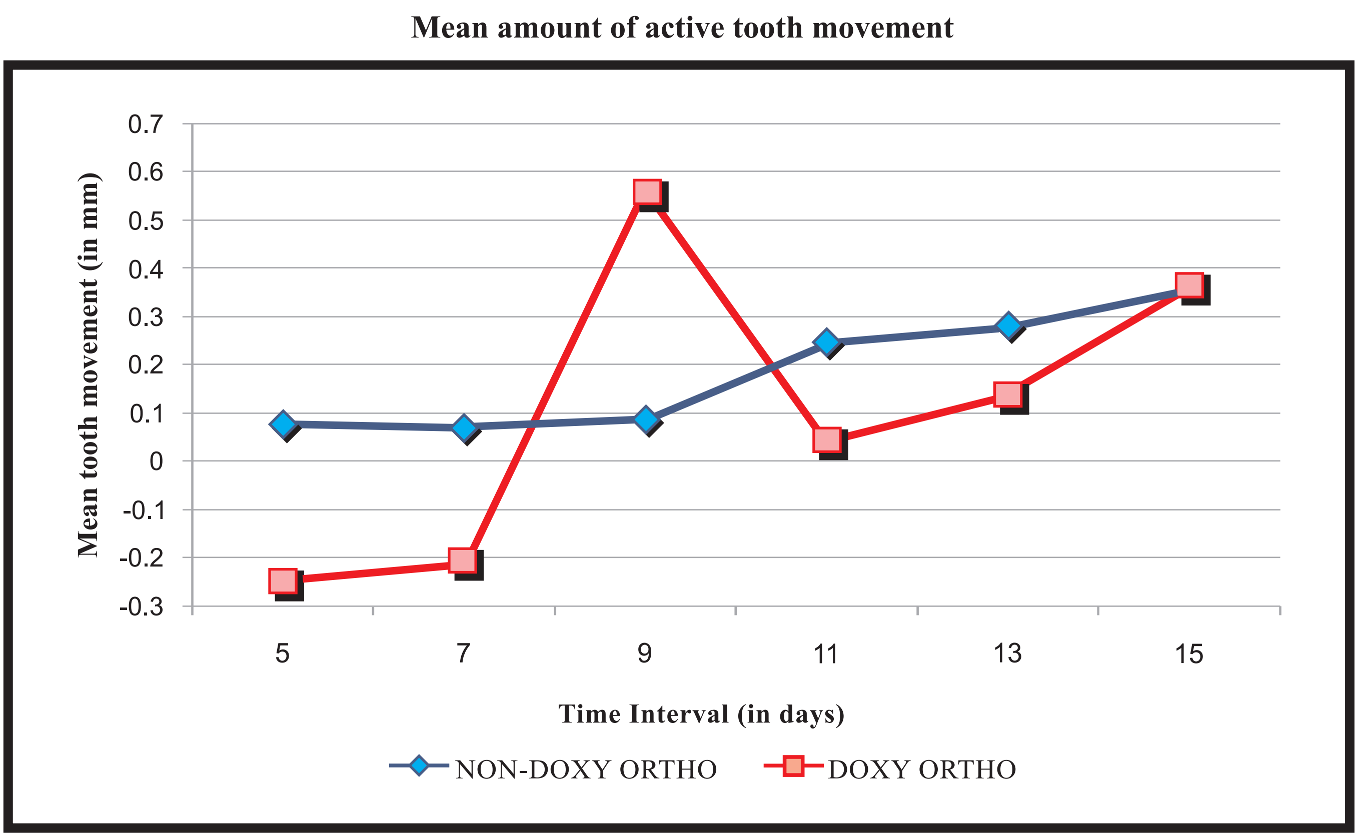

Figure 6. Mean amount of active tooth movement at each time period

Table 1. Comparison of mean separation between the experimental groups (mm)

Day	Non-Doxy Ortho		Doxy Ortho		P (Mann Whitney)
	Mean	±S.D.	Mean	±S.D.	
5	0.0787	0.03290	-0.2480	0.32775	0.000*
7	0.0700	0.02708	-0.2100	0.04243	0.000*
9	0.0850	0.07326	0.5600	0.04243	0.000*
11	0.2450	0.18806	0.0400	-	0.000*
13	0.2800	0.36428	0.1400	-	1.000
15	0.3567	0.45347	0.3600	-	1.000

* - significant difference
α= 0.05

placement (Day 0), no space was seen between the maxillary incisors and this was measured as the baseline value. All linear measurements were taken using a digital caliper (Carrera Precision) with 0.01mm graduation. The first measurement of tooth movement was done on Day 3 of appliance wear (Appendix F). From this value, the measurement recorded at Day 5 was subtracted from recorded reading at Day 3. The difference was the amount of tooth movement produced by the reciprocal force of the appliance. Separation from day 5 to day 7 was also documented. This procedure was repeated for the subsequent measurements of tooth movement, until the last day of observation period. The mean amount of active tooth movement at each time period for the Non-Doxy Ortho and Doxy Ortho groups was computed (Appendix G). The guinea pigs whose pump and appliance were dislodged within the required time were excluded. Results of the statistical analysis showed significant difference (α=0.05) at day 5, 7, 9 and 11(P = 0.000). There was no significant difference observed in the mean active tooth movement at day 13 and 15.

Histologic Examination

After an observation period of 15 days, animals were euthanatized intraperitoneally. Specimens, which included maxillary incisors and adjacent periodontal tissues from all the animals were excised, fixed in formalin, and demineralized. After devhydration in ascending concentrations of alcohol, the specimens were embedded in wax with the longitudinal axis of the teeth oriented parallel with the plane of section. Serial mesio-distal sections in the vertical plane were cut at 6µm and stained with hematoxylin and eosin. Serial sections of maxillary incisors were examined for the presence or absence of osteoclasts and odontoclasts on the areas of interest. The histologic examination was performed without the pathologist and investigator knowing which slides corresponded to which treatment group. The limitation of the present study was the quantity of slides optimal for interpretation. Non-parametric test (Kruskal-Wallis test) was utilized to determine if there were significant differences in the quantity of osteoclasts obtained among the 4 groups (α= 0.05). It showed that there was no significant difference (P = 0.166). For the analysis of the quantity of odontoclasts, non-parametric test (Kruskal-Wallis test) was also employed to determine if there were significant differences in the mean number obtained between the groups. However, the parameters were not satisfied since only a number of sections showed that odontoclasts were present.

Discussion

Changes in weight

In this study, it was observed that all groups did not show slight reduction in spontaneous activity during the observation period, no diarrhea; no abnormal defecation or vomiting was noted. Furthermore, their weight loss was regained after a number of days from pump implantation, making it proper to say that they did not experience stress in the course of the treatment. Observations of Mavragani et al[11] whose purpose was to investigate the effect of systemic administration of low-dose doxycycline on orthodontic root resorption, were the same and they noted that the orthodontic appliance and the implanted mini-osmotic pump were tolerated well.

Tooth separation

In this study, male guinea pigs that were systemically administered with a low dose (0.5 [±0.1] µl/hour or 0.24mg DC/day or 1.2mg DC/kg bodyweight/day, for fifteen days) of Doxycycline, a member of the tetracycline antibiotics commonly used to treat a variety of infections such as respiratory tract, ENT, GUT, skin and soft tissue, a day before orthodontic appliance wear, demonstrated decreased rates of tooth movement during the first seven days of active tooth movement as compared to the male guinea pigs subjects which were not treated with Doxycycline (Non-Doxy Control). This finding of inhibition of tooth movement due to the influence of chemically modified tetracycline (CMTs), which lacked antimicrobial activity but retained anti-MMP activity, is similar to the study of Bildt, *et. al.* in 2007 where eighteen Wistar rats received a standardized orthodontic appliance at one side of the maxilla.[12] During 14 days, three groups of six rats received a daily dose of 0, 6 or 30 mg/kg CMT-3 orally and tooth displacement was measured. They concluded that CMT-3 inhibits tooth movement in the rat, probably by the reduction of the number of osteoclasts at the compression side, made possible by inducing apoptosis in activated osteoclasts or reduced osteoclast migration. Reduction of MMP activity by CMT-3 may also have contributed to directly inhibit degradation of the organic bone matrix. In the study of Bildt, tooth displacement at day 7 of tetracycline treated rats has significantly exceeded the mean distance obtained by the control group. In contrast to the present study, mean amount of movement in the Doxy-Ortho group significantly surpassed the non-treated ortho animals at day 9 which was then reversed at day 11, causing the non doxy group to again exhibit increased amount of tooth separation until day 13, similar to Bildt's observations, which later on, measurements were found to be equal in both groups. However, at the end of the experimental period, non-treated Wistar rats in his protocol, exhibited the highest amount of tooth displacement. The dissimilarity is that in the ongoing research, after 15 days, only 1 guinea pig, with both appliance and pump intact, was left for measurement, the probable reason for the mean amount of movement to be the same in both groups.

There may be another explanation to this occurrence. Clark concluded that a therapeutic effect was reached by administration to a period of 10 days postsurgically, wherein it coincides with the peaks of appearance of inflammatory cells in wound repair following surgery. This may account for the increased amount of mean tooth movement within 1 week. In addition, Linge[13] suggested that an extracellular accumulation of cell bodies from disintegrating cells in the collagen fibre network undergoing forced reorientation, may cause stimulation of resorptive activity. When cells are stimulated, it produce factors, which mediate tissue damage such as osteoclast activity. All types of cells contributing to hard tissue degradation are present in the wound, including odontoclasts, osteoclasts, and mononuclear cells. Brudvik emphasized that these cells have a certain life span. After a certain period of time, the resorptive potential subsides. This may clarify the significant decrease of the mean amount of tooth movement after reaching its peak. Brudvik further speculated on how the process of root resorption is enhanced. This is affected by the main mass of necrotic tissue compressed between the tooth and bone. Andreasen[14] on the other hand, assumed that cementum-resorbing cells require prior activation or continual triggering by such factors as infection, bacterial products, inflammation and necrotic debris and this seems to be present in the periodontal ligament. If the area of root surface was damaged, it will be resorbed if active force is continued for a sufficiently long period. This may also mean that if in clinical treatment, force is reactivated during active root resorption, the process will continue. If the appliance is removed allowing the tooth to relapse back, root resorption will stop. This may explain for the decreased amount of mean tooth movement in the guinea pigs of the present study, whose appliances were detached in the course of the observation period. In Brudvik's experiment, active force ended, but passive stress of the PDL remained through retention of the obtained tooth movement, then root resorption continued as long as there is presence of necrotic tissue close to the resorption site. In clinical application, force is reactivated while necrotic tissue persists near the resorption site, then root resorption is likely to continue.

Mini Osmotic Pump Drug Administration

To verify that experimental results are derived from continuous administration of the drug solution, DURECT Corporation recommended that ALZET pump users verify the blood levels of drug at several points during the course of infusion. If it is not possible to determine the circulating blood levels or if it is not technically desirable, there are several alternative techniques suggested that will verify the accuracy of mini-osmotic pumps, and will ascertain if they deliver correctly.

The reservoir volume of ALZET mini-osmotic pump is slightly larger than that required assuring pumping for the complete 15 days. As a result, at the end of the pumping duration, some of the drug solution will remain in the pump. This solution can be aspirated from the pump using the blunt-tipped filling tube and a 1.0ml syringe. Flushing the reservoir with additional solvent can do enhancement of the recovery of the drug solution. The active agent in the solution, which was recovered from the reservoir, can then be assayed using an appropriate technique.

At the end of the experimental period in the present study, the pumps were removed from the surgical site after they had an overdose of anesthetic. The drug contained in each pump was aspirated using a 1ml syringe (Terumo).

Figure 7. Remaining drug inside the pump was aspirated

The following enumerates the amount aspirated on each guinea pig's pump:

Doxy Control: Guinea pig # 1.3-0.17ml of Doxycycline was left, # 2.1-0.1ml, # 2.3-0.18ml, # 2.4-0.1ml, and for # 3.1-0.15ml. On the other hand, for the Doxy Ortho group, for animal # 1.2-0.17ml of the drug was aspirated, # 2.2-0.12ml, # 3.4-0.15ml, # 4.1-0.18ml, # 4.2-0.13ml, and for the experimental animal # 4.3-0.18ml was measured.

The data above showed that the drug was systemically administered. Performing blood assay in the present study was not carried out because the performance of Mini-osmotic pumps to deliver substances was already established in existing literature.[15,16]

Orthodontic appliance

Those animals whose appliances were detached during the observation period were excluded in the computation of the mean amount of tooth movement at a given time period. Significant difference was found in the obtained tooth separation until day 11. From day 13 to day 15, no statistically significant difference was established in the mean amount of incisor movement. A small number of guinea pigs whose pumps and appliance were left intact in both Ortho groups could have contributed to the trivial statistical variance.

Bildt's findings also showed a reduction in the number of osteoclasts at the compression side of treated rats. The study of Holliday and colleagues[17] in 2003 showed that in the presence of an MMP inhibitor (Ilomastat), tooth movement, by means of a nickel titanium closed coil spring, at day 10 was significantly inhibited. During the early days of observation, at day 3, tooth movement kinetics was significantly lower in the control group compared to the tetracycline-treated male Sprague-Dawley rats. Measurements changed at day 7, in which control group had substantially progressed compared to the 30mg/kg CMT-treated rats, leaving 6 mg/kg CMT treated rats with the highest tooth displacement in that time period. Similarly, in the present study, mean tooth movement in the treated guinea pigs was significantly higher at day 9, which declined at day 11, allowing the non-antibiotic treated group to once again possess increased separation at day 11 onwards, except for day 15 where equal measurements were observed. This again may be attributed to a reduced number of subjects due to dropouts. In Bildt's rats, tooth displacement in control and CMT-treated animals (6mg/kg CMT) became equivalent at day 9, and later on the control group had the highest displacement, leaving both (6mg/kg CMT and 30 mg/kg CMT) CMT-treated groups' mean amount of tooth separation significantly lower. According to Holliday, their findings showed that blocking matrix metalloproteinases disrupted osteoclastic bone resorption in cultures simulated with calcitrol, PTH or bFGF. Others have proposed several inhibitory effects of CMTs on osteoclasts. Particularly in vivo and in vitro studies suggest that CMTs inhibit the differentiation of osteoclasts from their precursors or stimulate osteoclast apoptosis.[18,19] Since CMT-3 had no effect on the number of osteoclasts at the control roots of Bildt's study, an inhibitory effect on differentiation is more likely than a stimulation of osteoclast apoptosis. However, the number of ED-1 positive cells in the PDL was not affected by CMT-3. This suggests that CMT-3 has only an inhibitory effect on active osteoclasts, and not on osteoclast recruitment. It might only have stimulated apoptosis in activated osteoclasts, which explained its lower number in Bildt's treated rats. He further explained in another way, the number of ED-1 positive multinuclear cells in the PDL (ED-1mouse-anti-rat monoclonal antibody used for immunohistochemistry) was decreased, but it was compensated by osteoclasts detached from the bone. Moreover, Rifkin showed that tetracycline reduced the number of podosomes in osteoclasts, which suggests that the adhesion of osteoclasts to the bone was impaired. Podosomes are ring-like projections, which mediate cell-extracellular matrix interactions, and are essential for invasion and metastasis. These are active structures formed by cell types of monocytic origin, such as macrophages, dendritic cells and osteoclasts. It is safe to say that tetracyclines decreased the capacity of the osteoclasts to invade and metastasize.

Root and bone resorption

The frequency of root resorption cavities and extent of bone loss subsequent to periodontal surgery was investigated by Grevstad in albino rats.[20] Preventive effect on root resorption and bone loss, that was associated with flap operations involving exposure of periodontal ligament and bone, was exhibited following systemic doxycycline administration of 0.5mg/ml Doxylin during the 10 days post surgery. After a healing period of 3 weeks, animals were euthanatized and serial sections of first molars were examined for the presence or absence of cervical resorption cavities on palatal root. Resorption lacunae coronally located to bone crest were absent in both untreated and gingivectomized animals. In flap-operated group, all specimens contained at least one resorption cavity on the palatal root facing gingiva. Only one of 10 specimens which underwent surgery and doxycycline adminstration showed evidence of cervical resorption. This was in contrast to the findings in the present study, where even in the Non-doxy treated animals, a mean number of osteoclasts revealed an amount of 1.2, while the Doxy ortho group possessed the highest mean number, which were both not statistically significant with the other two groups. This may be attributed to unequal number of decipherable slides produced during tissue processing. Grevstad pointed out a potential concern regarding the duration of post-surgical administration of antibiotics, specifically doxycycline. It can be deduced that a therapeutic effect was reached by administration confined to a period of 10 days postsurgically. This time period was considered to be appropriate, as it coincides with the peaks of appearance of inflammatory cells in wound repair following surgery.[21,22] These cells when stimulated, apparently produce factors which mediate tissue damage such as osteoclast activity. Already within 1 week, all types of cells contributing to hard tissue degradation are present in the wound, including odontoclasts, osteoclasts, and mononuclear cells. This may give explanation for the changes observed in the present study at day 9, where mean amount of tooth movement was seen to be at its peak then declined at day 11. As stated 10 days post surgery, inflammatory cells would reach its peak of appearance for repair. On the 10th day, Doxycycline with its non-antimicrobial property inhibited the action of MMPs by mediating bone resorption, thus demonstrated decreased mean amount of tooth movement. Both studies similarly have shown that systemic doxycycline prevents bone loss.

Linge remarked that a time factor is involved in root resorption. It usually does not start immediately, but once started, it remains active as long as treatment influences are continued. In the present study, those guinea pigs whose appliance was still in place until the last day of observation period signifies resorptive process still occurred because the treatment influences were maintained. Mavragani mentioned that superficial root resorption might be considered part of the mechanism of repair when the PDL is damaged, either as a consequence of periodontal disease and its treatment or during orthodontic tooth movement. Reitan observed that root resorption increases with the duration of the experiment and that it occurs in all experiments of 25 days duration.

Mean values of osteoclasts and odontoclasts were analyzed by the non-parametric Mann-Whitney test. A p value of less than 0.05 was considered significant. The majority of specimens viewed for experimental group failed to exhibit any detectable odontoclasts. Overall, it was impossible to do any reliable analysis on the quantity of these cells secondary to the systemic administration of Doxycycline antibiotic.

For technical reasons, the number of sections planned for quantification of resorptive cells was low. A higher number of specimens would be more appropriate for statistical evaluation. However, the significant movement exhibited from day 5 to day 11, wherein Non-Doxy treated Ortho group had higher mean amount of active tooth movement from day 5 to day 7, suggests the potential inhibiting role of Doxycycline in initially decelerating tooth movement in the early stages of orthodontic treatment. In an article by Apajalahti, it was stated that since there is a delay in the occurrence of bony response after force application, the elevated pattern of MMP-1 activity in GCF might be apparent only at the later stage of orthodontic tooth movement. This may explain for the significantly decreased mean amount of active tooth movement in the Doxy treated group, due to the MMP inhibiting role of Tetracycline, which help mediate bone resorption. As days progressed, at day 9, the mean distance between the incisors of Doxycycline-treated animals considerably exceeded the amount of movement attained by the first group, which then declined at day 11, allowing Non-doxy group to carry out statistically significant higher mean amount of tooth separation. In the remaining days of observation, from day 13 to day 15, Non-Doxy Ortho group remained to have an increased mean amount of incisor distance, but did not demonstrate significant difference.

Conclusions

Under the conditions of this experiment, animals treated with low dose Doxycycline exhibited a significant decrease in the mean amount of active tooth movement, which suggests the potential inhibiting role of Doxycycline in mediating bone resorption. It was confirmed in this study that this could initially lead to significantly slower tooth movement in the initial days of the experimental procedure but would keep pace with the attained amount of movement in the non-treated Doxycycline-Orthodontic group. Further studies are still needed to confirm this outcome.

No conclusions can be made with regard to the comparison of the number of osteoclasts and odontoclasts between the Doxy Ortho and Non-Doxy Ortho groups due to low number of optimally prepared sections.

Among all the period of measurements done, there was a significant difference in the mean weight change observed at day 5 due to the transient loss in weight following anesthesia and appliance placement.

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Cephalometric Floating Norms as a Guide towards a Harmonious Individual Craniofacial Pattern among Filipinos

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Objective: *To construct a harmony box based on correlated cephalometric variables, which may serve as a valuable diagnostic tool in orthodontic treatment planning, by analyzing the harmonious relationship of existing individual craniofacial pattern among Filipinos.*
Materials and Methods: *81 subjects, 37 females and 44 males were selected from the student population of a University according to established inclusion criteria. Five cephalometric angular measurements were obtained and digitized. Pearson correlation coefficients described the high association among the five variables. The bivariate linear regression analysis was used to construct a harmony box, which contain the cephalometric floating norms of the five correlated variables. Multiple regression analysis and the standard error of the estimate were calculated to construct the harmony schema, which describe the individual craniofacial pattern.*
Results: *Correlations between the five variables were significant at 0.001 and 0.05 levels. Linear regression equations with corresponding r^2 and standard error of the estimate (SE) were illustrated as the harmony box. The multiple correlation coefficients R, the adjusted R^2, and the standard error of the estimate when predicting one of the five measured variables from the remaining four by means of a multiple regression analysis were displayed as the harmony schema.*
Conclusion*: The cephalometric floating norms describing the individual craniofacial pattern among Filipinos were established based on five correlated variables in the form of a harmony box.*

Preface

The concept of "craniofacial pattern" is described by significant correlations between the vertical and sagittal skeletal parameters. This implies that even though all the cephalometric values of a patient lie beyond one standard deviation from the population mean, they may still be considered acceptable if they maintain certain relationships with each other. Thus, the term "floating norms" is used to describe the individual norms that vary (float) in accordance with the variations of correlated cephalometric measurements. This study aims to provide the floating norms for Filipino adult.

Introduction

After Broadbent[1] and Hofrath[2] simultaneously published methods to obtain standardized head radiographs in 1931, numerous cephalometric analyses dealing with standardized norms have been developed. These norms were derived from an untreated sample of subjects from the same ethnic group, who were selected from a population with the so-called "ideal" or "well-balanced" faces with normal occlusion.[3-33] For several years, these methods provided useful guidelines in orthodontic diagnosis and treatment planning.

Solow[34] stated that a major drawback of these conventional cephalometric analyses was the use of isolated craniofacial parameters, without taking into account their possible interdependence. Accordingly, he demonstrated significant correlations among sagittal and vertical cephalometric variables, leading to the concept of "craniofacial pattern". This implies that even though all the cephalometric values of a patient lie beyond one standard deviation from the population mean, they may still be considered acceptable if they maintain a certain correlation with each other. Hasund et al.[35] made the first effort to describe combinations of acceptable values for different facial types. Finally, a comprehensive analysis for the assessment of individual craniofacial pattern was performed by Segner[36] and by Segner and Hasund[37], who constructed floating norms for the description of sagittal and vertical skeletal relationships in a sample of European adults.[38] Thus, the term "floating norms" was used to describe the individual norms that float in accordance with the variation of correlated cephalometric measurements. The five basic cephalometric measurements (SNA, NL-NSL, NSBa, ML-NSL, SNB) which were found to show evidence of correlations with each other, were SNA, representing maxillary prognathism, SNB, representing mandibular prognathism, NL-NSL, representing maxillary inclination, ML-NSL, representing mandibular inclination, and NSBa, representing the cranial base angle. The intermaxillary angle (ML-NL) was calculated as the difference between ML-NSL and NL-NSL (Figure 1).[36] It should be noted that the sella-nasion line was shared by all the measurements, thus enhancing the power of mathematical correlation among the five variables.[34] After showing evidence of statistical correlation with one another, the linear regression with the corresponding r^2 and the standard error of the estimate were computed and illustrated in a graphical box-like form called correlation box or harmony box (Figure 2).

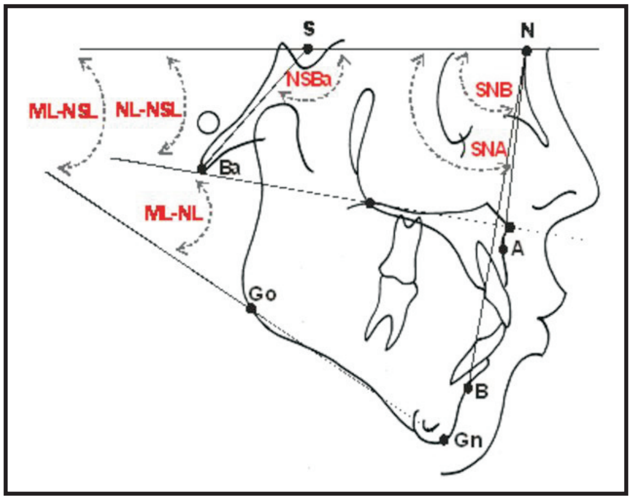

Figure 1. Cephalometric landmarks and correlated angular measurements

The harmony box

The harmony box was constructed by Segner[36] and by Segner and Hasund[37] and was patterned primarily after the Bergen cephalometric analysis established by Hasund et al.[35] It was regarded as the first stage of the floating norms for describing individual skeletal characteristics. The accepted norms of Björk[39] was used and floating norms were developed for commonly used sagittal and vertical measurements, which were represented in the Bergen box.[40]

At present, the improved Segner-Hasund[41] harmony box is widely used as a valuable adjunct in orthodontic diagnosis and treatment planning. It is a method describing the individual skeletal pattern by illustrating the sagittal and vertical skeletal relationships using floating norms. It also reveals the facial type of a patient, and determines whether the face is harmonious or disharmonious. It is divided into three zones, the retrognathic, orthognathic and prognathic zone depending on the ANB value of the subject. A horizontal line connecting the values of the five cephalometric variables inside the box represents the harmony line of the subject. A straight horizontal line suggests that the face is harmonious and the facial type is determined according to the zone where the cephalometric values of the subject fall. For every horizontal harmony line, a range of accepted variability is allowed, which is derived from the standard error of the estimate of the multiple regression analysis and represented by the harmony schema (Figure 3). The line in the middle of the schema represents the mean values of the five correlated cephalometric variables. It can be shifted upon the harmony box to include all the five cephalometric variables of the subject. A subject whose cephalometric values lie inside the schema displays a harmonious skeletal pattern. However, any value which lies outside the schema is the parameter causing the disharmony to the face. Thus, the face is disharmonious.

SNA	NL-NSL	NSBa	ML-NSL	SNB	ML-NL
62	14	141	43	64	28
63	●	140	42	65	●
64	13	139	41	66	27
65	●	138	40	67	●
66	12	137	39	68	26
67	●	136	38	69	●
68	11	135	37	70	25
69	●	134	36	71	●
70	10	133	35	72	24
71	●	132	34	73	●
72	9	131	33	74	23
73	●	130	32	75	●
74	8	129	31	76	22
75	●	128	30	77	●
76	7	127	29	78	21
77	●	126	28	79	●
78	6	125	27	80	20
79	●	124	26	81	●
80	5	123	25	82	19
81	●	122	24	83	●
82	4	121	23	84	18
83	●		22	85	●
84	3		21	86	17
85	●		20	87	●
86	2		19	88	16
87	●		18	89	●
88	1		17	90	15
89			16	91	●
90			15	92	14
91			14	93	●
92				94	13
93				95	●
94				96	
95				97	
96					
97					
98					
99					
100					
101					
102					
103					

Zones (top to bottom): Retrognath, Orthognath, Prognath

Figure 2. Segner-Hasund harmony box

A number of studies were written about floating norms. Aside from the study of Segner[36] which established floating norms for central Europeans, Franchi, Baccetti and McNamara[38] established floating norms for North American adults. Tollaro et al[42] provided floating norms for the evaluation of individual skeletal patterns in subjects with full deciduous dentition. Lavergne and Gasson[43] presented a cephalometric classification of facial patterns for younger subjects using floating norms. Ngarmprasertchai[44] and Mahaini[45] constructed floating norms for Thais and Syrians respectively.

The present study aims to establish floating norms for the description of individual craniofacial pattern among Filipinos.

MATERIALS AND METHODS

Samples

The study was based on 81 subjects, 37 females and 44 males, who were selected from the student population of a University. All subjects were Filipinos with an average age of 18 years (S.D. = 4.17), with Angle Class 1 occlusion without crowding or spacing, no previous history of orthodontic treatment and displayed good facial esthetics. Approval from the ethics committee was sought before the interview, clinical examination and the taking of the cephalograms were conducted.

The lateral cephalogram of each subject was taken using one X-ray machine (Panoura, Yoshida Co. Ltd) and by one technician.

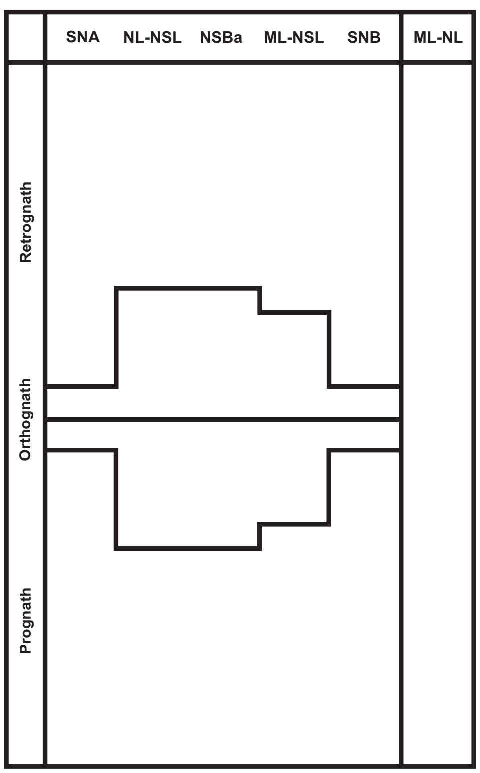

Figure 3. Segner-Hasund harmony schema

The cephalometric film of each subject was traced by one investigator. The landmarks were identified and the five cephalometric angular measurements were obtained and digitized with the aid of a computer program, DiagnoseFix (Dr. Jörg Wingberg, Diagnostik Wingberg GmbH, Buxtehude, Germany). The error of the method was determined by re-tracing and re-measuring the films generating an average error of less than 0.3 degrees.

Statistical analysis

Descriptive statistics (mean, standard deviation, range) was calculated for the five cephalometric variables. Pearson correlation coefficients described the high association among the variables used in constructing the harmony box. The bivariate linear regression analysis was used to construct the harmony box. Multiple regression analysis, particularly the standard error of the estimate, was calculated to construct the harmony schema. All data analyses were performed using the SPSS program for Windows, version 11.5 (SPSS Inc, Chicago Ill).

RESULTS

The means, standard deviations and ranges for the five cephalometric variables are presented in Table 1. The resulting correlation coefficients are shown in Table 2. All correlations

Table 1. Descriptive statistics (n=81)

Variables	Mean	SD	Min	Max
SNA	83.34	3.30	74.0	90.7
NL-NSL	9.44	2.98	3.1	19.2
NSBa	130.65	4.87	120.4	140.5
ML-NSL	33.43	4.79	20.5	42.6
SNB	79.87	2.79	71.8	86.6

Table 2. Linear correlation coefficients (r) between SNA, NL-NSL, NSBa, ML-NSL and SNB of Filipinos (n=81)

Variables	NL-NSL	NSBa	ML-NSL	SNB
SNA	-0.34*	-0.42**	-0.26*	0.80**
NL-NSL		0.55**	0.30	-0.46**
NSBa			0.23	-0.45**
ML-NSL				-0.55**

**P<0.001, *P<0.05

between the five variables were significant at the 0.001 and 0.05 levels. Linear regression equations with corresponding r^2 and standard error of the estimate (SE) are reported in Table 3 and illustrated in Figure 4 as the harmony box with floating norms. The multiple correlation coefficients R, the adjusted R^2, and the standard error of the estimate when predicting one of the five measured variables from the remaining four by means of a multiple regression analysis are displayed in Table 4 and illustrated in Figure 5 as the harmony schema.

DISCUSSION

Facial Type

Broadbent and Enlow[46] and Nanda and Ghosh[47] stated that although cephalometric norms for each race and ethnic group have been established, individual variation still exist. An isolated measured angle or line should not be considered, but rather, should be described in relation to the background of the individual's facial type.[48]

The present study provides floating norms in the form of a harmony box and schema to describe the individual craniofacial pattern among Filipinos. Unlike the conventional cephalometric

Table 3. Linear regressions with corresponding r^2 and standard error of the estimate (SE) of Filipinos (n=81)

Variables	Regression equations	R2	SE
NL-NSL	= -0.31 SNA + 35.4	0.11	2.82
NSBa	= -0.61 SNA + 181.63	0.16	4.46
ML-NSL	= -0.37 SNA + 64.23	0.53	4.66
SNB	= 0.67 SNA + 23.74	0.63	1.69
SNA	= -0.28 SNA + 120.13	0.16	3.02
SNB	= -0.26 NSBa + 113.40	0.19	2.51
ML-NSL	= -0.95 NSBa + 109.28	0.30	4.01

Table 4. Standard errors of the estimate when predicting one of the variables SNA, NL-NSL, NSBa, ML-NSL and SNB from the other four by means of a multiple regression analysis of Filipinos (n=81)

Variables	*R*	*R^2*	*S.E.*
SNA	*0.83*	*0.68*	*1.88*
NL-NSL	*0.61*	*0.34*	*2.43*
NSBa	*0.60*	*0.33*	*3.97*
ML-NSL	*0.64*	*0.37*	*3.80*
SNB	*0.88*	*0.77*	*1.34*

	SNA	NL-NSL	NSBa	ML-NSL	SNB	ML-NL
	64	15.3	142.6	40.6	66.6	25.1
	65	14.9	142.0	40.2	67.3	25.1
	66	14.6	141.4	39.8	68.0	25.0
	67	14.3	140.8	39.4	68.6	24.9
	68	14.0	140.2	39.1	69.3	24.9
	69	13.7	139.5	38.7	70.0	24.8
	70	13.4	138.9	38.3	70.6	24.8
	71	13.1	138.3	38.0	71.3	24.7
Retrognathic	72	12.8	137.7	37.6	72.0	24.6
	73	12.5	137.1	37.2	72.7	24.6
	74	12.2	136.5	36.9	73.3	24.5
	75	11.8	135.9	36.5	74.0	24.5
	76	11.5	135.3	36.1	74.7	24.4
	77	11.2	134.7	35.7	75.3	24.3
	78	10.9	134.1	35.4	76.0	24.3
	79	10.6	133.4	35.0	76.7	24.2
	80	10.3	132.8	34.6	77.3	24.2
	81	10.0	132.2	34.3	78.0	24.1
	82	9.7	131.6	33.9	78.7	24.0
Orthognathic	83	9.4	131.0	33.5	79.4	24.0
	84	9.1	130.4	33.2	80.0	23.9
	85	8.7	129.8	32.8	80.7	23.9
	86	8.4	129.2	32.4	81.4	23.8
	87	8.1	128.6	32.0	82.0	23.7
	88	7.8	128.0	31.7	82.7	23.7
	89	7.5	127.3	31.3	83.4	23.6
	90	7.2	126.7	30.9	84.0	23.6
	91	6.9	126.1	30.6	84.7	23.5
	92	6.6	125.5	30.2	85.4	23.4
	93	6.3	124.9	29.8	86.1	23.4
Prognathic	94	6.0	124.3	29.5	86.7	23.3
	95	5.6	123.7	29.1	87.4	23.3
	96	5.3	123.1	28.7	88.1	23.2
	97	5.0	122.5	28.3	88.7	23.1
	98	4.7	121.9	28.0	89.4	23.1
	99	4.4	121.2	27.6	90.1	23.0
	100	4.1	120.6	27.2	90.7	23.0
	101	3.8	120.0	26.9	91.4	22.9
	102	3.5	119.4	26.5	92.1	22.8
	103		118.8	26.1	92.8	

Figure 4. The Filipino harmony box

analyses in which the cephalometric values of a subject are compared with established population norms specific for an ethnic group, cephalometric evaluation by means of floating norms are based on correlation patterns among the five measured variables. This means that as long as the sagittal (SNA, SNB) and vertical (NL-NSL, MN-NSL) cephalometric measurements of an individual exhibit correlation with one another, the skeletal pattern is considered acceptable.

Table 1 presents the mean sagittal and vertical cephalometric measurements for Filipinos. Statistical correlation among these variables was revealed in Table 2. SNA and SNB displayed the highest correlation at 0.001 levels, while ML-NSL exhibited lesser correlation with the other parameters at 0.05 levels. Table 3 illustrated the linear regressions which were used to construct the harmony box displayed in Figure 4. The three zones describing the facial types were based on the ANB values, obtained as the difference between SNA and SNB.

In the upper zone of the harmony box, the SNA and SNB values are below the mean values given in Table 1, with a corresponding ANB value of 0-4 degrees. Here, the facial type is described as retrognathic. In the middle zone, the SNA and SNB values agree with the mean values in Table 1, with an ANB value of 2-6 degrees. Here, the facial type is described as orthognathic. In the lower zone, the SNA and SNB values are above the established mean values, with an ANB value of 4-8 degrees. Hence, the facial type is prognathic.

Vertically, the facial type is determined by the degree of inclination of the mandible (ML-NSL) in relation to the anterior cranial base. Thus, an individual may be characterized as having an obtuse (skeletal open bite), normal, or acute (skeletal deep bite) skeletal pattern. In Figure 4, the retrognathic zone displays greater values of ML-NSL, NL-NSL and NSBa, while in the prognathic zone, the ML-NSL, NL-NSL and NSBa values are decreased. Generally, the greater the cranial base angle, the more retrognathic the face becomes and the smaller the cranial base angle, the more prognathic the face becomes. These have been confirmed in the present study.

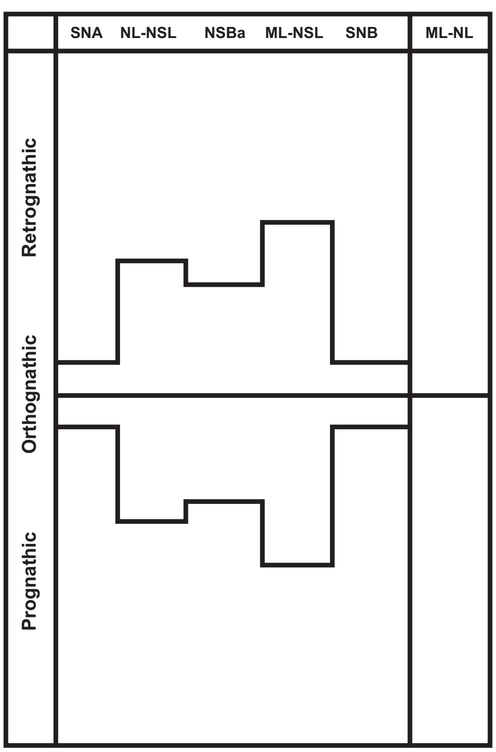

Figure 5. The Filipino harmony schema

The harmony concept

Di Paolo et al[49] emphasized that a cephalometric analysis should not only detect, but locate the area of the skeletal dysplasia. The harmony box is an adjunctive tool to detect and locate the skeletal dysplasia in the craniofacial complex. Furthermore, it should determine whether the combination of the five correlated cephalometric variables inside the harmony box are harmonious. The harmony schema shown in Figure 5 is constructed by computing the standard error of the estimate when predicting one of the cephalometric variables from the other four by multiple regression analysis shown in Table 4. It represents the degree of variability allowed among the five correlated cephalometric measurements to describe a harmonious face. It could be shifted on the different zones of the harmony box to include all the five cephalometric variables of a subject. A subject whose cephalometric values fall inside the harmony schema is said to display a harmonious skeletal pattern. A harmonious combination from a correlation point of view would not necessarily require the values to lie on a perfectly straight horizontal line.[36] Hence, a subject may be described as retrognathic and harmonious, orthognathic and harmonious, and prognathic and harmonious. Figure 6 shows an example of harmonious combinations represented in the orthognathic zone. All the values of the patient lie inside the schema, thus the patient is described as orthognathic and harmonious.

On the other hand, a disharmonious combination may be presented. While the SNA and the vertical values fit into the schema, the value SNB may not. In this case, the problem is sagittal and the mandible (SNB) is the jaw at fault. To determine the individualized ANB, a horizontal line from the value SNA to the SNB column is followed, and the difference is computed. In a growing patient, functional jaw orthopedics may be employed by prescribing the use of bionator to advance and rotate the mandible posteriorly. In an adult patient, orthognathic surgery will correct the facial disharmony. The harmony schema of the Filipinos (Figure 5) is comparable to the Segner-Hasund harmony schema (Figure 3) in four parameters namely, SNA, NL-NSL, NSBa and SNB. Yet, the ML-NSL angle among Filipinos showed a greater degree of variability.

Comparison of the Filipino harmony box and schema with the Thais and Syrians

The mean cephalometric values of the five correlated variables among the Thais and Syrians were plotted on the Filipino harmony box and schema (Figure 7). The Syrians corresponded to the orthognathic zone and all the variables lie inside the schema as it is moved slightly upward. This means that the craniofacial morphology of the Filipinos and Syrians is largely similar. Most of the Thai variables lie in the orthognathic zone, with the exception of the ML-NSL angle, which lies outside the schema on the prognathic zone. This means that the Thais show a more anterior rotation of the mandible. Thus, they exhibit a shorter vertical facial height compared to the Filipinos and Syrians.

CONCLUSION

The cephalometric floating norms for the description of the individual craniofacial pattern among Filipinos are established based on five correlated variables.

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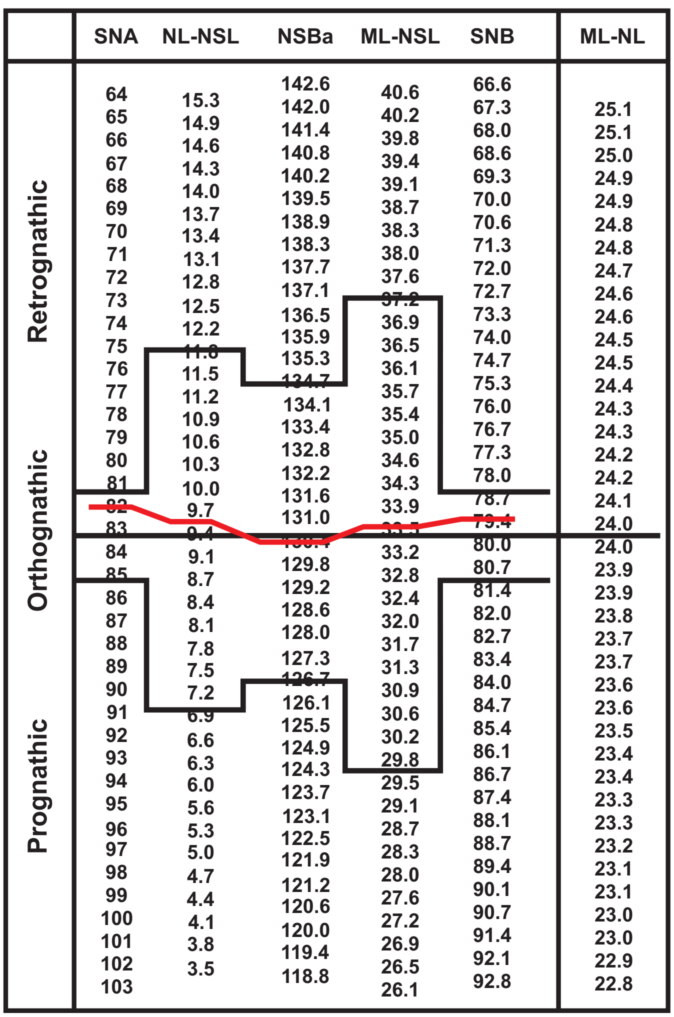

Figure 6. Harmonius combinations

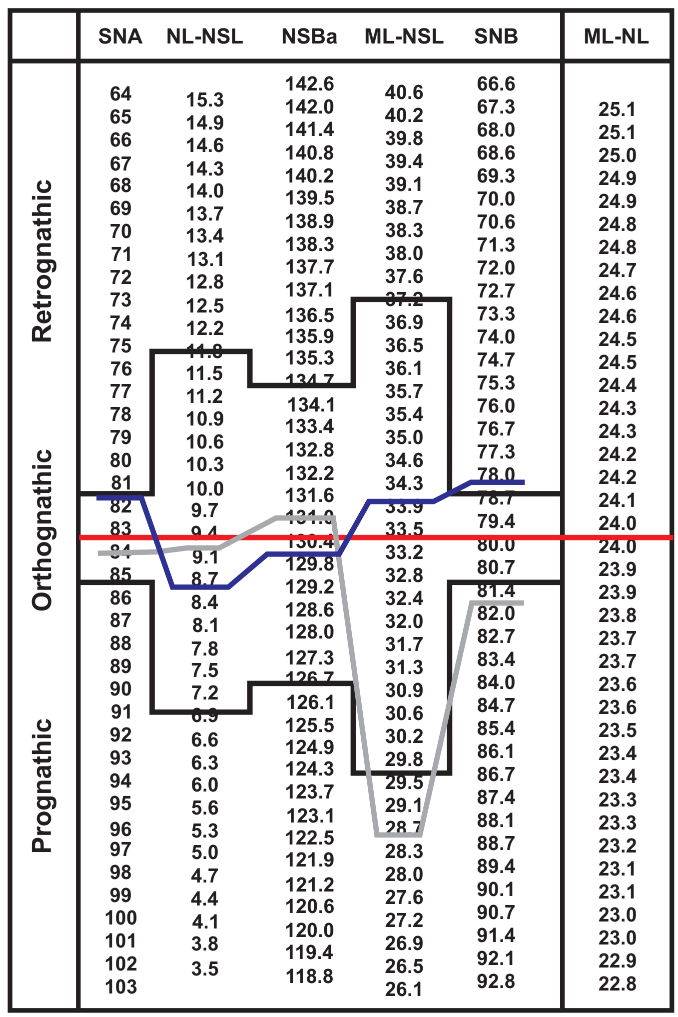

Figure 7. Comparison with Thais (light) and Syrians (dark)

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Malocclusion Features and Orthodontic Treatment Need among 6-8 year old Children seen at the CEU School of Dentistry in Manila and Malolos Campuses

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The objective of this study was to determine the malocclusion features and orthodontic treatment need among 6-8 year old Filipino children seen at the CEU School of Dentistry, Orthodontics - Pedodontics clinic in Manila and Malolos campuses. A case series observational study was done at the dental infirmaries with 70 subjects selected according to established criteria. Orthodontic diagnostic records were taken to evaluate the skeletal and dental status of each subject and to determine the need for early orthodontic intervention based on the dental health component of the Index of Orthodontic Treatment Need (IOTN). Percentage distribution described the various parameters. Sexual differences in occlusal traits were validated by independent sample t-test. One way analysis of variance was used to determine the effect of age on skeletal jaw relationship. Normal skeletal jaw relationship was found in 66 (94.3%) children. Profile convexity was observed in 40 (57%) subjects. Class one molar relationship was found in 47 (67%) children. Based on the IOTN, 35 (50%) subjects revealed dental anomalies. No significant differences in occlusal traits were found between boys and girls. The ANB value tends to decrease as age increased. Malocclusions of dental etiology were seen among 6-8 year old Filipino children revealing a need for early orthodontic intervention.

Preface

The American Association of Orthodontists (AAO) recommends that orthodontic check-up for children should not be later than seven years old. However, several authors suggest that orthodontic screening should start at age nine to eleven, at which stage all malocclusion features can readily be seen. This study was conducted to investigate if malocclusion features can be seen among 6-8 year children.

INTRODUCTION

Advances in preventive dentistry, improvement in oral health education and oral hygiene practices have dramatically decreased the incidence of caries among children in the last decade. These factors have shifted the emphasis from purely conservative-restorative treatment approach towards the provision of early orthodontic treatment (Wei et al. 1989). One of the major goals of children's dentistry is the establishment of a functional and aesthetically acceptable adult occlusion, thus, early recognition and treatment of abnormal growth and developmental patterns have become essential considerations (Braham and Morris 1985). However, a controversy exists regarding how early the recognition or treatment should begin. The principal concern weighs the benefit of treatment in the early mixed dentition stage of development against treatment started in the late mixed dentition stage (Gianelly 1995). According to Moyers, early treatment can take advantage of normal growth to correct malocclusions before they became severe (Moyers 1988). McNamara and Brudon reinforced Moyer's argument that early treatment can eliminate or modify skeletal, muscular and dentoalveolar abnormalities before the eruption of full permanent dentition (McNamara and Brudon 1993). Dugoni and Lee emphasized that the time required for treatment in the second phase of treatment can be reduced by initiating phase one treatment between the ages seven and nine years (Dugoni and Lee 1995). Rolling and Heikinheimo et al. believed that screening for orthodontic treatment is not sensible before the age of 9-10 years because many malocclusion features are not yet manifested (Rolling and Heikinheimo 1978, 1982). To evaluate whether malocclusion features are readily observed in the early mixed dentition period (i.e. 6-8 year old children), a study using the index of orthodontic treatment need (IOTN) dental health component was conducted among 6-8 year old Filipino children.

The purpose of this investigation is to determine the incidence of malocclusion and orthodontic treatment need among 6-8 year old Filipino children seen at the orthodontics-pedodontics clinics at Centro Escolar University in Manila and Malolos campuses.

MATERIALS AND METHODS

Study Design

Determining the malocclusion features and treatment need among pediatric subjects is an observational study, specifically a case-series study conducted at the Orthodontics-Pedodontics Clinic of the CEU College of Dentistry.

Setting

The study is conducted at the CEU Orthodontics-Pedodontics section. Subjects are screened according to eligibility criteria pertaining to the early mixed dentition period. Junior clinicians are required to present such cases as part of their subject requirement in Orthodontics.

Subjects

Junior clinicians under Clinic I select patients for the study based on all of the following eligibility criteria: 1) Filipinos by nationality and are 6-8 years of age, 2) four permanent first molars must be present, 3) four permanent lower incisors must be present. The inclusion criteria implied that the subjects belonged to the early mixed dentition stage. The exclusion criteria are subjects with history of extraction of permanent incisors and first molars.

Materials

After the subject meets the inclusive criteria, cephalograms, panoramic radiographs, study models, intraoral and extraoral photos are taken at the CEU radiology department and clinical infirmary. The principal investigator then validates all the previously mentioned materials on his second clinical visit.

Parameters

The age and gender of subjects will be taken for demographics purposes. Based on cephalograms, skeletal jaw relationship will be classified based on ANB values using longitudinal cephalometric analysis designed by Bishara (normal value = 1°- 8°) specifically for early mixed dentition subjects (Class I, II, and III) (Bishara 1981). Soft tissue profile such as straight, convex, and concave will be determined based on Steiner's S-line (Jacobson 1985). The main criteria to indicate malocclusion among 6-8 year old children are listed below. The following anomalies will be recorded:

Dentition status: missing permanent teeth, supernumerary teeth using the panoramic radiographs.

Space conditions: crowding or spacing based on mixed dentition analysis using Go75 method on study models (GO 1991).

Occlusion: overjet, crossbite, overbite, openbite, crowding, molar relationship based on Angle classification.

Need for treatment:

The dental health component of the Index of Orthodontic Treatment Need (IOTN), which was developed in Sweden and designed to reflect those occlusal traits, which could affect the function and longevity of the dentition, will be used (Mitchell 2001). Traits of each subject will be listed and graded from 1 (no need for treatment) to 5 (great need for treatment) as shown in Table 1. The data entered in the patient's personal record will be re-evaluated by the principal investigator for accuracy and precision of analysis and to avoid inter-observer variability. The lower the grade, the lesser is the need for orthodontic treatment. The higher the grade, the greater is the need for orthodontic treatment.

Table 1. The Index of Orthodontic Treatment Need

Grade 1 (None)	
1	Extremely minor malocclusions including displacements less than 1mm
Grade 2 (Little)	
2a	Increased overjet 3.6-6 mm with competent lips
2b	Reverse overjet 0.1-1 mm
2c	Anterior or posterior crossbite with up to 1mm discrepancy between retruded contact position and intercuspal position
2d	Displacement of teeth 1.1-2 mm
2e	Anterior or posterior open bite 1.1-2 mm
2f	Increased overbite 3.5 mm or more, without gingival contact
2g	Prenormal or postnormal occlusions with no other anomalies; includes up to half a unit discrepancy
Grade 3 (Moderate)	
3a	Increased overjet 3.6-6 mm with incompetent lips
3b	Reverse overjet 1.1-3.5 mm
3c	Anterior or posterior crossbites with 1.1-2 mm discrepancy
3d	Displacement of teeth 2.1-4 mm
3e	Lateral or anterior open bite 2.1-4 mm
3f	Increased and complete overbite without gingival trauma
Grade 4 (Great)	
4a	Increased overjet 6.1-9 mm
4b	Reversed overjet greater than 3.5 mm with no masticatory or speech difficulties
4c	Anterior or posterior crossbites with greater than 2 mm discrepancy between retruded contact position and intercuspal position.
4d	Severe displacement of teeth, greater than 4 mm.
4e	Extreme lateral or anterior open bites, greater than 4 mm
4f	Increased and complete overbite with gingival or palatal trauma
4h	Less extensive hypodontia requiring pre-restorative orthodontic space closure to obviate the need for a prosthesis
4l	Posterior lingual crossbite with no functional occlusal contact in one or both buccal segments
4m	Reverse overjet 1.1-3.5 mm with recorded masticatory and speech difficulties
4t	Partially erupted teeth, tipped and impacted against adjacent teeth
4x	Supplemental teeth
Grade 5 (Very Great)	
5a	Increased overjet greater than 9 mm
5h	Extensive hypodontia with restorative implications (more than one tooth missing in any quadrant) requiring pre-restorative orthodontics
5i	Impeded eruption of teeth (with the exception of third molars) due to crowding, displacement, the presence of supernumerary teeth, retained deciduous teeth and any pathological cause
5m	Reverse overjet greater than 3.5 mm with reported masticatory and speech difficulties
5p	Defects of cleft lip and palate
5s	Submerged deciduous teeth

Statistical Treatment

Most parameters will be treated with percentage distribution. Sexual dimorphism will be determined among skeletodental parameters such as overbite, overjet, skeletal-jaw relationship and molar relationship using the independent sample t-test. Influence of age on skeletal-jaw relationship will be evaluated using one-way analysis of variance (Dawson 1990, SPSS 1998).

RESULTS

In the total population studied (n=70), there were more boys (41) than girls (29) who were mostly seven years of age. (Table 2)
According to the percentage of children who had specific types of skeletal jaw relationships, most subjects (94.3%) had Class I relationship. Class II was rare in the sample, representing 5.7%. No Class III relationship was present among the sample population. (Table 3)
A majority of 57.1% exhibited soft tissue profile convexity while 42.9% featured a straight profile. No concave profile was observed among the subjects. (Table 4)

Dentition status

The frequency of congenitally missing teeth was 4.3%. There was only one case of a supernumerary tooth. No case of severe malformation and ectopic eruption were present. Rotations were observed in 20% of the children examined. (Table 5)

Space condition

Crowding was found to be the most common type of disorder in the dental arches and was recorded in 24.3% of the whole sample.

Table 2. Age and sex distribution (n = 70)

Age/yr	Boys	Girls	Total
6	3	6	9
7	22	15	37
8	16	8	24
Total	**41**	**29**	**70**

Table 3. Distribution according to skeletal jaw relationship (n = 70)

Skeletal Classification	n	%
Class I	66	94.3
Class II	4	5.7
Class III	0	0
Total	**70**	**100**

Table 4. Distribution according to soft tissue profile (n = 70)

Soft Tissue Profile	n	%
Straight	30	42.9
Convex	40	57.1
Concave	0	0
Total	**70**	**100**

TABLE 5. Distribution according to malocclusions

Malocclusions	n	%
Dentition status		
Supernumerary teeth	1	1.4
Missing permanent teeth	3	4.3
Rorations	14	20.0
Space conditions - MDA		
Crowding > 2 mm	17	24.3
Spacing > 2 mm	39	55.7
Occlusal anomalies		
Maxillary overjet > 3.6 mm	16	22.8
Mandibular overjet	5	7.1
Anterior crossbite	14	20.0
Overbite > 3.5 mm	16	22.8
Openbite	2	2.8

Spacing occurred in more than half (55.7%) of the sample population. (Table 5)

Occlusal anomalies

Maxillary overjet (>3.6 mm) was found in 22.8%, while mandibular overjet was noticed in 7.1% of the sample. Crossbite was observed in 20% of the children involving one incisor only.

Table 6. Distribution according to antero-posterior molar relation (n = 70)

Angle Classification	Right molar		Left molar	
	n	%	n	%
Class I	47	67.1	46	66
Class II	16	22.9	19	27
Class III	7	10	5	7
Total	**70**	**100**	**70**	**100**

Table 7. Treatment need (%) distribution (n = 70)

Category	n	%
Grade 1 (No need)	35	50
2 (Little)	20	28.6
3 (Moderate)	14	20
4 (Great)	1	1.4
5 (Very Great)	0	0
Total	**70**	**100**

Table 8. Influence of age on skeletal jaw relationship

Age	N	ANB (Mean)	Std. Deviation
6	9	5.50	2.80
7	37	4.60	2.55
8	24	4.06	1.66
Total	**70**	**4.53**	**2.33**

Deep bite (>3.5 mm) was seen in 22.8%, while frontal open bite was evident in 2.8% of the sample population. (Table 5)

A trend towards a Class I molar (Angle) relationship was observed in 67% of the subjects. Class II (distal molar) and Class III (mesial molar) molar relationships showed a decreasing incidence in the sample representing 25% and 8% respectively. (Table 6)

Treatment need

According to the Index of Orthodontic Treatment Need (IOTN), 50% of the children examined showed a significant need for orthodontic treatment. A large proportion of 28.6% had little need while 20% showed moderate need for orthodontic treatment. One case exhibited a great need for treatment due to supplemental tooth with the presence of other dental discrepancies. (Table 7)

Other findings

Using one-way analysis of variance, it was observed that the mean ANB value tend to decrease as children increased in age. (Table 8)

No significant differences in occlusal traits between girls and boys in this study were determined using the independent sample t-test. (Table 9)

TABLE 9. Characteristics of the sample population - Age and continuous occlusal characteristics (41 boys, 29 girls)

Parameter and Gender	Mean	SD	Difference
Age			
Boys	7.32	0.61	0.25
Girls	7.07	0.70	
Overjet			
Boys	2.05	2.11	0.24
Girls	2.29	1.94	
ANB			
Boys	4.83	2.68	0.73
Girls	4.10	1.66	
Space conditions			
Boys	2.07	4.90	0.99
Girls	3.06	4.10	
Molar relation (right)			
Boys	0.23	2.19	0.16
Girls	0.07	0.99	
Molar relation (left)			
Boys	0.48	2.45	0.03
Girls	0.45	1.24	

*ρ = ns

DISCUSSION

The 'cephalocaudal gradient of growth' stating that structures farther from the brain cease to grow at a later time means that the skull ceases to grow earlier than the maxilla, which ceases to grow earlier than the mandible (Proffit 1993). Thus, the mandible continues to grow even after the skull and the maxilla have stopped growing. This explains the large ANB value among the mixed dentition subjects. The mandible has not attained its full size yet, therefore the difference between the maxillary (SNA) and the mandibular (SNB) positions in relation to the cranial base is larger compared with that of the adults. This similarly explains the profile convexity among most of the subjects (57%) (Naranjilla and Rudzki-Janson 2005). While the mandible grows forward as age increases, the ANB measurement, along with the soft tissue profile convexity decreases. This is particularly evident in the present study.

Majority (94.3%) of the subjects displayed a Class I skeletal jaw relationship indicating a normal sagittal relationship of the jaws in relation to the cranial base. This was based on the ANB value of 0-8 degrees using the longitudinal cephalometric analysis designed by Bishara specifically for early mixed dentition subjects. This value is relatively larger compared to the adult Filipino ANB value of -0.5-4.5 degrees (Myllärnemi 1970).

A normal Class I occlusion was found in most of the subjects (67%), which was similar to studies on Caucasian children with 70% having Class 1 occlusion (Lavelle 1976, Thilander and Myrberg 1973, Haynes 1970, Helm 1968, Al-Emran et al. 1990). Class II occlusion seen in 27% of children was almost the same as in Caucasians with 25%. Only 10 % exhibited a Class III occlusion which was mainly due to mesial drifting of the first molars after premature extraction of the deciduous molars.

The malocclusion features which were manifested in the study were dental in origin. Mesiodens was found in one of the subjects, which posed a great need for orthodontic treatment based on the Index of Orthodontic Treatment Need (IOTN). Mesiodens may cause spacing between two central incisors, which may eventually lead to crowding. Therefore, the mesiodens should be removed to close the space between the two incisors.

The most frequent congenitally missing teeth among the subjects were the mandibular second premolars followed by the maxillary lateral incisors. A similar finding has also been reported among Saudi Arabian children (Ingervall et al. 1972). This sequence for the most common absent teeth has been reported by several authors (Rölling 1980, Grahnen 1956, Wisth et al.1974, Clayton 1956, Glenn 1961, Richardson 1973). Missing teeth may cause diastema, supraerution of opposing tooth and drifting of adjacent teeth into the space created by the missing tooth. Therefore these consequences should be properly considered in orthodontic diagnosis and treatment planning.

Rotations of anterior teeth due to crowding and over-retained deciduous teeth were seen in 20% of the subjects. Crowding in the mandibular anterior segment was seen in 24.3% of the children, a finding which is similar to a study done by Richardson and Ana in a Nigerian sample (Proffit 1993). This period when the mandibular incisors are crowded is a normal developmental stage at this age (Kerosuo et al. 1988). Continued development of the arches will improve the spacing situation, which agrees with the results of a study done by Kerosuo et.al, which revealed that crowding was more common in younger age groups than in the oldest one (Smith and Bailit 1977). However, this contradicts previous studies which showed that crowding generally increases with age (Lavelle 1976, Proffit 1993, Cons et al. 1978). Anterior spacing in the maxilla occurred in more than half (55.7%) of the samples which is in agreement with Cons et al. and Abuaffan (Abuaffan 1987, Burdi 1988). Typically, occlusion at 7-8 years old is characterized by complete closure of primate spaces in the lower arch and interdental spacing in the maxillary anterior region (Proffit 1993).

Mandibular overjet and crossbite involving one incisor were seen in 27% of the subjects. A crossbite relationship of one or two anterior teeth may develop in a child who has good facial proportions especially in the presence of severe crowding (Burdi 1988). A cephalometric analysis is recommended to eliminate the possibility of a developing skeletal Class III malocclusion.

The occurrence of deep bite greater than 3.5mm (22.8%) corresponds with the number of overjets exceeding 3.6mm (22.8%). From the early mixed dentition to the completion of the permanent occlusion, the average overbite increases slightly and then decreases. It is correlated with a number of vertical facial dimensions like ramus height, whereas overjet is a reflection of the anteroposterior dental relationship. During growth, the severe Class II and Class III malocclusion, the overbite and overjet, must adapt to the abnormal skeletal relationships. Compared with the African and Caucasian children, the frequency of anterior open bite was extremely lower (2.8%) (Helm 1968, Smith and Bailit 1977).

In the present study, half of the subjects displayed a mild to moderate need for orthodontic intervention due to alignment and space problems. Minor tooth movements and space maintenance using two by four mechanics, space maintainers, and simple removable appliances may be recommended.

CONCLUSION

Malocclusions of dental etiology were observed in fifty percent of the subjects seen at the orthodontics-pedodontics clinic of CEU Manila and Malolos campuses.

Forty nine percent displayed a mild to moderate need for orthodontic treatment due to crowding, rotations, simple anterior crossbite, increased overjet and overbite.

One case of supernumerary tooth (mesiodens) revealed a great need for orthodontic treatment.

RECOMMENDATION

Interceptive orthodontic measures should be strengthened in the undergraduate dental curriculum.

The results of the present study suggest that early intervention by interceptive orthodontic treatment should be practiced, not only at the university dental infirmaries, but in private dental clinics as well.

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A Case Report on Hemimandibular Elongation (Part I)

Rosa Maria Wilhelima DL. Gener, DMD, Orthodontics Certificate

Dr. Gener received her dental training at the University of the Philippines Manila-DDM (2005) and Orthodontic Certificate (2010). She is currently completing her Master's Degree, and is presently a faculty member of the Postgraduate Program in Orthodontics of the University of the Philippines Manila.

The following is the first of a three-part presentation of a patient with hemimandibular hyperplasia undergoing orthodontic treatment and will be treated with orthognathic surgery.

Condylar hyperplasia is a pathological overgrowth condition at the condylar process, of non-neoplastic origin, causing variable abnormal mandibular or facial asymmetry.[i] Based on clinical and radiological findings, two different forms have been differentiated: hemimandibular hyperplasia and hemimandibular elongation. Hemimandibular hyperplasia is characterized by three-dimensional diffuse enlargement of half of the mandible, including the condyle, the condylar neck, and the mandibular ramus and corpus, terminating at the symphysis of the affected side.[ii] The anomaly usually begins before puberty, enabling the maxilla to follow the downward growth of the mandible on the affected side, resulting in the canting of the occlusal plane, while the teeth generally remain in occlusion.[iii] However, the mandibular midline is generally not shifted.[iv] The unilateral increase in height of the face on the affected side results in a rotated facial appearance. Because the mandibular corpus is affected, a double contour can be seen on the lateral cephalogram. Panoramic radiograph will reveal an increased size of the affected mandibular corpus and ramus, and increased distance between the tooth root apices and the inferior mandibular border.[v]

On the other hand, hemimandibular elongation, the more common type of condylar hyperplasia, differs in its clinical and radiological view from hemimandibular hyperplasia. It is characterized by a horizontal elongation of the affected hemimandible and may affect the condylar neck, the ramus, and corpus.[vi] The condylar head does not seem to be enlarged, and a flattening of the gonial angle on the affected side is observed but the mandibular corpus remains on the same level on both sides, resulting in the absence of a double contour on the lateral cephalogram.[vii] On the panoramic radiograph, there seems to be no increase in the height between the tooth root apices and the inferior mandibular border. Lower dental midline is displaced to the healthy side, and the facial asymmetry is very noticeable. A crossbite is usually present on the unaffected side. Despite division of the condylar hyperplasia into two forms, a mixture of these can be often seen.[viii]

The exact etiology of condylar hyperplasia is still unknown, although genetic factors, hormonal disturbances, traumatic lesions have been proposed.[ix] Condylar growth pattern can be evaluated by serial clinical comparisons, cephalometric tracings, and bone scanning with technetium 99m technetium. However, no ideal method has been found to assess whether condylar overgrowth is "inactive." Therapy is largely based on the patient's age, condylar growth activity, and the severity of facial appearance.[x] Various treatment modalities have been proposed, ranging from condylectomy to orthopedic maxillary management. Strong consideration should be given to refraining from surgery until growth activity has stopped.[xi]

In June of 2008, a 26-year-old female was referred to the Postgraduate Program in Orthodontics, University of the Philippines Manila, complaining of lower jaw deviation. There was no hereditary history of the same condition, or history of trauma. Clinical examination revealed facial asymmetry, with deviation of the mandible and shifting the midline of the chin to the same side, and an increase in the vertical height of the middle and lower facial thirds on the right side (Figure 1). The maximum mouth opening was 37 mm, excursion and protrusive movements

Figure 1. Patient's preoperative photograph (frontal view) showing the evident facial asymmetry.

Figure 2. Preoperative dental occlusion showing Class III canine relationship on the right side.

Figure 3. Preoperative dental occlusion showing Class II canine relationship on the left side.

Figure 4. Preoperative occlusion showing both dental midlines deviated to the left and with the presence of a crossbite.

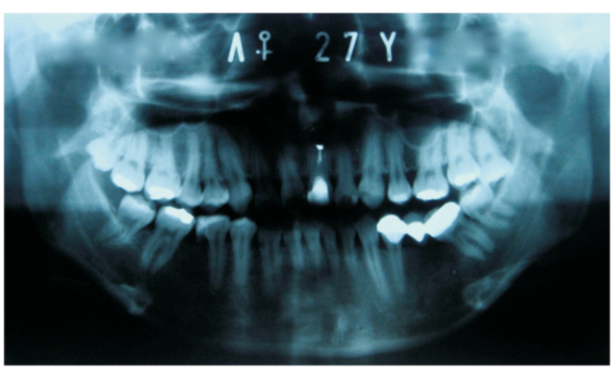

Figure 5. Preoperative panoramic radiograph showing enlarged right condyle, elongated right ascending ramus, as well as an enlarged right hemimandible. The gonial angle was characteristically rounded off, and the mandibular canal was displaced to the lower border of the mandible

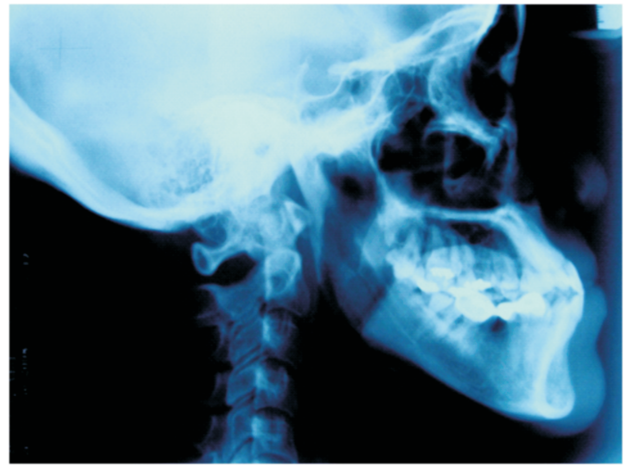

Figure 6. Preoperative cephalometric radiograph analyses revealing a Class III skeletal profile.

Figure 7. Preoperative postero-anterior radiograph showing marked deviation of the mandible to the left, and occlusal plane canted left superiorly and right inferiorly.

a. DOWN'S ANALYSIS

	MEAN	PATIENT'S VALUES	REMARKS
A. SKELETAL			
Facial Angle	85.5	96.5	Overdeveloped mandible
Angle of Convexity	4.7	-8.5	Normal
A-B Plane to Facial Plane	-3.7	5.5	Class III
Mandibular Plane Angle	28.7	31.0	Normal
Y-Axis	65.0	57.5	Horizontal growth
B. DENTAL			
Cant of Occlusal Plane	10.9	3.5	Low-angled
Interincisal Angle	122.8	118.0	Normal
LI - Occlusal Plane	24.3	25.0	Normal
LI - Mandibular Plane	6.0	-1.5	Normal
UI - A-Pog Plane	8.6	10.0	Normal

> Down's analysis suggests a Class III skeletal malocclusion attributable to an overdeveloped mandible; Y- axis reveals a horizontal growth pattern.

b. STEINER'S ANALYSIS

	MEAN	PATIENT'S VALUES	REMARKS
SNA	84.5	85.5	Normal
SNB	82.0	90.0	Over developed mandible
ANB	2.5	-4.5	Class III
OCCLUSAL PLANE – SN	13.5	11.0	Normal
GoGn (MP) – SN	31.3	33.5	Normal
UI – NA (mm)	6.4	5.0	Normal
UI – NA (angle)	24.7	32.0	Proclined
LI – NB (mm)	7.5	7.5	Normal
LI – NB (angle)	29.8	36.0	Normal
Interincisal Angle	122.8	118.0	Normal
LI – Chin			
Po – NB (mm)	0.7	3.0	Distal displacement of lower incisors relative to the mandible.

> STEINER'S ANALYSIS reveals Class III skeletal malocclusion attributable to a normal maxilla but an overdeveloped mandible.

c. TWEED'S ANALYSIS

	MEAN	PATIENT'S VALUES	REMARKS
FMA	28.7	31.0	
FMIA	55.3	62.5	
IMPA	96.0	88.5	

d. WITS APPRAISAL

	MEAN	PATIENT'S VALUES	REMARKS
BO TO AO (mm)	-1 to 1	-12.0	Skeletal Class III

> WITS APPRAISAL reveals skeletal Class III malooclusion.

were not restricted, and presence of clicking was heard during opening. The dental occlusion showed a Class III canine malocclusion, the presence of anterior and posterior crossbites, its upper dental midline was 2.0 mm deviated to the left of the facial midline, and its lower dental midline was 5.0mm deviated more to the left of the facial midline (Figures 2-4). Panoramic radiograph revealed a discrepancy in size and morphology between the right and left condyles, enlargement of the right condyle, and elongation of the right ascending ramus, as well as enlargement of the base of the right side of the mandible. A rounding off of the gonial angle was present, and the mandibular canal was displaced to the lower border of the mandible (Figure 5). Analyses of the cephalometric radiograph showed Class III skeletal malocclusion, attributable to an overdeveloped mandible, its Y-axis revealing a horizontal growth pattern (Figure 6). Postero-anterior radiograph showed asymmetry between the right and left halves of the maxilla and mandible, with marked deviation of the lower jaw to the left. The occlusal plane was also canted left superiorly and right inferiorly (Figure 7).

Clinical and radiographic findings were consistent with a diagnosis of right hemimandibular elongation. A combination of orthodontics and orthognathic surgery was planned, dividing the treatment into three phases: (1) pre-surgical orthodontics, (2) surgery and stabilization, and (3) post-surgical orthodontics. The objective of the pre-surgical phase was to orthodontically align the teeth, correcting tooth inclinations and angulations, and decompensate the dental arches. In the surgical phase, Le Fort I osteotomy with advancement, and sagittal split osteotomy with mandibular setback and condylectomy will be performed, to correct skeletal Class III relationship, to level the lower border of the hyperplastic side of the mandible with the normal contralateral side, and to improve facial esthetics. An ideal occlusion with maximum intercuspation will be developed during post-surgical orthodontics.

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Treatment of a Class II Malocclusion with 2nd Molar Extraction

Maria Laarni P. Serraon, DMD, MSD, Diplomate, Philippine Board of Orthodontics

Dr. Maria Laarni P. Serraon received her dental degree from the University of the Philippines in 1988 and Masteral Degree in Orthodontics from the University of the Philippines in 2000.

The case report that follows describes the orthodontic treatment of a female patient with a chief complaint of labioverted upper canines. The patient was 13 years and 11 months at the time she sought for consultation.

History and Etiology

Chief Complaint: Labioverted canines and lower midline deviation

Etiology: Crowding due to tooth size and jaw base discrepancy resulting to displacement of the canines labially. Crossbite on 25 and interferences lead to deflection of the mandible to the left resulting to facial asymmetry and midline deviation.

Medical History: Good overall health. No significant medical findings.

Analysis of Records

Facial photos: There is slight facial asymmetry wherein the right side of the face is wider than the left side. She has a convex profile with good incisor show when smiling.

Dental: Caries present on 16, 25, 36, 46, 47. She has a dental class 2 malocclusion. The molars and canines are in class 2 relationship. There is a 3mm overbite.13 and 23 are both erupting labially due to insufficient space. Lower midline is deviated to the left by 3mm. Lower arch crowding of 6mm.

Panoramic radiograph reveals all teeth are present. There is a deep restoration on 16 and deep caries on 25. No other pathologies are noted in the radiograph.

Cephalometric Summary: Mild skeletal class 2 (convex profile) with an ANB of 7°.

Maxilla is within normal whereas the mandible is a bit retrusive.

Mandibular plane angle is quite high (SN-MP of 42° and FMA of 36 °).

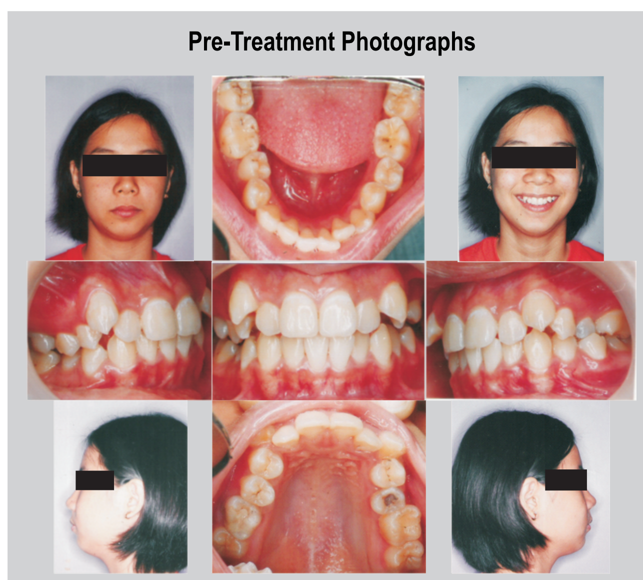
Upright upper incisors with normal inclination of mandibular incisors.

Diagnosis:

Skeletal class 2, dental class 2, labioverted canines, upper arch crowding and midline deviation.

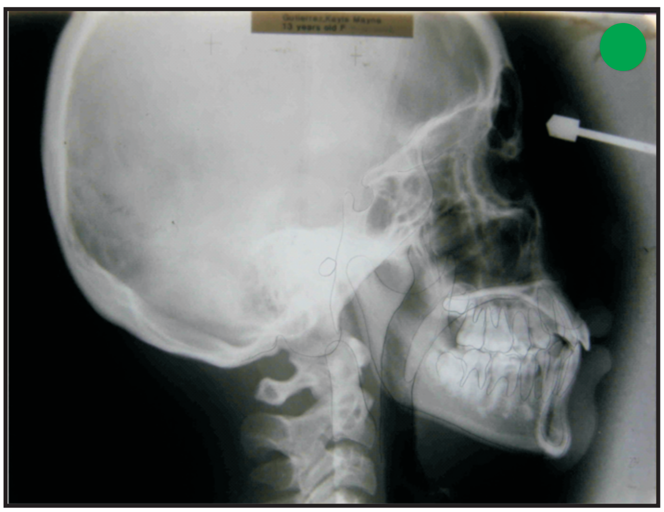
Problem List:

1. Anteroposterior:
   Skeletal: Mild class 2 convex profile due to mildly retrognathic mandible.
   Dental: Dental class 2 (molars and canines) Severe denture base discrepancy Upright maxillary incisors and normal inclination for lower incisors.
2. Transverse:
   Dental: collapsed archform at posteriors Posterior crossbite of 25.



Pre-Treatment Photographs

Pre-treatment Panoramic X-ray



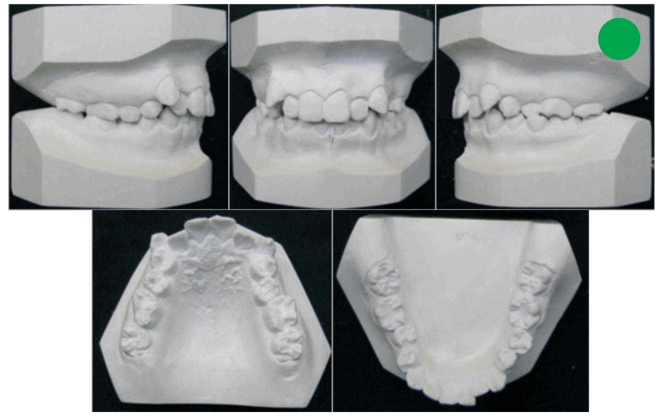
Pre-treatment Cephalometric X-ray

3. Vertical:
   Skeletal: mandibular plane angle is quite high.
   Dental: moderate overbite.
4. Alignment:
   Maxillary arch: crowding of 14mm.
   Mandibular arch: crowding of 6mm.

Specific Objectives of Treatment (A-P, Transverse, Vertical)

Maxilla:
- Maintain the AP length of the maxilla.
- Maintain transverse width of the maxilla.

Mandible:
- Maintain transverse width of the mandible.
- Avoid clockwise rotation by controlling the extrusion of molars during alignment and leveling.



Pre-Treatment Study Model Casts

Maxillary Dentition:
- Level & align the labioverted canines
- Expand the maxillary dentition to correct the archform and crossbite on 25
- Distalization of upper molar to class 1 relationship, gain space for correction of crowding, and midline correction.
- Upright the molars
- Achieve good cusp-fossa relationship with the lower dentition.

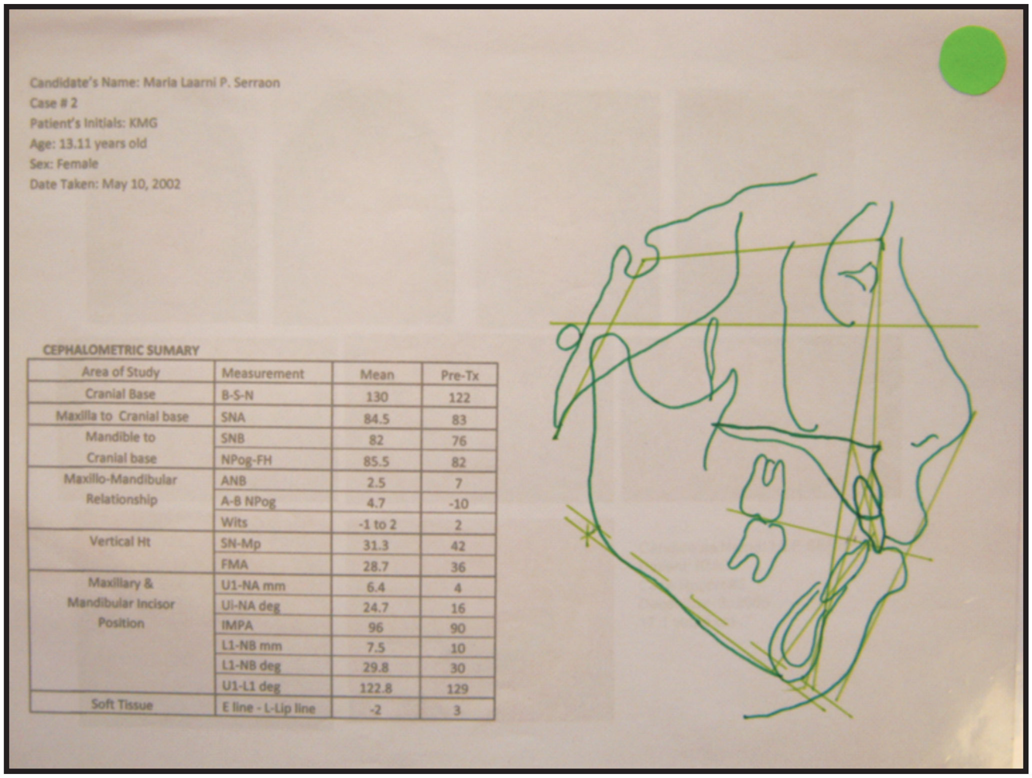
Mandibular Dentition:
- Level & align
- upright the posterior teeth
- Correction of midline –coordinate with upper midline
- Protraction of molars to obtain class 1 molar relationship
- Guard against molar supra-eruption (due to high mandibular plane angle)
- Achieve proper overjet & overbite.

Occlusion:
- Obtain self-maintaining overjet & overbite.
- Achieve Class I canine and molar relationships
- Achieve anterior and canine guidance
- Achieve a functional occlusion that preserves the integrity of the stomatognathic system.

Facial Esthetics:
- To improve patient's profile and achieve a more pleasing smile.

Treatment Plan:

1. Full upper and lower fixed orthodontic treatment with .018 Roth Prescription Straight Wire Appliance.
2. Extraction of upper second molars was the treatment of choice to avoid retroclination of upper incisors and



Candidate's Name: Maria Laarni P. Serraon
Case # 2
Patient's Initials: KMG
Age: 13.11 years old
Sex: Female
Date Taken: May 10, 2002

CEPHALOMETRIC SUMARY

Area of Study	Measurement	Mean	Pre-Tx
Cranial Base	B-S-N	130	122
Maxilla to Cranial base	SNA	84.5	83
Mandible to Cranial base	SNB	82	76
	NPog-FH	85.5	82
Maxillo-Mandibular Relationship	ANB	2.5	7
	A-B NPog	4.7	-10
	Wits	-1 to 2	2
Vertical Ht	SN-Mp	31.3	42
	FMA	28.7	36
Maxillary & Mandibular Incisor Position	U1-NA mm	6.4	4
	Ui-NA deg	24.7	16
	IMPA	96	90
	L1-NB mm	7.5	10
	L1-NB deg	29.8	30
	U1-L1 deg	122.8	129
Soft Tissue	E line - L-Lip line	-2	3

Pre-Treatment Cephalometric Tracing

flattening the profile. The extraction space will be utilized for distlization of the molars to obtain a class 1 molar relationship. The size of the third molar is favorable as a replacement for the extracted second molars.

3. Finishing and detailing.
4. Debonding and retention.

Treatment Progress/Mechanotherapy:

1. Extraction of Upper second molars (17 and 27)
2. Full Upper & Lower Straight Wire Appliance .018 Slot Roth Prescription
3. Leveling & Alignment of teeth.
   Upper Braided archwire (initial wire).
   - .014 to .016 NiTi wires.
   - .014 to .016 Stainless Steel Wire with coil springs to open up space. For canine alignment and to distalize the molars. The space gained will also be used for mild midline deviation.

   Lower Braided archwires (initial wire).
   - .014 to .016 NiTi wires.
   - .014 to .016 Stainless Steel Wire.
4. MEAW mechanics to correct class 2 malocclusion.
5. Asymmetric elastics were used to coordinate the upper and lower midlines. Stripping was also done to correct lower midline deviation.
6. Detailed Occlusion with archwire bends & elastics.
7. Debonding & Retention.

Results Achieved (A-P, Transverse, Vertical)

Maxilla:
- Maintained AP length of the maxilla.
- Postpubertal growth displaced maxilla forward.
- Maintained transverse width of the maxilla.

Mandible:
- Maintained transverse width of the mandible.
- Slight counter-clockwise rotation of the mandible.
- Forward positioning of the mandible concomitant with growth and treatment.

Maxillary Dentition:
- Leveled & aligned.
- Controlled tipping of the anteriors.
- Midlines not coinciding, lower midline shifted to the left.

- Distalization and uprighting of molars into class 1 molar relationship.
- Achieved good cusp-fossa relationship with the lower dentition.

Mandibular Dentition:

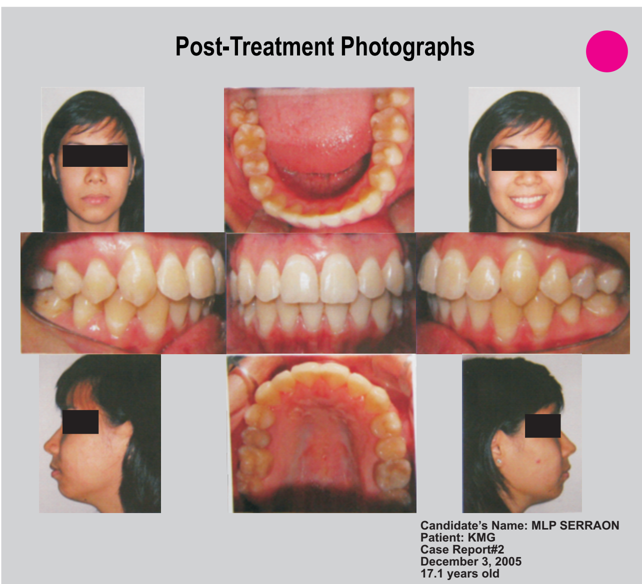
- Leveled & aligned.
- Supraversion & maintained tipping of the anteriors.
- Supraversion and uprighting of posterior teeth.
- Contained the lower anteriors within proper overjet & overbite.
- Midlines still deviated to the left.

Occlusion:

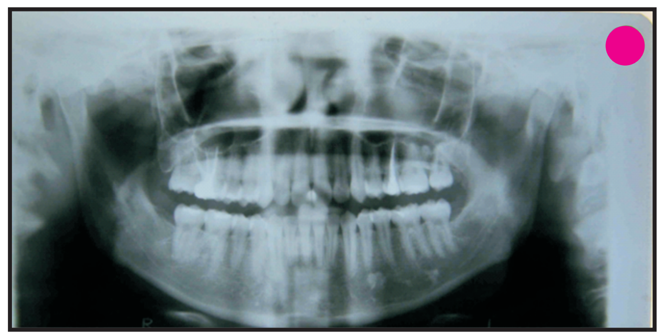
- Obtained good overjet & overbite.
- Achieved Class I canine and molar relationships.
- Achieved incisal and canine guidance.
- Achieved a final occlusion that preserves the integrity of the Stomatognathic system.

Facial Esthetics:

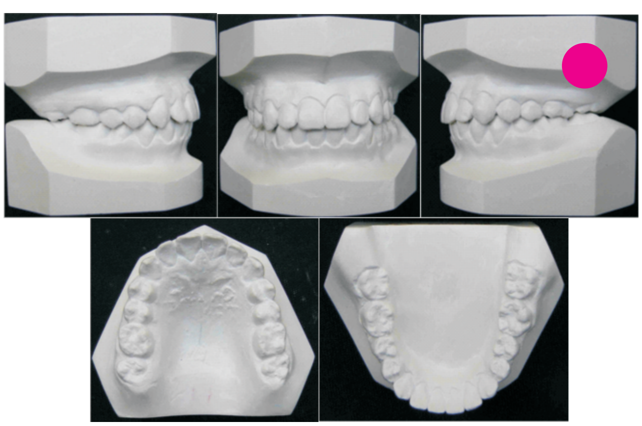
- Existing Facial profile & type remained essentially the same.
- Improved smile esthetics.



Post-Treatment Photographs

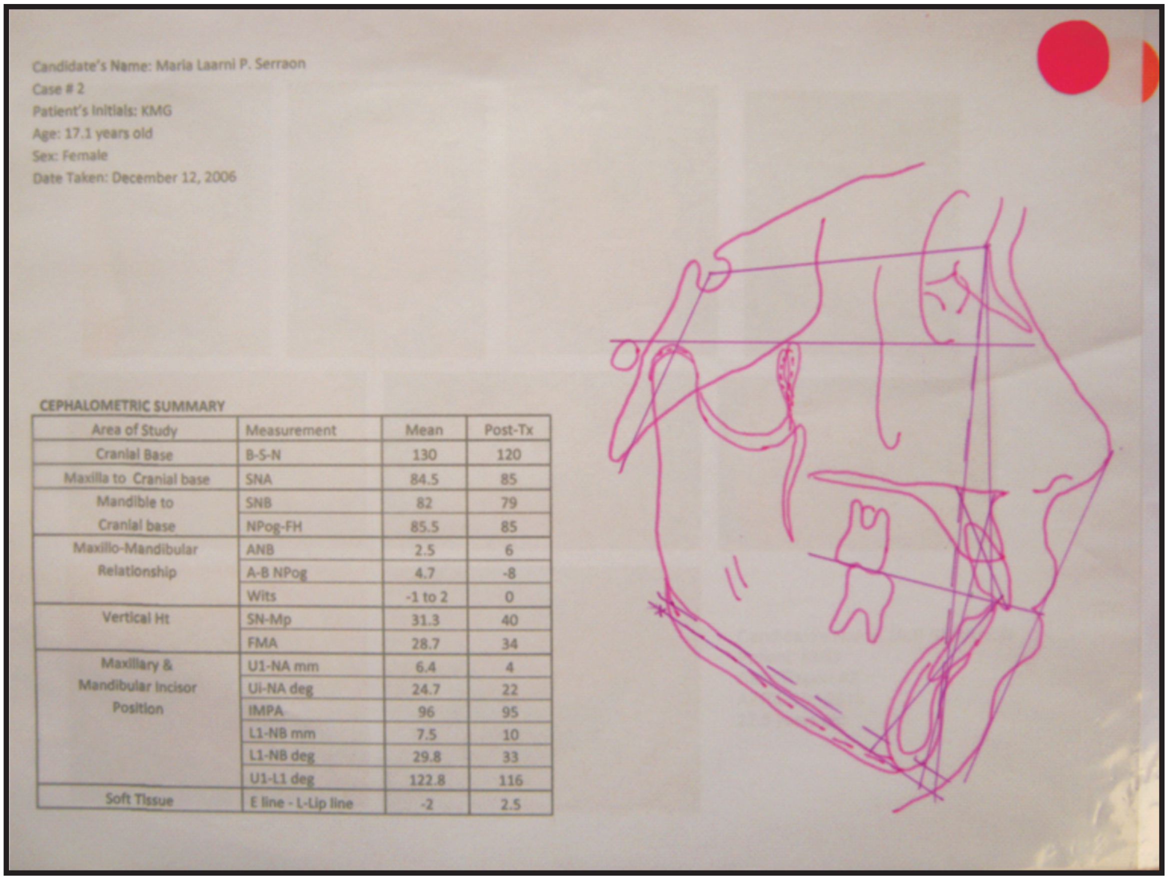


Post-Treatment Panoramic X-rays



Post-Treatment Study Model Casts

Post-Treatment Cephalometric X-rays

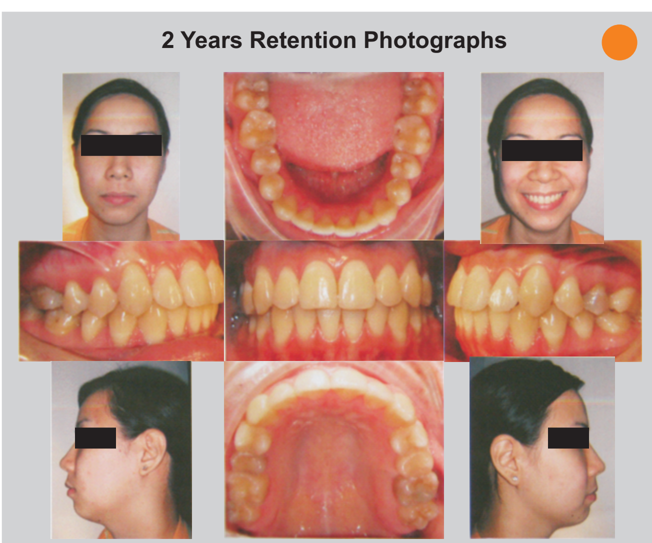


Candidate's Name: Maria Laarni P. Serraon
Case # 2
Patient's Initials: KMG
Age: 17.1 years old
Sex: Female
Date Taken: December 12, 2006

CEPHALOMETRIC SUMMARY

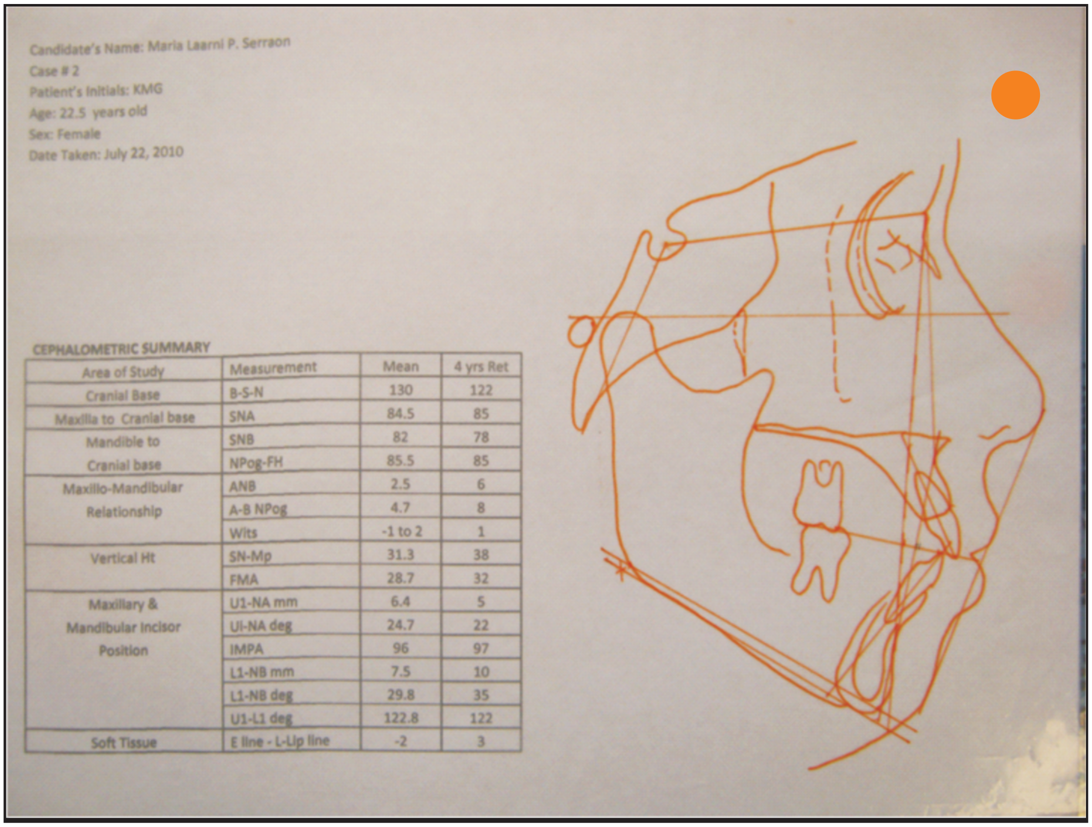
Area of Study	Measurement	Mean	Post-Tx
Cranial Base	B-S-N	130	120
Maxilla to Cranial base	SNA	84.5	85
Mandible to Cranial base	SNB	82	79
	NPog-FH	85.5	85
Maxillo-Mandibular Relationship	ANB	2.5	6
	A-B NPog	4.7	-8
	Wits	-1 to 2	0
Vertical Ht	SN-Mp	31.3	40
	FMA	28.7	34
Maxillary & Mandibular Incisor Position	U1-NA mm	6.4	4
	Ui-NA deg	24.7	22
	IMPA	96	95
	L1-NB mm	7.5	10
	L1-NB deg	29.8	33
	U1-L1 deg	122.8	116
Soft Tissue	E line - L-Lip line	-2	2.5

Post-Treatment Cephalometric Tracing



2 Years Retention Photographs

2 Years Retention Study Model Casts

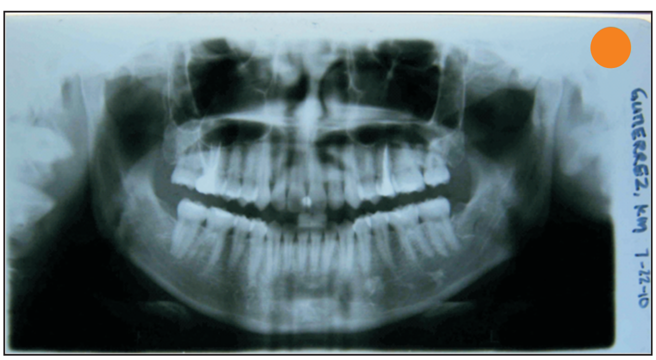


Candidate's Name: Maria Laarni P. Serraon
Case # 2
Patient's Initials: KMG
Age: 22.5 years old
Sex: Female
Date Taken: July 22, 2010

CEPHALOMETRIC SUMMARY

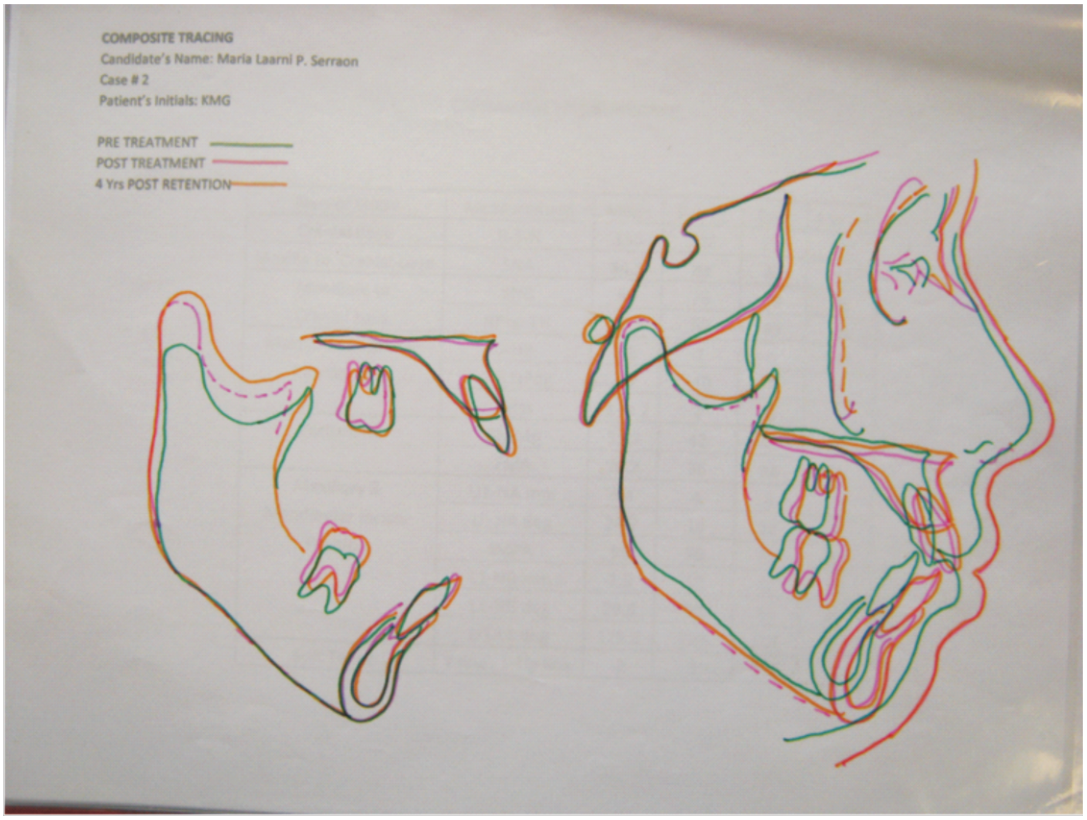
Area of Study	Measurement	Mean	4 yrs Ret
Cranial Base	B-S-N	130	122
Maxilla to Cranial base	SNA	84.5	85
Mandible to Cranial base	SNB	82	78
	NPog-FH	85.5	85
Maxillo-Mandibular Relationship	ANB	2.5	6
	A-B NPog	4.7	8
	Wits	-1 to 2	1
Vertical Ht	SN-Mp	31.3	38
	FMA	28.7	32
Maxillary & Mandibular Incisor Position	U1-NA mm	6.4	5
	Ul-NA deg	24.7	22
	IMPA	96	97
	L1-NB mm	7.5	10
	L1-NB deg	29.8	35
	U1-L1 deg	122.8	122
Soft Tissue	E line - L-Lip line	-2	3

2 Years Retention Cephalometric Tracing



2 Years Retention Panoramic X-Rays

2 Years Retention Cephalometric X-rays



Composite Tracing

Area of Study	Measurement	Mean	Pre-Tx	Post	4- yr ret
Cranial Base	B-S-N	130	122	120	122
Maximilla to Cranial base	SNA	84.5	83	85	85
Mandible to Cranial Base	SNB	82	76	79	78
	NPog-FH	85.5	82	85	85
Maxillo-Mandibular Relationship	ANB	2.5	7	6	6
	A-B NPog	4.7	-10	-8	8
	Wits	-1 to 2	2	0	1
Vertical Ht	SN-Mp	31.3	42	40	38
	FMA	28.7	36	34	32
Maxillary & Mandibular Incisor Position	U1-NA mm	6.4	4	4	5
	Ui-NA deg	24.7	16	22	22
	IMPA	96	90	95	97
	L1-NB mm	7.5	10	10	10
	L1-NB deg	29.8	30	33	35
	U1-L1-deg	122.8	129	116	122
Soft Tissue	E line - L - Lip line	-2	3	2.5	3

Cephalometric Summary

Retention:

Upper wrap-around and lower Hawley retainers were installed after the debonding. The patient was instructed to wear her upper retainer full time for 2 year. After this, a 6 months night time wear was prescribed. And another 6 months of every other night time wear again was prescribed. Retainers were discontinued after 3 years of retention. Patient was recalled every 6 months for check up & evaluation. A 4 year post retention record was taken.

Final Evaluation of Treatment:

The extraction of the second molar was opted to prevent flattening of the profile. Although coil springs were used to open up the space (reciprocal forces) the position of the incisors were controlled because the patient was cooperative in wearing the anterior vertical elastics. Since non extraction was done on the lower arch, midline correction was compromised. Stripping was opted but patient refused to have stripping of incisors. The case was debonded with the midlines still slightly uncoordinated. But even if it was so, we were able to establish a class 1 canine relationship. Anterior and canine guidance was achieved with good molar to cusp relationship. The corrected overbite and overjet appears to be stable 4 years after debonding.

Superimposition of the Cephalometric x-rays at ages 13.11; 17.1 and 22.5 shows the following:

1. Maxillo-mandibular relationship shows downward positioning of the maxilla and the mandible with growth and treatment combined.. There was controlled movement of the maxilla with controlled positioning of the maxillary incisors. The mandible shows downward movement with growth at the condyles and repositioning of the symphysis. The position of the mandibular incisors was maintained.
2. Inclination of the upper incisors increased but vertical and anterior position of upper incisors were controlled. The lower incisors erupted with controlled tipping movement where as the upper molars distalized with controlled vertical position. The lower molars supraerupted and uprighted. Growth of the mandible with equal eruption of the lower molars resulted to clockwise rotation of the mandible. (FMA from 36° to 32°; SN-Mp 42° to 38°).

From Heavy Metal to Plastic Jazz!!!

The new face of Orthodontic Appliances …

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He passed his MDS exams securing the highest marks in Orthodontics in the State of Karnataka in RGUHS. He has trained in the use of Lingual Orthodontic appliances in Germany, UK, Korea and is amongst the first few to use Plastic Aligner therapy in India, for which he holds the international certification in three different systems and is also an international trainer for one of the CAD CAM Systems. Dr Vaid is a Fellow of the World Federation of Orthodontics and the Pierre Fauchard Academy. He is an International Member of the American Association of Orthodontics.

Dr. Vaid has been appointed by the Asia Pacific Orthodontic Society as the Founder Editor of "APOS Trends in Orthodontics-"A web based international journal; has to his credit, various publications in national and international journals, and was the Joint Editor of the Journal of the Indian Orthodontic Society. Currently he is an Executive Committee Member of the Indian Orthodontic Society, in his third term; he is the Founder Editor of IOS Times - The Newsletter of the Indian Orthodontic Society, and was the Chairman- Scientific Committee, "Beyond Boundaries 09", in Thailand; was the Org.Secretary of "Beyond Boundaries-10" held in Hong Kong & Macau in collaboration with the Hong Kong University, and he is also a core committee member of APOC 2012, and Chairman-Publications & PR for the same.

Dr Vaid has lectured at many international and national dental and orthodontic forums, including the FDI & the WFO. He has been awarded the best paper & poster award by the Indian Orthodontic Society on four occasions.

His current interests include Cruising, Modern Indian Art, Bollywood Flicks & of course…Single Malts, explaining his spirited stand on most things in life & Orthodontics!!!

"Invisibility" is the buzz word courting and enticing the next-gen orthodontic professional. From the regimented environs of the dynamics of aesthetics, diagnostic acumen, incorporation of biomaterial advancements and mechanical ramifications of treatment protocols ….a supposedly unchartered territory stares the dental professional recommending Orthodontics, and the Consultant Orthodontist delivering care, straight and hard in their faces…The visibility and "flaunt-value" of Orthodontic appliances!!!

The dilemma of contemporary practice is compounded by the direct marketing of the techniques, lack of formal education ,even in post graduate orthodontic curriculums and the fundamental learning curve the "Invisible or the Inconspicuous" appliance techniques pose.

These psychological barriers magnify and fortify the mental demons about their efficacy and role in contemporary practices.

This article discusses the rationale, science and role of inconspicuous orthodontic protocols with respect to Aligner therapy in expanding the envelope of patient centered Orthodontic protocols.

Specific laboratory considerations are explained with clinical examples.

Is the practice of Aligner Therapeutics really a mystique, occult, fantasy science for the elitist "Jazz " connoisseur, and an infringement into the conventional and populist "Heavy Metal" orthodontic mechanotherapy,as a well executed con-job for the gullible ready to spend a fortune???or based on a scientific rationale???

Demystification of this "new face of Orthodontic Appliances" is what this article will strive to do!!!

INTRODUCTION

The illustrious pages of orthodontic history are decorated by mechanotherapy that has transcended tooth movement brought about by finger pressure to magnets or technology driven and designed appliances. The most important factors that have traditionally determined the longevity and popularity of a treatment protocol or appliance have been biomechanical efficacy.

However, as society transformed itself to embrace image and appearance consciousness, the oldest specialty of dental professionals constantly evolved its repertoire to integrate the destination and the journey that exemplify it. If aesthetics is an important goal of our maneuvers, why shouldn't our appliances strive to attain the same during the course of this attainment? If functional efficacy is an important goal of our maneuvers, why should our appliances restrict or impede mastication or speech during course of treatment? Whether, this quest for convenience driven appliance designs compromises the efficacy of our endeavors, is the million –dollar question?

Figure 1.

Inconspicuous appliances date back to 1945.The tooth positioner and the dental contour appliance were amongst the first prototypes of the modern day aligners. Lingual Orthodontics popularized itself in the 1970's.The Orthodontic community, internationally was skeptical about the efficacy of all these appliances with respect to efficiency and ability to deliver precision with respect to finishing and detailing of occlusion. The waxing and waning interest was also compounded by the fact that metals and wires were in our comfort zone, and all types of inconspicuous appliances required stepping onto a learning curve, embrace technology and laboratory skills and ….foray into previously unchartered terrain!!!

The turn of the century saw unprecedented direct marketing of aligner therapy, which made Orthodontics sit up and take notice. As ethics of professional conduct, commerce & the corporatization of orthodontic therapy was the subject of bewilderment and deliberation, the scientific rationale and organized literature without marketing undercurrent's on the therapy was scarce and pushed to the backdrop. The opinion leaders of our science chose to ignore the treatment modality staring at its face, until market demand forced a rethink on the same.

The last decade has seen organized reviews, clinical studies and incorporation of technology to enhance the possibilities of aligner therapeutics. The envelope of discrepancies that this modality can address has definitely widened .Contemporary orthodontic literature definitively states that aligner therapy will have a certain role to play in the way orthodontic care is delivered in the future.

Figure 2. A Plastic Aligner that is contoured to overlay the dentition

Plastic Aligners: Definition

Are a series of thermoplastic acrylic sheets contoured to overlay the dentition, and serve to bring about tooth movement in a gradual and sequential manner ,determined by a pre ordained diagnostic set-up, which is prepared by either manual or virtual procedures.

Different Aligner systems are available to the clinician. However, a classification based on their use and fabrication is more appropriate for a thorough understanding of what these systems entail.

Classification

1) Based on clinical applications
   *Retention Appliances
   *Active Tooth Moving Appliances
2) Based on method of thermo plasticizing
   *Vacuum Formed, i.e., Invisalign, Orthoclear, 3D Ortholine, Clear Aligner Intl.,Essix
   *Pressure Formed, i.e., Essix
3) Based on Manufacturing Procedure
   *CADCAM or Virtual set up based commercial systems, i.e., Invisalign, Orthoclear,3D Ortholine
   *Laboratory/Clinician controlled fabrication with manual set up, i.e., Essix,Clear Aligner Int'l.
4) Based on frequency of Fabrication
   *Serial Aligners. (Lab/Company governed), i.e., Invisalign, Orthoclear, 3D Ortholine
   *Step wise gradual fabrication (Clinician governed), i.e., Essix, Clear Aligner Int'l.

(The definition and classification has been suggested by the author)

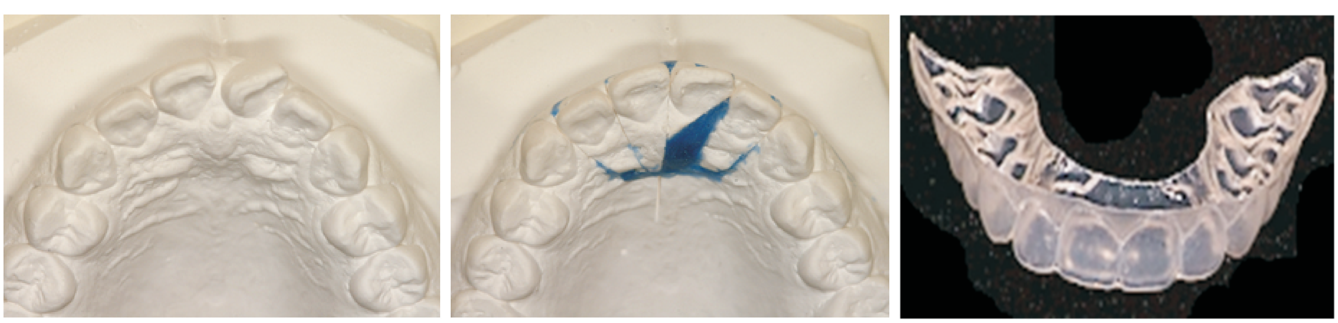

Figure 3. Tooth movement carried out with a manual set-up, to fabricate an aligner that will exert gradual pressure to cause tooth movement.

Scope of Aligner Therapy

It is imperative that the limitations of an appliance therapy are thoroughly deliberated and considered before employing it clinically. Aligners generally are efficient and effective in treatment of certain conditions, and have shortcomings or hurdles to accomplish in others. They will never ever replace fixed appliances completely with respect to biomechanical efficiency, but today have an increased role to play in orthodontic practice.

The use of adjuncts, attachments, auxiliaries, and staging of treatment protocols have definitely expanded the envelope of discrepancies that can be addressed by aligner therapeutics.

Indications of Aligner Therapy:

- **Arch expansion or constriction**
- **Intrusion**
- **Space closure (less than 4mm)**
- **Root Movements & Torque Control(to some extent with CAD CAM appliances)**
- **Treatment of crowding**
- **Treatment of relapse**
- **Buccal segment relationships and Mild skeletal disharmony**
- **Occlusal seating**
- **Adolescent & Mixed Dentition treatment-Eruption Guidance, Space Maintenance & Regaining**
- **Correction of Cross-bites**
- **Mesial or distal tipping of posterior teeth**
- **In combination with fixed labial/lingual appliances**

Difficult indications with Aligner therapeutics:

- **Anterior Axis Control**
- **Extraction cases**
- **High labially/palatally placed teeth**
- **Molar Uprighting and Torque**
- **Translation of molars**
- **Un cooperative patients (since aligners are removable appliances)**

Orthodontic Force Delivery from Plastic Aligners

Force systems exemplify the premise on which orthodontic tooth movement is based. Plastic aligners deliver forces due to the following factors:

- **Elastic property of the aligner**
- **Occlusal forces**
- **The use of adjuncts, auxiliaries, and attachments**

The aligners are worn on a premise that they produce intermittent force and offer 3D force application. Literature does indicate that light, short term or cyclic force applications can produce tooth movement that is comparable to light, continuous forces. The duration of aligner wear should be 10-12 hours at least in adolescents and children, and 18-20 hours for adults.

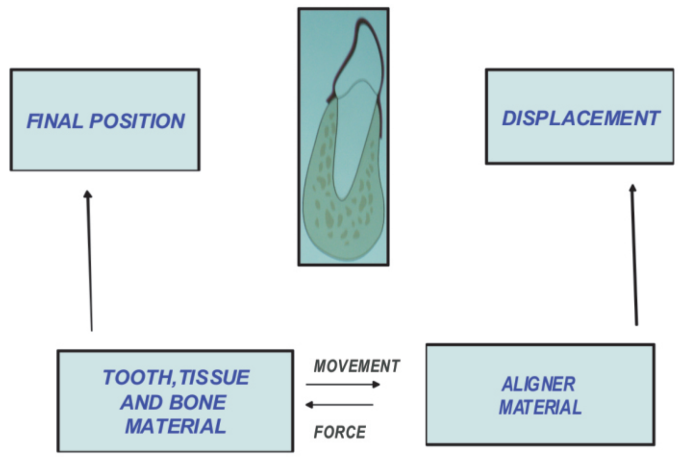

Figure 4. Force Delivery from Aligners

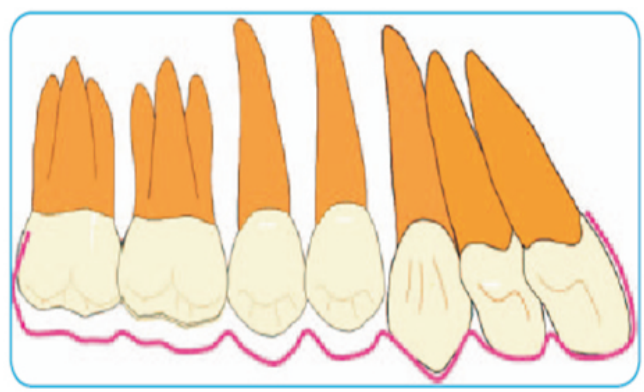

Figure 5. Occlusal forces cause better seating of the aligner, aiding in application of desired pressure on teeth to cause tooth movement.

The frequency of change and the amount of tooth movement brought about by a single change of aligner is determined by the specific system employed by the clinician and the dictates of the planned sequence of movements by the diagnostic set up.

Clinical Protocols while using CAD-CAM Aligner Systems

Diagnosis, Case Selection and Treatment Planning to a very large extent determine the success of Aligner therapeutics. Though the laboratory steps and methodology of fabrication of different aligner systems vary, clinical management across appliance systems, more or less follows similar protocols. Though a lot of CAD-CAM Aligner companies offer certification on using these systems to dentists, Orthodontic treatment involves more with respect to planning compared to the execution, hence it is recommended that a trained Orthodontist is in control, while planning and monitoring an aligner therapy.

Pre Treatment Records

Patient evaluation includes a detailed patient identification questionnaire and comprehensive records that include

- Upper and lower PVS impressions and bite registration covering the last erupted tooth.
- Panoramic and Cephalometric X-Rays(Preferably Digital)
- Extra oral photographs-Frontal, Right and Smiling.
- Intra oral photographs-Frontal, Right, Left, Upper and Lower occlusal
- A completely filled Aligner case order / prescription form for CADCAM aligners.

Laboratory Procedures

A) Scanning-CT or Laser scanners are used. The impression or a poured cast are scanned.

B) Virtual Set up & treatment Planning-The clinician ,lab personnel and the patient can visualize and plan anticipated treatment

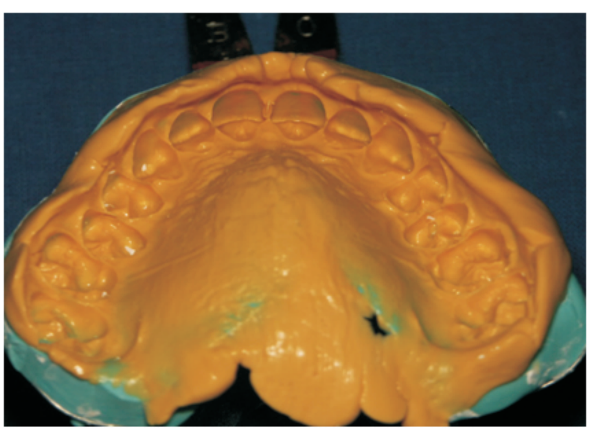

Figure 6. Accurate PVS impressions

Measurement	Active	Dev. Unit	<	Aver...	>	Diff.	Correction
Skeletal Analysis							
SNA	83.8°	N	80.0°	82.0°	84.0°	1.8°	
SNB	78.8°	N	78.0°	80.0°	82.0°	-1.2°	
ANB	5.0°	N	1.0°	3.0°	5.0°	2.0°	
SND	77.0°	N	74.0°	76.0°	78.0°	1.7°	
Posterior Condylion...	19.9	-X	20.0	22.0	24.0	-2.1	Incrase -0.1
Po to S-N	57.6	XXX	49.0	51.0	53.0	-2.1	Decrase 4.6
Occl. to S-N	22.8°	XX	10.0°	14.0°	18.0°	8.8°	Decrease 4.8°
GoGn to S-N	22.8°	-XX	28.0°	32.0°	24.0°	-11.2°	Incrase -7.2°
Dental Analysis							
UI to N-A (mm.)	6.9	XX	3.0	4.0	5.0	2.9	Decrease 1.9
LI to N-B (mm.)	9.3	XXX XX	3.0	4.0	5.0	5.3	Decrease 4.3
Po to N-B (mm.)	2.3	-X	3.0	4.0	5.0	-1.7	Increase -0.7
LI to UI (Angle)	117.8°	-XX	125.0°	131.0°	137.0°	-13.2°	Incrase -7.2°
UI to N-A (Angle)	23.8°	N	20.0°	22.0°	24.0°	1.8°	
LI to N-B (Angle)	33.5°	XXX X	23.0°	25.0°	27.0°	8.5°	Decrase 6.5°
Soft Tissue Analysis							
Upper Lip Protrusion	-1.5	N	0.0	0.0	0.0	-1.5	Increase -1.5
Lower Lip Protrusion	-1.0	N	0.0	0.0	0.0	-1.0	Increase -1.0

Figure 7. Thorough clinical evaluation with comprehensive diagnostic data are imperative for success of aligner therapy.

C) Aligner Fabrication - The 3D Computer images are converted to physical models by a method of rapid prototyping, called steriolithography.The aligners are fabricated serially using a pressure forming technique and trimmed robotically on a mechanical five axis milling machine.

Monitoring CAD CAM Aligner wear

The Clinician with these systems receives the following from the laboratory-

- Patient's instruction booklet.
- Doctor's instruction list.
- CD for the clinical check points.

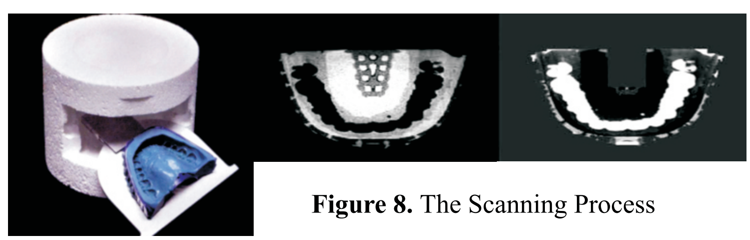

Figure 8. The Scanning Process

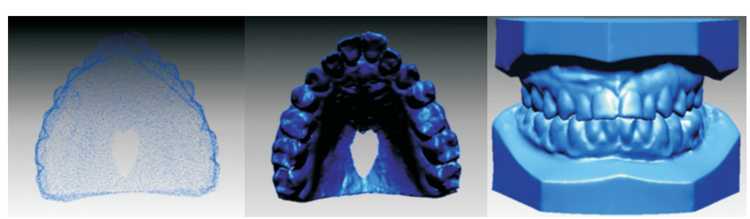

Figure 9. Creation of an accurate Virtual Set-Up

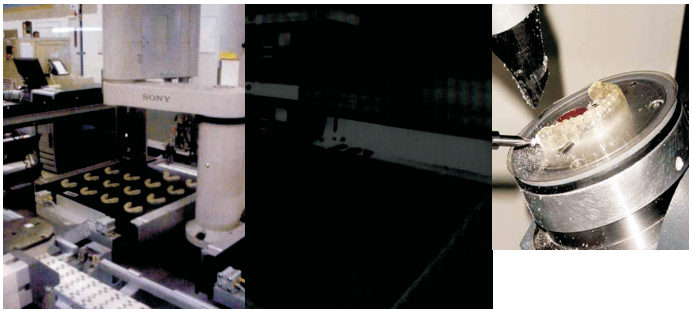

Figure 10. Rapidly Prototyped Models and aligners fabricated on them for different stages of treatment.

- Clinical instruction which includes details about stripping (if needed) like the amount, place and timing. Also details about attachments or any modification needed in a particular case.
- Aligner's box.

Important guidelines during the therapy are-

- Monitoring optimal wear as directed(observing colour change on compliance indicators, observing the snug fit and comparison with tooth movement sequence images on the virtual set-up)
- Ensuring all dental treatments required are carried out prior to aligner fabrication and course of treatment
- Carrying out the IPR and Attachment placements as directed ,accurately and at appropriate stages
- Ensuring the correct sequencing of aligner wear and explaining to patient their importance, and contingency measures in case of lost/broken aligners.
- Being alert to treatment goals or aligner fit mid treatment not adhering to plans, and initiating mid course correction protocols.

Advantages of Aligners as a Therapeutic Modality

Patient benefits:

- **Aesthetics-** Aligners are clear, comfortable, and removable. They are comparable to lingual appliances in aesthetic appeal but offer greater comfort to the wearer and the clinician. Ceramic brackets cannot even compare aesthetically to aligners. Aligners are the appliance of choice for patients who are in the public eye.
- **Removable-** This allows the patient to maintain their oral hygiene regimen. There are no food restrictions as with fixed appliances. Important social occasions can be

- Case 1 …
- 15 year old boy, poor oral hygiene, adamant on not wanting braces
- Canine in crossbite corrected with cad cam aligners in 6 months time

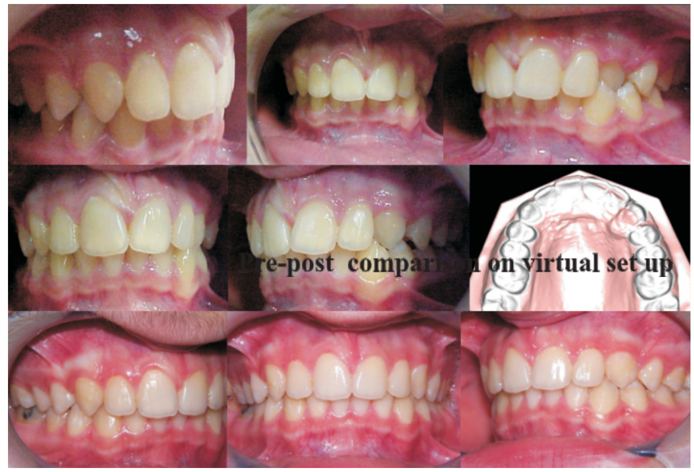

Figure 11. Case 1: M.N…correction of crooked canine in crossbite

* referred by a colleague from Europe.female-47 years
* In India, for 4 months
* Wants gaps in front teeth closed
* Doesn't want braces, cosmetic dental crowns, laminates in her case will harm natural teeth in the pre treatment position

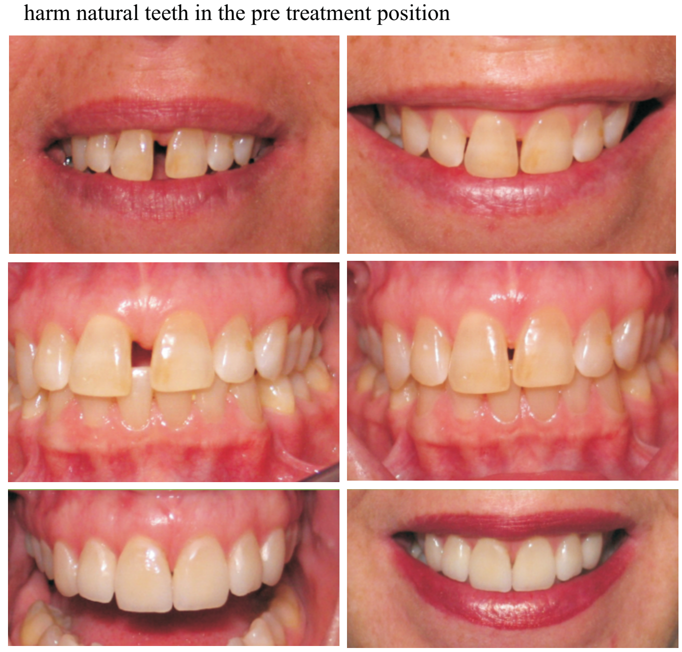

Figure 12. Case 3…J.K. Treatment Time: 3.5 Months of Aligner wear

attended by the patient by removal of aligners for a short duration.

- **Comfort-** Aligners do not cause irritation to the mucosa and surrounding tissues as can happen with brackets, wires, or ligatures. CAD CAM aligner treatment allows slow programmed tooth movement into each aligner. Hence, less discomfort and pain.
- **Speech-** The aligners do not cover the palate and thus produce minimal or no speech impediments.
- **Visualization of planned treatment-** The virtual set up in CAD CAM aligners offer the patient an informed course of treatment effects ensuring more confidence in the process.

Clinician benefits:

- **Practice growth-** Aligners, due to various patient benefits are extremely popular with patients and thus serve as a great public relation tool for ensuring practice growth.
- **Chair side time-** More time is spent by the clinician organizing the lab procedures of aligner therapy. Clinical chair side time is minimal which means that the" time spent to profitability ratio" is increased .More time is spent on building patient rapport which adds value to the practice.
- **Minimal chair side armamentarium-** Chair side armamentarium required is minimal. The huge orthodontic inventory is virtually eliminated. Interproximal reduction and attachment placements are the only chair side procedures required.
- **Complex Bonding Procedures-** Aligners can be used on patients for whom conventional fixed appliances are contra indicated, like metal allergies or enamel defects. Teeth with multiple restorations and crowns require extensive bonding techniques. Aligners accomplish movement of these teeth with greater convenience.
- **Fewer emergencies-** there are instances where the aligner may break or get lost, but neither situation requires immediate attention. Patients can either move on o the next aligner or schedule an appointment at their convenience.
- **Advantages with respect to root resorption, vertical control, periodontal health maintenance, parafunctional habits** have already been documented in orthodontic literature.
- **Visualization of planned treatment-** The CAD CAM aligners control tooth movements individually. The virtual setup acts as an important diagnostic tool and a source of motivation to patients.
- **Enhancing the scope of orthodontics-** Special patient population, like musicians who play instruments and athletes who risk breakages with conventional appliances, can receive orthodontic treatment with aligners. A study by Clear Aligner International states that, 70% of adults requiring some sort of orthodontic intervention refuse treatment due to visibility of appliances or bonded appliance concerns. Aligners offer this population the benefits of orthodontics.
- **Integrating Aesthetic Dental procedures-** Bleaching under supervision using aligners is very much a possibility and has been reported in literature.

Limitations of Aligner Therapeutics

Despite all the benefits of plastic aligners as an appliance system their limitations and specific constraints still limit their use as an appliance of choice, in contemporary practice.

- Aligners are removable and have the potential for misuse by patients.
- They are cumbersome for a few patients. People wearing sequential aligners have to carry them and maintain the wear schedule. Non compliant and careless patients may tend to lose the appliance once too often, compromising treatment.
- Aligners are expensive compared to conventional bracket treatment options. On the Indian terrain there is currently no service provider offering CAD CAM aligners. Thus, the cost to the clinician is almost four seven times the cost of the lingual appliance systems and almost seven-ten times the cost of a good ceramic bracket system.
- Limitations with respect to certain malocclusions and specific tooth movements have been deliberated earlier.
- There is a lack of operator control in CAD CAM appliances. Since the aligners in CAD CAM appliances are serially manufactured, they cannot be modified to a large extent without compromising upon the fit of the subsequent serial aligner in the event of non compliance, a patient receiving dental treatment or undesired treatment effects. A reboot of treatment, increasing treatment cost is then entailed.
- Commercial marketing of aligner systems moves it out of the exclusivity of the orthodontic domain. The laboratory systems have marketed themselves internationally and also within India to both orthodontists and general dentists, making the execution of tooth movement, out of the orthodontic specialist's purview in certain respects, having the potential of causing a dilution in the standards of orthodontic care.

Conclusion

India is a developing country with a vast population of young adults experiencing the effects of a vibrant economy. The social fabric is undergoing a metamorphosis, changing the profile of the way aesthetics and quality of life is perceived. The aware patient of today is ready to pay more and thus demands more out of the health care delivered. The “flaunt value “of orthodontic appliances, in the light of this evolving scenario, definitely plays an important role in contemporary practice.

Aligners are indeed the “new face” of the orthodontic therapy that serves to fuel the journey towards aesthetic harmony, structural balance and functional efficacy. They are positively tailored by a scientific rationale and technological research. Their scope, efficacy and benefits are now proven and here to stay, and it is up to the clinicians to judiciously apply the effects of this therapeutic modality to augment its place in orthodontic protocols!!!