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Separation Effects and
Dislodgement of Orthodontic
Separators.



Cranial Base Dimensions in Down
Syndrome: A Comparative
Cephalometric Study



Horizontal Reference Planes in the
Cephalometric Assessment of
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Case report: Non-surgical
Correction of Skeletal Anterior
Open-bite.



Orthodontic Management of an
Adult Patient

A Comparative Evaluation of the Separation Effects and Dislodgement Rate of Four Different Orthodontic Separators.

Oshomoji VO, Otuyemi OD, Kolawole KA

Abstract

Background: Recently, there have been a lot of discussions on the effectiveness of the different available separators used in the separation of teeth for the purpose of accurate and atraumatic banding during fixed orthodontic therapy. This prospective study compared four types of orthodontic separators (dumbbell elastomeric, round elastomeric, stainless steel, and nickel-titanium), their separation effect, the dislodgement rate, the effect of patient's age and gender on separation effect.

Methods: Fifty pre-orthodontic patients scheduled for fixed orthodontic treatment at the Obafemi Awolowo Teaching Hospital, Ile-Ife had four different types of orthodontic separators randomly placed in the mesial and distal interproximal contact points of each first permanent molar, in all the four quadrants. After five days of separation, the number and types of separator loss were recorded to assess the dislodgement rate. After separator removal, the separation effect for each type of separator was measured with a leaf gauge. Statistical analysis was done using ANOVA, and Tukey's tests were used to compare the mean separation effects with statistical significance set at $p < 0.05$.

Results: Dumbbell separators achieved the greatest mean separation effect (0.40mm), while nickel-titanium achieved the least (0.26mm). The dislodgement rate for dumbbell, round, stainless steel, and nickel-titanium separators were 7%, 2%, 0%, and 2% respectively.

Conclusions: Dumbbell separators achieved the most significant separation effect and may be useful in achieving greater separation effects. No separator dislodgement was observed with the stainless-steel separator. Separation effectiveness was not associated with age and gender differences.

Keywords: Orthodontic Separators, Separation effect, Dislodgement

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Introduction

Different types of orthodontic separators are widely used in the interproximal contact points of teeth to create space for accurate and atraumatic banding during fixed orthodontic therapy.^{1,2} An ideal separator needs to provide rapid and maximum separation with minimal separator loss.³ Many authors have reported that orthodontic separators vary in their effectiveness in terms of separation effects and rate of dislodgement.^{1,3-6} Malagann and associates reported that among four different types of separators, the dumbbell produced the greatest amount of

separation.⁶ Other studies concluded that the round elastomeric separators consistently produced a greater amount of separation than nickel-titanium (Neet), stainless springs, or brass wire separators.⁷⁻⁹

Most of the currently available separators have a major drawback in that they may dislodge from their position, resulting in separation failure.⁷ Studies by various researchers have indicated a wide variation in separator dislodgement rate from 0% to 16%.^{4,6-7} These wide variations have resulted in several controversies as to the effectiveness of the different separators used in pre-orthodontic treatment.¹

For more efficient clinical management of orthodontic patients, a refined protocol for separation should be determined for a patient, to guide the clinician in separator selection.

Therefore, the purpose of this study was to compare the rate of dislodgement, the separation effectiveness, effects of patient's age, gender, and anatomical (mesial or distal, maxillary or mandibular) placement of separators on the separation effectiveness of four types of orthodontic separators (dumbbell elastomeric, round elastomeric, stainless steel, and nickel-titanium metallic separators) during orthodontic tooth separation.

Materials and Methods

This prospective clinical study recruited 50 pre-orthodontic adolescent and adult patients at the Department of Child Dental Health, Obafemi Awolowo University Teaching Hospitals' Complex, Ile-Ife, Nigeria for a period of 12 months (May 2013 to April 2014). Ethical approval (ERC/2013/05/02) for the study was obtained from the Ethics and Research Committee of the Obafemi Awolowo University Teaching Hospitals' Complex, Ile-Ife, Nigeria. Written and informed consent was obtained from adult patients, parents, and assent from adolescents using the subject's informed consent/assent form.

Participants were informed about the purpose, procedure, benefits and risks associated with the study through the subject's information sheet and were further informed about the freedom of voluntary withdrawal from the study at any time without any consequences or penalty. The sample size was determined by a statistical formula for calculating sample size for comparative research studies proposed by Eng.¹⁰ The calculated minimum sample size required with a 10% attrition rate was 50 patients.

Inclusion criteria included all patients with a healthy periodontium as well as those with approximal contact points, with all the first permanent molars mesially and distally in all quadrants. Patients with a history of orthodontic treatment and missing or extracted teeth adjacent to the first permanent molar were excluded from the study.

The socio-demographic status (age and gender) of the patients was obtained using an interviewer-administered questionnaire. For this study,

categorisation of age into adolescents and adults was obtained from the rating index of adolescents (12-17 years) and adults (≥ 18 years) given in earlier extensive research work on the effect of age on the orthodontic procedure by Brown and Moerenhout.¹¹

The tightness of each contact point was confirmed by failure to pass a leaf gauge (Huffman Dental Products L.L.C., Springfield, OH, USA) between all the first permanent molars and the adjacent teeth. The leaf gauge consists of a series of plastic materials, each calibrated and arranged sequentially in ascending thickness, and expressed in millimetres to provide the metered separation with each leaf of 0.1mm thickness. All measurements were taken with each subject-seated upright in the dental chair.

Using the same manufacturer type of each separator for all the participants, the four types of separators; Dumbbell elastomeric (Five Star Orthodontic Products Denton, Texas USA), Round elastomeric (Ortho Technology Products Florida, USA), Stainless Steel (LaPorte Orthodontic Products USA) and Tru-flex Nickel-Titanium metallic separators (Ortho technology Products Florida, USA) were placed in the contact point of each participant (Figure 1).



Figure 1: Picture of the different separators and leaf gauge.

Each participant was instructed to randomly pick a paper from a basket containing four rolled papers, one at a time. This was done following the Federation of Dental Internationale, an international standard organization designation system of double-digit clockwise direction notation of quadrant.¹¹ The name (separator type) on the first randomly picked paper out of the four papers by all subjects was inserted at

the mesial and distal interproximal contact areas of the upper first permanent right molar (16). Subsequent randomly picked ballots were inserted at the mesial and distal interproximal areas of the upper left (26), lower left (36) and lower right first permanent molar (46).

The separators were inserted at the mesial and distal interproximal contact area of all first permanent molars using universal separation pliers (AEZ, Ormco, Glendora, CA, USA) for round, Mathieu steel for dumbbells, and Weingart universal pliers (Dentarium) for nickel- titanium and stainless steel.

The number and types of dislodged separators were recorded after five days of separation to determine the rate of dislodgement of the different separators. The separators were then removed with a curved probe (round elastomeric separators) and light wire pliers (dumbbell, stainless steel and nickel-titanium separators).

After this, an air spray was used to dry the interproximal contact of all first permanent molars, and the amount of separation gained for each separator was measured mesially and distally with the Huffman leaf gauge. Thus, the amount of mesial and distal separation effect respectively was measured twice for each separator. The mean value of the mesial and distal separation effect for each separator type represented the amount of separation effect for that separator type. The separation effect was not assessed in dislodged separators.

Statistical analysis

Data was analyzed with Statistical Package for the Social Sciences (SPSS version 22 Inc., Chicago, IL, USA). Descriptive statistics was carried out for socio-demographic variables such as age, sex, frequencies and percentages. Analysis of Variance (ANOVA) and Post hoc Tukey's multiple tests were used for pairwise multiple comparisons of the mean separation effects among the four separators with significant values set at $p \leq 0.05$. Independent sample t-test was used to determine the effect of gender and age on the mean separation effects of the different separators

Results

The mean age of the 50 participants (20 males and 30 females) was 21.70 ± 6.27 years. Thirty-three patients (66%) were from the adult group (≥ 18 years), while 17 (34%) were from the adolescent

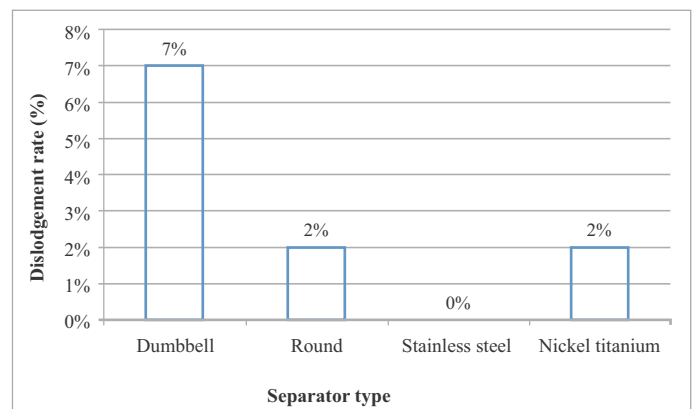


Figure 2: Comparing the rate of dislodgement in each separators

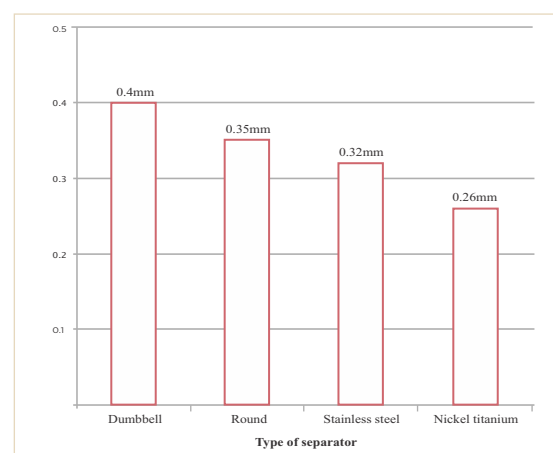


Figure 3: Comparing the mean separation effect of the four separators

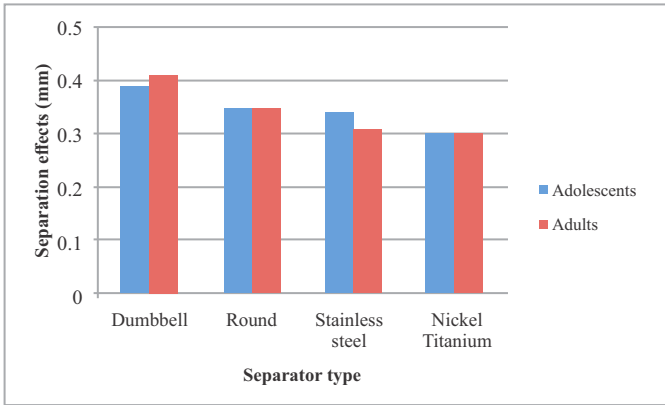


Figure 4: Effect of age on separation effects

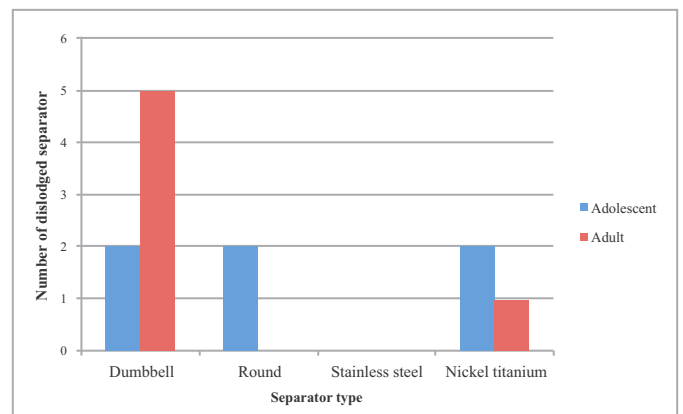


Figure 6: Effect of age on number of dislodged separators

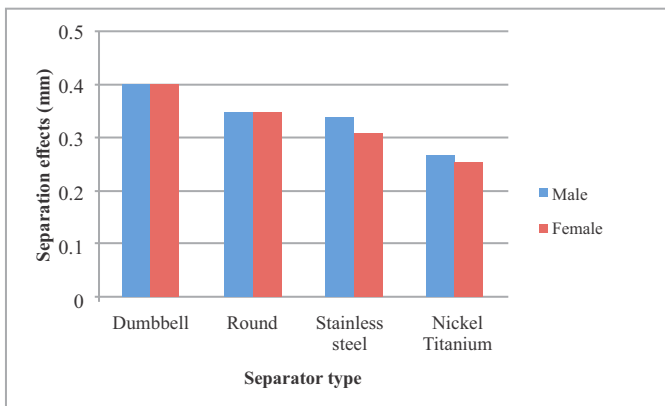


Figure 5: Effect of gender on separation

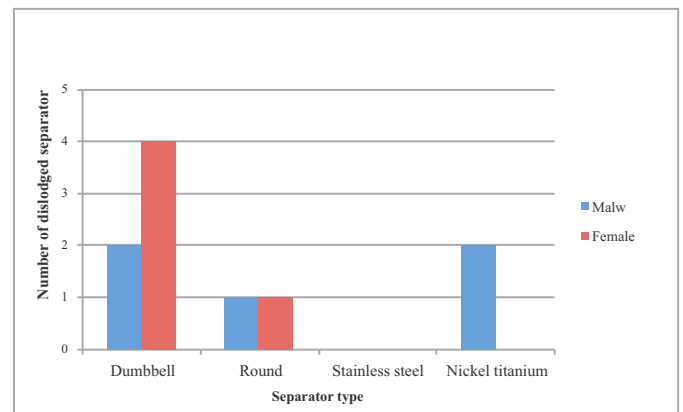


Figure 7: Effect of gender on number of dislodged separators

Table 1: Multiple pairwise comparisons of the mean separation effects of the four separators.

Dependent Variable	Separator Type	Separation effects (mm)		p-value
		Mean \pm SD	Mean difference \pm SD	
Dumbbell	Round	0.35 \pm 0.08	0.05 \pm 0.04	0.26
	Stainless steel	0.32 \pm 0.04	0.08 \pm 0.05	0.00*
	Nickel-Titanium	0.26 \pm 0.04	0.14 \pm 0.09	0.00*
Round	Dumbbell	0.04 \pm 0.10	-0.05 \pm 0.04	0.26
	Stainless steel	0.32 \pm 0.04	0.03 \pm 0.01	0.00*
	Nickel-Titanium	0.26 \pm 0.04	0.09 \pm 0.07	0.00*
Stainless steel	Dumbbell	5.13 \pm 3.06	-0.08 \pm 0.05	0.01*
	Round	3.42 \pm 1.98	-0.03 \pm 0.08	0.00*
	Nickel-Titanium	2.70 \pm 0.97	0.06 \pm 0.02	0.28
Nickel-Titanium	Dumbbell	5.13 \pm 3.06	-0.14 \pm 0.10	0.01*
	Round	3.42 \pm 1.98	-0.09 \pm 0.07	0.00*
	Stainless steel	2.75 \pm 0.97	-0.06 \pm 0.02	0.28

Post-hoc Tukey's multiple pairwise tests (significant level $p \leq 0.05$)

Table 2: Comparing the mesial and distal mean separation effect of the different separators

Separator	Mean separation effects (mm)		P-value
	Mesial Mean \pm SD	Distal Mean \pm SD	
Dumbbell	0.39 \pm 0.14	0.40 \pm 0.13	0.94
Round	0.34 \pm 0.11	0.35 \pm 0.08	0.84
Stainless	0.32 \pm 0.08	0.32 \pm 0.07	0.76
Nickel	0.25 \pm 0.08	0.26 \pm 0.06	0.62

Independent t-test $P < 0.05$

Table 3: Comparing the maxillary and mandibular mean separation effect of the different separators

Separator	Mean separation effects (mm)		P-value
	Mesial Mean ± SD	Distal Mean ± SD	
Dumbbell	0.40 ± 0.14	0.40 ± 0.19	0.64
Round	0.35 ± 0.12	0.35 ± 0.08	0.86
Stainless Steel	0.32 ± 0.09	0.33 ± 0.06	0.13
Nickel-Titanium	0.26 ± 0.04	0.25 ± 0.05	0.24

Independent t-test $P < 0.05$

Discussion

One of the most important stages at the very onset of fixed orthodontic appliance therapy is the creation of space at the interproximal contact points of the posterior teeth with the use of different types of orthodontic separators.¹ An ideal separator needs to provide rapid and maximum separation with minimal separator loss.³ This study compared the effectiveness of four types of orthodontic separators, with the dumbbell elastomeric separator achieving the greatest separation effect and the nickel-titanium metallic spring separator producing the least. This result is in agreement with the only study that compared the four separators in literature⁵. Thus, concerning the amount of separation generated, the dumbbell separator proved to be the most effective of all four types of separators used.

However, in our study, the amount of measured separation effect was greater for each separator type than in the earlier study done by Malagan and co-workers.⁶ This may be because the separation effect

in our study was measured after five days and not three days as in the case of the other study. Therefore, the separation effectiveness of orthodontic separators depends on the duration of separation.

Identical to the previous studies,^{4,6,7} our result showed that dumbbell and round elastomeric separators produced significantly greater separation effects than that derived from nickel-titanium and stainless-steel metallic separators. This has led to the greater use of elastomeric separators in clinical orthodontics. This greater separation effects of dumbbell and round elastomeric separators may be due to the presence of three-dimensional cross-link elastomeric chains that are formed during the vulcanization process at the manufacturing stage of elastomeric separators.¹³ This long polymer chain, which is absent in metallic separators enables elastomeric separators to quickly expand and retract back immediately after deformation, thereby resulting in a greater and more rapid separation effect.¹³

Although, previous studies^{4,6,7} have shown that the majority of the available separators were considered clinically equivalent by the ability to generate the 0.25mm separation benchmark required for adequate banding with all the four separators. However, consideration for a greater amount of separation of up to 0.4mm may be required especially in the separation of ectopically erupted molars.¹³ In such a situation dumbbell may be very useful in achieving a greater and more rapid separation effect.

This study was unable to establish any significant association between gender and separation effects. Identical patterns of lack of gender differences in separation effect had earlier been reported by other studies.^{4,6,7} No significant difference was observed in the separation effect between the adult and adolescents, however, there are no studies in the literature comparing the separation effect between the different age groups.

With the four separators used, in this study, no statistically significant difference was observed in the amount of separation between the upper and lower arches. In explaining similar findings, Kim and Jung concluded that there was no difference between the degree of interproximal tooth separation effect between the maxilla and the mandible.¹⁴ Similarly, no statistically significant difference was observed in the amount of separation at the mesial and distal interproximal contacts. This affirms the study done by Bondermak and co-researchers.³ This observation may be because the amount of separation effect generated by a separator is primarily a function of the type of separator used and its mechanical properties, rather than the anatomical location of the separator.

Premature dislodgement of separators leads to unproductive visits and time wastage, not only for the patients but also for the orthodontist.¹ In this

particular study, eleven separators were dislodged out of the total number of four hundred used. The rate of dislodgement in this study is higher than that observed in two other previous studies on the dislodgement rate of separators.^{4,8} The difference may be because these other studies considered only two types of separators and did not use dumbbell separators.

In this present study, seven of the eleven dislodged separators were dumbbells and most dislodgements with dumbbell separators occurred two days after insertion. This higher dislodgement rate of dumbbell separators is in accordance with the finding of a similar study reported by Malagan and co-workers⁶ This finding may be a reflection of the large and rapid amount of separation effect generated by dumbbell elastomeric separators within a short time. Thus, they are prone to become loose and fall out once they accomplish their separating effect.

There was no loss of separator with stainless-steel spring separator. This may be due to the presence of a connecting bar that prevents the dislodgement of stainless-steel separators, even after separation is complete. However, this finding is contrary to two other studies^{4,6} that recorded a 2% separator loss with a stainless-steel separator.

The rates of dislodgement for round and nickel-titanium were lower than that recorded by Cureton and Bice.⁷ This may be due to differences in the duration of separation and while this study was limited to five days; their study was conducted over a period of nine days. The longer the separator is kept in place the higher the chance of dislodgement. The dislodgement rate for the elastomeric round separator in this study was, however, similar to the previous study of dumbbell, round, nickel-titanium and stainless-steel separators by Malagan and others.⁶

Conclusion

Of the four separators studied, dumbbell elastomeric separators were the most effective in terms of separation effect while nickel-titanium achieved the least effect. Dumbbell separators recorded the highest dislodgement rate, while the stainless-steel separator showed no dislodgement. The patient's gender and age had no significant effect on the degree of orthodontic separation. There were no significant differences in the separation effect generated at the maxillary or mandible arch and in the mesial or distal interproximal contact areas

Recommendations

1. Dumbbell elastomeric separators may be useful to achieve a rapid and greater amount of separation

2. Dumbbell separators should be used for a shorter period of days (2 days) to prevent dislodgement or loss.
3. Stainless Steel separators may be useful in separation for a longer period of days without the risk of dislodgement.

Contributors

All the authors contributed to the design, data collection, analysis and write-up of the manuscript.

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Conflict of Interest

Nil

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- Double-space throughout including title page, abstract, text, acknowledgements, references, tables and figure legends. Start each of these sections (in same order) on a new page, numbered consecutively in the upper right hand corner, beginning with the title page.
- Use at least 12 point font size (Times New Roman or Arial).
- Submit photographs and transparencies in a separate heavy paper envelope (enclosed in cardboard, to prevent bending during mail handling).
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The page should contain (i) the title of the article: which should be concise but informative (simpler the title the better; preferably it should contain all the key words to help electronic retrieval reliably); (ii) a short

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Each manuscript should be accompanied with a structured abstract (divided into background, methods, results and conclusions) in no more than 250 words. Four to five key words to facilitate indexing should be provided in alphabetical order along with the abstract. The text should be divided in sections on introduction, methods, results, discussion and conclusion.

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Abstract and Key Words

The second page should carry an abstract in case of original article (250 words), review article (200 words), brief report (100-150 words), and case report (50 words), respectively. For original article and reviews, the abstract should be structured as detailed earlier. For brief reports, the abstract should state the purpose of the study, basic methodology, main findings (giving specific data and statistical significance) and key conclusion(s). Below the abstract, authors should provide 3-5 key words for indexing; terms from the Medical Subject Headings (MESH) list of Index Medicus should be used. The basic structure of a paper follows the well known acronym IMRAD, which stands for Introduction (what questions was asked), Methods (how was it studied), Results (what was found) and Discussion⁴.

Introduction

The introduction must clearly state the question that the author(s) tried to answer in the study. It may be necessary to briefly review the relevant literature. Only cite those references that are essential to justify the proposed study.

Materials and Methods

The methods section should describe, in a logical sequence, how the study was designed (e.g., how randomization was done), carried out (e.g., how subjects were chosen or excluded, ethical considerations, accurate details of materials used, exact drug dosage and form of treatment, etc.) and data were analyzed (e.g., an estimate of the power of the study, exact test used for statistical analysis, etc.). For standard methods, appropriate references are sufficient, but if standard methods are modified these should be clearly brought out.

Authors should provide complete details of any new methods or apparatus used (manufacturer's name and address in parentheses).

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When reporting experiments on human subjects, authors should indicate whether the procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional or regional) and with the Helsinki Declaration of 1964, as revised in 2000.

They should indicate whether the study was approved by the Institutions' Ethical Committee, and whether informed consent was obtained from the study participants. They should not use patients' names, initials, or hospital numbers, especially in illustrative material. This journal reserves the right to reject a manuscript on ethical grounds, on the basis of recommendations of its "Ethical Committee", even if the research has been cleared by the institutional ethical committee. Moreover, when reporting experiments on animals, authors should indicate whether the institutional and national guide for the care and use of laboratory animals was followed.

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Authors should describe statistical methods with enough detail to enable a knowledgeable reader with access to the original data to verify the reported results. When possible, they meet to quantify findings and present them with appropriate indicators of measurement error or uncertainty (such as confidence intervals). Actual P values are provided rather than stating as just <0.05 or >0.05 etc. References for the design of the study and statistical methods should be to standard works when possible (with pages stated) rather than to papers in which the designs or methods were originally reported. Any general-use computer programs used should be specified and statistical terms, abbreviations, and most symbols be defined.

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This section should include only relevant, representative data and not all information collected during the study. Major findings should be presented clearly and concisely. Text, tables, and illustrations should be used sensibly while avoiding repeating in the text all the data depicted in the tables or illustrations and emphasizing or summarizing only important observations. Tables and figures should be restricted to those needed to explain the argument of the paper and to assess its support. It is necessary to cite the tables in the text and type them on separate sheets. It may also be useful to mention what the study did not find.

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Discussion ordinarily should not be more than one third of the total length of the manuscript. This section should include a summary of the major findings, their relationship to other similar studies, limitations of methods and implications of these findings in future research. Conclusions should be linked to the goals of the study. Unqualified statements and conclusions which are not completely supported by the data should be avoided. Authors should also refrain from making statements on economic benefits and costs unless their manuscript includes economic data and analyses.

Acknowledgements

In acknowledgements section, it is suitable to list all contributors who do not meet the criteria for authorship, such as a person who provided purely technical help, writing assistance, or a department head who provided only general support. Financial and material support should also be acknowledged.

Groups of persons who have contributed materially to the paper but whose contributions do not justify authorship may be listed under a heading such as "clinical investigators" or "participating investigators", and their function or contribution should be described, for example, "served as scientific advisers", "critically reviewed the study proposal", "collected data", or "provided and cared for study patients". A written consent is required from all the persons acknowledged, indicating their acceptance for the same.

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In the case of multiple author-ship, authors are expected to state clearly their contributions to the paper being considered for publication in terms of study initiation, design including methodology, data collection, analysis and final write-up. The editorial board reserves the right to remove any author's name if the contribution is insignificant.

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Journal Article

List all authors when 6 or less. When 7 or more, list only first six and add et al. Ngan P, Yiu C, Hu A, Hagg U, Ei SHY, Gunel E. Cephalometric and occlusal changes following maxillary expansion and protraction. *Eur J Orthod* 1998; 20: 237-254.

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Each table should be typed in double-space on a separate sheet of paper. Tables not submitted as photographs must be numbered consecutively (Arabic numerals) in the order of their first citation in the text, with a brief but self explanatory title for each.

Each column should have a short or abbreviated heading. Explanatory matters are placed in footnotes, not in the heading. In footnotes all nonstandard abbreviations that are used in each table should be explained adequately. Statistical measures of variations should be identified such as standard deviation and standard error of the mean. Be sure that each table is cited in the text. If data are used from another published or unpublished source, it is necessary to obtain permission and acknowledge them fully.

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Figures should be professionally drawn and photographed; freehand or typewritten lettering is unacceptable. Instead of original drawings, X-ray films, and other material, sharp, glossy, black-and-white photographic prints of high quality are necessary, usually 127x 173 mm (5x7 in) but no larger than 203x254 mm (8x10 in) For color illustrations negatives or positive transparencies are provided, along with color prints. It is preferable to have the photograph in portrait form rather than in landscape form to fit easily into one column. Letters, numbers and symbols in photographs should be clearly legible.

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Measurements of length, height, weight, and volume should be reported in metric units, i.e., meter(m), gram(g), or liter(l) or their decimal multiples.

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Only standard abbreviations are used in the text while avoiding abbreviations in the title and abstract.

The full term for which an abbreviation stands should precede its first use in the text unless it is a standard unit of measurement. Year, month, day, hour, minute and second should be abbreviated as yr, mon, d, h, mm, and s in tables respectively.

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Appendix 1:

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