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EVALUATION OF TREATMENT OUTCOME WITH PALATAL PLATE VS CONVENTIONAL TOOTH BORNE ANCHORAGE IN CLASS III PATIENTS (CONTROLLED RANDOMIZED COMPARATIVE IN VIVO STUDY)

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ABSTRACT

Background: Patients with skeletal class III patients need early treatment intervention. Clinical dental adverse effects accompanied by skeletal orthopedic treatment need introducing new treatment modalities.

Aim: the purpose of this study was to compare the results of maxillary protraction in skeletal class III patients using facemask with two different intra oral anchorage devices.

Materials and methods: 14 growing patients with age range (9-12 years) were included in this study. Patients were diagnosed with skeletal class III deficient maxilla. All patients received face mask treatment; first group was treated using trans palatal arch (TPA) with hooks for face mask, while the second group was treated using mini screw retained palatal plate. Lateral cephalometric x ray before and after treatment measurements were measured, superimposed and compared using onyxceph software.

Results: first group (TPA) show statistically lower SNA amount of difference after treatment compared to palatal plate group, while SNB amount of difference was not statistically significant between the two groups. ANB amount of difference after treatment was statistically higher in palatal plate group than TPA group, Wits appraisal was not statistically different. Upper central incisor inclination was statistically significant lower in palatal plate group.

Conclusion: both groups were able to successfully be treated. Palatal plate group had advantage of less dental side effects.

Introduction

Skeletal class III can exhibit a variety of etiological factors including deficient maxilla, protruded mandible or a combination of them. Studies showed that around two thirds of skeletal class III cases were due to deficient maxilla either alone or accompanied by mandibular prognathism [1,2,3].

Skeletal class III malocclusion is one of the most challenging malocclusions in orthodontics. Early intervention is advised as unfavorable growth worsen the case which leads to reduced self-esteem, esthetics and difficulties in chewing function and speech. Moreover, early treatment reduces the future need for orthognathic surgeries [4,5,6].

Several treatment protocols were advocated using skeletal and dental anchorage. Face mask protraction is the golden treatment protocol in deficient maxilla growing patients either with or without expansion [7]. Face mask usually is used with conventional dental anchorage trans palatal arch. This dental anchorage led to some dentoalveolar side effects as extrusion and mesialization of upper first molar, proclination of upper incisors and retroclination of lower incisors [8,9].

Alternative treatments were studied to use skeletal anchorage in treatment of skeletal class III malocclusion. First class III intraoral elastics were attached to miniplates placed in the infrazygomatic region and the anterior portion of the mandible. Although this approach was successful it needed a moderate surgical intervention under general anesthesia [4,10,11].

Second when the patient suffers from constricted maxilla; face mask with rapid maxillary expansion protocol could be used and mini screw could be added to the hyrax to minimize the dental side effects. It did not need surgical intervention but it is preferably made

using surgical guide for mini screw positioning. This approach was effective for patients with constricted maxilla [10,11,12,13].

Lately a new approach was studied using a mini screw supported palatal plate instead of trans palatal arch with face mask for patients with normal maxillary width and it did not any need surgical procedure [(14)].

In this study face mask conventional dentally anchored trans palatal arch was compared to face mask skeletally anchored to minis crew supported palatal plate. Cone beam CT was used to precisely position the mini screws.

Aim:

Evaluation of treatment outcome with palatal plate vs conventional tooth prone anchorage in skeletal class III patients.

MATERIALS AND METHODS

This is a controlled randomized comparative in vivo study; using computer aided randomization method. Comparing between bone borne anchorage using palatal plate and mini screws versus conventional tooth borne (TPA) anchorage used with face mask in class III growing patients. This study was approved by the Research Ethical Committee of Quality Education Assurance Unit, Faculty of Dental Medicine, Cairo, Egypt. Approval code (P-OR-23-05).

A-Subjects:

Patients grouping and intervention:

According to statistical sample size calculation (power of study) 14 patients was randomly divided in to two intervention groups; to compensate for drop out patients; 25% was added ending to total number of 18 patients (9 patients in each group).

18 patients were selected according to the following criteria from those attending the outpatient clinic, Department of Orthodontics, Faculty of Dental Medicine, Al Azhar University Girls';

These patients were divided into two groups;

Group(A): patients were treated by conventional TPA (trans-palatal arch) with hooks for face mask and face mask.

Group (B): patients were treated by 3D printed palatal plate with hooks for facemask, fixed by four TADs (temporary anchorage device) on hard palate and face mask.

Inclusion criteria:

- Patients free from any systematic disease and in good health.
- Patients with skeletal class III malocclusion with retrognathic maxilla.
- Growing patients according to their lateral cephalometry using (CVM) cervical vertebrae maturation method.
- Patients with anterior crossbite to edge to edge bite.
- Patients without history of previous orthodontic treatment.
- Patients with Good oral hygiene.
- Patients having no anatomical anomalies or other craniofacial syndromes, ex: cleft lip or palate.
- Patients who are motivated to go through the treatment and cooperative.

B- Methods:

1-The aim and methods of the study was explained to the patients and consents were signed by all willing participants before being enrolled in the study.

2- The following records had been taken for each patient before treatment and after clinical examination;

- Orthodontic study model.
-Lateral Cephalometric Radiograph.
- Digital Panoramic Radiograph.
- Extra and Intra -oral photographs.
- CBCT in group (B).

3- All patients were assessed after orthopedic treatment and orthodontic treatment were started if needed.

4- All patients signed an informed consent, after clear explanation for the treatment procedures.

5-Subjects randomization:

According to the power of study calculations; sample of patients was randomly and equally divided in to the control group (A) and the study group (B) using Microsoft Office Excel (2010).

C- Fabrication steps:

- Alginate impression was taken for group(A) patients for TPA fabrication by conventional methods.
- Patients in group (B) were asked to make CBCT on maxilla for TADs position and length selection.
- For group(B) patients 3 D model scan was made. Study casts were prepared to scan with desktop 3D scanner to produce STL file (stereolithography file).
- The digital procedures workflow for group (B) patients; using ONYXCEPH ORTHODONTIC SOFTWARE; it begins with software interface that enable saving of patient's data and records;

name, age and gender, then we add 2d and 3d records (casts and x rays).

- For group (B) patients; using patient's virtual file on software cast superimposition on CBCT was made then appliance designing and positioning for tads in the palatal safe zone. According to available bone tads size were selected. All tads had the same diameter 1.7mm with different lengths according to available bone to protect the maxillary sinus and all vital structures. Inclinations were made during tad positioning to reach maximum available tad length without harming the sinus. These inclinations were made in the tad fitting part in the appliance to make sure that while inserting the tad it will be guide to its optimum position and inclination. Four tads were used with each patient making a trapezoid like shape in the hard palate safe zone (between upper canine and upper second premolar), figure (1). After selecting the position of the screws, the appliance was designed by connecting the four screws with arms forming a trapezoid like shape with a screw in each corner. From this trapezoid two arms on each side (right and left) will be extended; anterior arm between first and second premolar with hook for facemask elastics and a posterior arm resting occlusally on upper first molar helps in accurate positioning and opening the bite, figure (2).

D- Appliance placement:

- For group (A) patients; glass ionomer cement was used on upper first molar band to cement the TPA with hooks for facemask, then a removable posterior bite plane was used to open the bite anteriorly. Facemask was adapted on the patient face with occlusal table 0^0 to 30^0 to the occlusal plane according to the patients' bite. Force gauge was used to properly select the size of extraoral elastics to reach 500 grams per side. In each follow up visit the intra and extra oral appliances were checked they are in their place. Also, the elastics force was checked with force gauge and smaller elastics sizes were used when needed, figure (3).
- For group (B) patients; patient was first asked to use Hexitol mouthwash, then glass ionomer cement was used on the upper first molar occlusal bands. Four mini screws (anchor essential) were placed in place using straight screw driver under few drops of local anesthesia. Mini screw size varied according to each case. Flowable composite (VOCO) was then used to cover each screw head, figure (4). Facemask was adapted on the patient face with occlusal table 0^0 to 30^0 with the occlusal plane according to the patients' bite. Force gauge was used to properly select the size of extraoral elastics to reach 500 grams per side. In each follow up visit the intra and extra oral appliances were checked; they are in their place. Also, the elastics force was checked with force gauge and smaller elastics sizes were used when needed.
- All patients were asked to wear the facemask from 12 to16 hours per day, figure (5). They were asked to sleep with it and to remove during eating or when going out (school, lessons or sports).

E- Treatment duration:

Each patient had a file with his data and the exact date of appliance placement and removal after finishing treatment with face mask and gaining positive overjet. To compare treatment duration with facemask between the two research groups. Patients after phase one (facemask treatment) had fixed orthodontic treatment when needed. Patients were asked to wear a chin cup while sleeping, till age of 18 years old.

F- Follow up visits:

All patients were asked to fill in their note book how long they wore their appliance.

All patients were asked to come to the clinic every month to check the extra oral and intra oral appliances and to check the extra oral elastics and change the size to a smaller one when needed. When the force is less than 300 N).

G- Lateral cephalometry measurements:

Before and after lateral cephalometric x ray were superimposed using ONYXCEPH ORTHODONTIC SOFTWARE. The following measurements were taken by two different doctors. Skeletal (SNA, SNB, ANB), dental (upper incisor with SN plane and upper incisor with Frankfort plane).

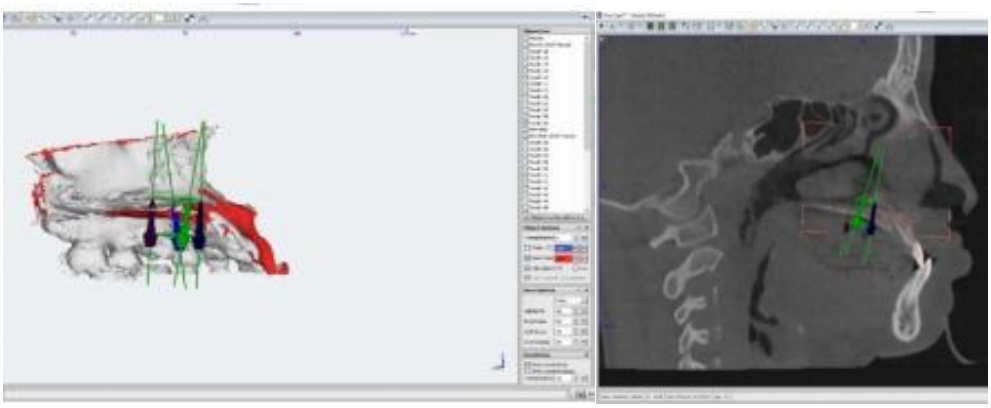

Figure 1. TAD position and length testing.

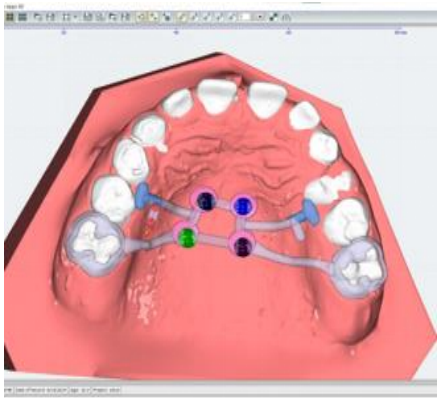

Figure 2. Appliance designing

Figure 3. TPA cementation

Figure 4 Palatal plate fixation

Figure 5. Patient wearing facemask

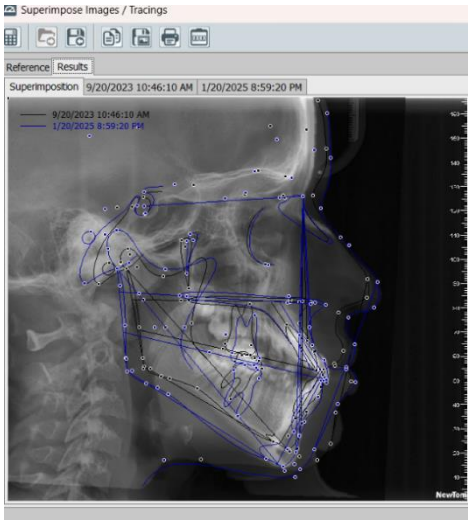

Figure 6. Onyxceph software used in cephalometric x-rays superimposition and measurements.

Statistical analysis:

Statistical analysis was performed using a commercially available software program (SPSS 20-Statistical Package for Scientific Studies, SPSS, Inc., Chicago, IL, USA) for Windows.

Numerical data were summarized using mean and standard deviation, confidence intervals and range. Data were explored for normality by checking the data distribution and using Kolmogorov-Smirnov and Shapiro-Wilk tests. Based on the parametric distribution of recorded pre and post data for SNA, SNB, U1/SN, U1/FH, nasolabial angle and duration; groups were compared using independent t test. Paired t test was used for intra group comparisons between pre and post treatment.

ANB and WITS showed a non-parametric distribution and were compared between groups using Mann Whitney U test, while Wilcoxon signed Rank was used for intragroup comparison between pre and post values.

The amount of difference between pre and post was calculated using the formula: (post-pre)

Data of the amount of difference for SNA, SNB, U1/SN, U1/FH and nasolabial angle showed a non-parametric distribution and therefore was compared between groups using Mann Whitney U test. Conversely, the amount of difference between pre and post values for ANB and WITS were normally distributed and were compared between groups using independent t test. Qualitative data (gender) were compared using chi square test. All p-values are two-sided. P-values ≤0.05 were considered significant.

Results

- **Demographic data:**

Age: The mean age of Palatal plate group was (11.14 ±0.9 years), compared to TPA group (10.29±0.76 years). The difference between groups was not statistically significant (p=0.08), (Table 1).

Gender: Palatal plate group consisted of 3 males (42.9%) and 4 females (57.1%), compared to 4 males (57.1%) and 3 females (42.9%) in TPA group. The difference between groups was not statistically significant (p=0.593), (Table 1).

Table 1. Demographic data and comparison of age (independent t test) and gender (chi square test)

	Groups	Value	test value	P value
Age (mean ±SD)	Palatal plate group	11.14 ±0.9	1.91	.08 ns
	TPA group	10.29±0.76		
Gender	Palatal plate group	Male: 3 (42.9%), Female =4 (57.1%)	.286	.593 ns
	TPA group	Male: 4 (57.1%), Female =3(42.9%)		

Significance level p≤0.05, ns=non-significant.

- **Amount of difference in SNA and SNB angles after treatment:**
  SNA: Palatal plate group recorded a median value= 6, with mean 6.02±1.88), which was significantly greater than TPA group recording a median value=2.95, with mean (3.12±1.43), (p=.015).
  SNB: Palatal plate group recorded a median value= .47, with mean (.34± .35), which was not significantly different from TPA group recording a median value= .50, with mean (.73±.75), (p=.442), figure (7).

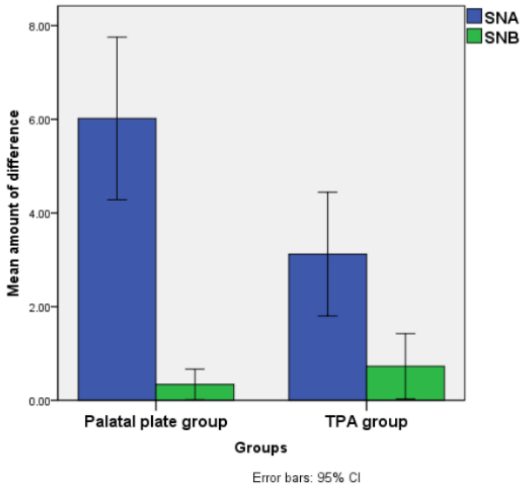

Figure 7. Bar chart illustrating mean value of amount of difference in SNA and SNB in Palatal plate group and TPA group.

- **Amount of difference in ANB angle and Wits appraisal after treatment:**
  ANB: Palatal plate group recorded a mean (6.26±2.08), which was significantly greater than TPA group recording a mean (2.93±1.07), (p=.003).
  WITS: Palatal plate group recorded a mean (12.47± 3.61), which was not significantly different from TPA group recording a mean (9.17±2.39), (p=.053), figure 8.

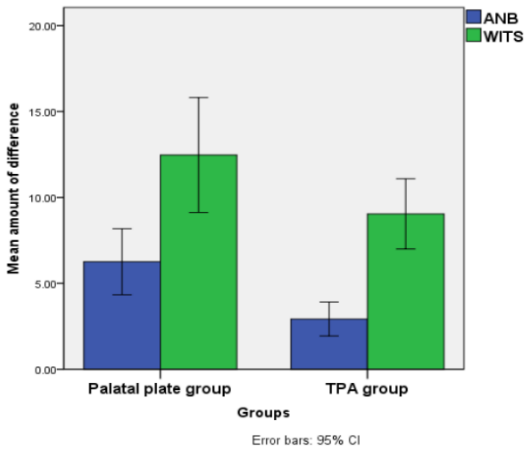

Figure 8. Bar chart illustrating mean value of amount of difference in ANB and WITS in Palatal plate group and TPA group.

- **Amount of difference in U1/SN plane angle and U1/Frankfort plane angle after treatment:**

U1/ SN: Palatal plate group recorded a median (.11) and a mean (-.89±2.89), which was significantly lower than TPA group recording a median (11) and a mean (15.22±9.38), (p=.001).

U1/FH: Palatal plate group recorded a median (.24) and a mean (-1.42± 4.19), which was significantly lower than TPA group recording a median (8.6) and a mean (9.91±4.62), (p=.000), figure (9).

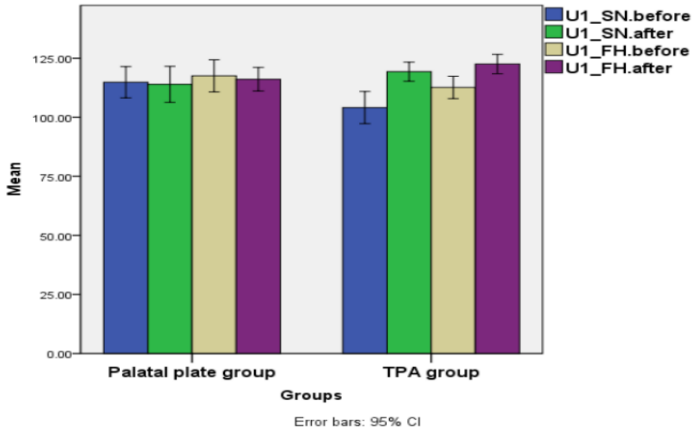

Figure 9. Bar chart illustrating mean value of amount of difference in U1/ SN and U1/FH in Palatal plate group and TPA group.

DISCUSSION

Skeletal Class III malocclusion (Cl III) presents a significant orthodontic challenge, particularly in growing patients, requiring interceptive treatment to achieve effective functional and aesthetic correction.

A change in the sagittal connection between the maxilla and mandible with mandibular protrusion, accompanied or not by retrusion (underdevelopment) of the upper jaw is referred to as skeletal class III malocclusion (Cl III). In the context of horizontal cephalometric analysis, key measurements include SNA, SNB, and ANB angles, which help assess the anteroposterior relationship between the maxilla and mandible. An ANB value of 2 ± 2 degrees typically indicates a Class I skeletal pattern, with deviations suggesting Class II (>4 degrees) or Class III (zero or less) [15,16,17,18]. These measurements help differentiate whether discrepancies in jaw relationships are due to excess or deficiency in the maxilla or mandible [19,20]. Additionally, the Wits appraisal offers further insight into the anteroposterior jaw relationship and skeletal divergence. Normal Wits values range from −1 mm ± 2 mm. A negative Wits value indicates increased divergence as the occlusal plane steepens [21,22]. These measurements were the main concern in this study to compare between the two study groups.

Functional appliances such as the Bionator or removable mandibular retractor (RMR), Frankel III appliance, reverse twin block (RTB), and orthopedic appliances, including FMs and the chin cup, have shown excellent results in correcting class III [23,24,25]. However, FMs indicated stronger skeletal effects in

maxillary protrusion, while RTB primarily revealed dentoalveolar alterations [26,27,28].

Nowadays, the combination of facial masks (FMs) and rapid palate expansion (RME) is the recommended treatment approach for correcting class III malocclusion in teenagers. Transverse palate expansion does not by itself result in increased maxillary protrusion [29,30].

To further encourage maxillary protrusion and enhance therapy results in Cl III patients, a novel method known as alternate rapid palate expansion and contraction (Alt-RAMEC) makes use of springs. Research has verified that the Alt-RAMEC approach in conjunction with FMs yields protrusion outcomes that are comparable to those of the conventional RME/FM protocol [31,32].

In situations when there is a maxillary deficiency, a FM for protrusion is advised. Unwanted side effects, including elevated facial height, excessive upper incisor proclination, and anterior displacement of upper molars, have been documented in trials that combine RME with dental anchoring. For Cl III patients with hyperdivergent growth patterns, the Hybrid Hyrax device with skeletal anchoring was created as an efficient substitute to lessen these consequences [33,34].

In a study by Lucia Cevidanes et al., two Class III correction protocols; first: Bone Anchored Maxillary Protraction (BAMP) and second: Rapid Maxillary Expansion with a face mask were compared in terms of dentoskeletal changes in patients. Results indicated that BAMP achieved superior maxillary advancement and midface lengthening, with greater vertical control than RME/FM, avoiding clockwise mandibular rotation. While RME/FM resulted in increased facial height and lower incisor inclination, BAMP reduced maxillomandibular divergence, showing more favorable control over mandibular rotation and vertical growth adjustments [35].

Several studies have reported periodontal damage from tooth-worn devices compared with the protocol on the bone. Because orthopedic force is transferred through skeletal anchorage, the risk of periodontal damage could be minimized with mini-implants anchored in the palate [36].

Also, Vaughn et al. compared the application of FMs with or without expansion. Patients were randomly divided into a group who received the FM with palatal expansion, a second group with the FM without palatal expansion, and a control group. Statistical analysis was executed with Student's t-test and showed no significative difference between the two groups with FMs with or without expansion, demonstrating that the early therapy with FM with or without expansion can be effective [37].

Lee et al. compared two types of face masks (PFFS and PTF) for Class III treatment, finding no significant differences except in overbite [38].

Husson et al. assessed FMs and rapid palatal expansion (RPE), noting both were effective for Class III, but the modified tandem appliance (MTA) outperformed the FM in controlling jaw rotation [39].

Seiryu et al. found FMs combined with mini-screws led to better skeletal outcomes with fewer side effects [(40)]. Liu et al. highlighted faster results with modified hybrid appliances compared to banded ones [41].

In 2024, this systematic review confirmed that traditional devices like the rapid palate expander (RME) and face mask (FM) remain effective for Class III treatment. However, innovative methods using skeletal anchors show significant benefits, including enhanced maxillary advancement and reduced dental side effects. The findings emphasize the importance of tailored device combinations based on individual patient needs, suggesting that a flexible and personalized approach may yield better results than standardized protocols [15].

Maxillary protraction using TADs is an efficient modality for growing patients with Class III malocclusion with maxillary deficiency. Palatal plates can provide anchorage for maxillary protraction. They require single and flap less placement compared with bilateral buccal plates and achieve the most desirable dentoskeletal effects compared with other appliances [(42,43)]. Our study evaluated the treatment effects of maxillary protraction using palatal plates.

Ngan et al demonstrated side effects such as extrusion of the molars in tooth-borne appliances. It seems to rotate the mandible clockwise. In contrast, palatal plate in our study minimized these side effects by using bone-borne appliances for maxillary protraction [44].

Regarding dental changes, palatal plate group showed no significant proclination of maxillary incisors (U1-FH). However, Cha and Ngan reported it increased by 1.6 + or - 4.4 in a miniplate group and 3.2

+ or - 4.1 in a conventional group. Therefore, maxillary incisor position with protraction using TSADs showed less protrusion tendency than conventional appliances [45].

You-Sun Lee et al, compared between palatal plate and hyrax tooth bonded both with face mask and concluded that facemask with palatal plate induced more maxillary advancement with less dental movement than conventional tooth-borne anchorage [46].

In this study the palatal plates had advantages such as flapless and single application and placement in tooth free bearing areas compared with other TSADs, which require bilateral invasive installation.

CONCLUSION

- Miniscrew retained palatal plate could achieve more maxillary protaction compared to transpalatal arch, although both of them were effective in retruded maxilla treatment
- Palatal plate showed minimum dental side effects compared to trans palatal arch group.

DECLARATION

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This research did not receive funding from any agency or institution.

Conflict of Interest
None to declare.

Patients consent
All the patients in this study have given their informed consent for publication.

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