THREE PIECE INTRUSION ARCH — Simplified
— A CLINICAL TIME AND MOTION STUDY

Authors:
Narayan Anjali, M.D.S.,
Senior Lecturer, M.R. Ambedkar Dental College

Joseph Sarojini, M.D.S.,
Professor, Oxford Dental College

Mohan K.A, M.D.S.,
Professor & H.O.D, M.R. Ambedkar Dental College

Abstract
The relationship of the maxillary incisors to the upper lip line is a critical factor that ensures a pleasing appearance. In clinical practice, the patients presenting with proclined incisors which are also erupted beyond the functional occlusal plane is common. Simple retraction or distal tipping of proclined incisors leads to further deepening of the bite and hence may not produce the ideal result. In this study, an appliance that can simultaneously intrude and retract incisors i.e., the three piece intrusion arch was analyzed in its efficacy in producing simultaneous intrusion and retraction in ten patients, who presented with maxillary incisors that were proclined as well as supra-erupted below the functional occlusal plane. Understanding the bio-mechanics of a system that produces simultaneous intrusion, retraction and translating the same into an efficient clinical appliance is important, for beginners. This article aims to simplify the concept with clinical evidence which gives a concept of the time and efficiency of the appliance.

Key Words
Simultaneous intrusion and retraction; three piece intrusion arch; time and motion study.

INTRODUCTION:
The new mantra in orthodontic practice is diagnosis based on the analysis of soft tissue as well as hard tissue parameters. The nasolabial angle is critical for an esthetically pleasing profile. The contour of the lips and its competency as well as the relationship of the maxillary incisors to the upper lip line is a critical factor that ensures a pleasing appearance. During the smile, the contour of the lower lip should conform closely to the incisal edges of the maxillary anterior teeth. At rest, an incisor exposure of 3mm is considered to be ideal. The reasons for excessive incisor display at rest may be attributable to the following soft tissue or hard tissue disharmony i.e.,

1. A short height of the philtrum of the upper lip,
2. Vertical maxillary excess,
3. Excessive clinical crown height, severely proclined incisors
4. Under-torqued maxillary incisors or
5. Over-eruption of maxillary incisors.

In the past, leveling procedures were being done by the injudicious use of continuous arch wires, which led to the extrusion of posterior teeth. The advent of improved diagnosis has evidence to show that depending on the growth pattern and the growth potential of a patient, different modalities of leveling should be instituted.

<table>
<thead>
<tr>
<th>Type of growth pattern</th>
<th>Growing patient</th>
<th>Non-growing patient</th>
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</thead>
<tbody>
<tr>
<td>Average grower</td>
<td>Molar extrusion / incisor intrusion</td>
<td>True Incisor intrusion</td>
</tr>
<tr>
<td>Horizontal grower</td>
<td>Molar extrusion</td>
<td>Mandibular Advancement And Molar Extrusion</td>
</tr>
<tr>
<td>Vertical grower</td>
<td>True Incisor intrusion</td>
<td>True Incisor intrusion</td>
</tr>
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Inter-occlusal space, convexity of the face, growth pattern of the patient and estimated growth remaining are excellent criteria that can be employed to select the criteria for leveling of the arches i.e., intrusion of anterior or extrusion of posterior segment.

Intrusion arches were first described by Burstone as a part of the segmented arch technique in 1977. Intrusive tooth movements appear to be most effective with low magnitude of forces of 12-15gms as suggested by Faber1. An essential feature of the intrusion arch is that it applies force via a single point of contact with incisors thereby making it a statically determinate force system. In the past, many intrusion arches have been described i.e., the Rickett’s utility arch, Connecticut intrusion arch etc., where in the intrusion arch was directly engaged into the brackets of the anterior segment thereby converting the force system into a statically indeterminate one1. Another problem that was found was that since the intrusive force was applied anterior to the center of resistance, the moment of the force was in a counter clockwise direction which resulted in labial flaring of the anterior segment as well.

Retraction or distal tipping of proclined incisors, which is a frequent problem leads to deepening of the bite and hence may prolong treatment time. An appliance that can simultaneously intrude and retract incisors is instrumental in shortening treatment duration. The simultaneous intrusion of the incisors along their long axis as well as their retraction can be achieved with the use of a three piece intrusion arch4. The low load deflection properties of the TMA wire; ensure delivering very light and constant forces, which minimizes the treatment side effects. The intrusive force components are engaged on to the distal extension of the anterior segment at a single point bilaterally, thereby providing a statically determinate force system.

A study was designed to analyze the efficacy of the three piece intrusion arch in achieving simultaneous intrusion and retraction of maxillary incisors that are proclined as well as supra-erupted below the functional occlusal plane. A time and motion study is one which measures the rate of tooth movement in a stipulated period of time.

AIMS & OBJECTIVES:
The aims of the present study were:

1. To formulate a treatment protocol for correction of deep bite and proclination using the three piece intrusion arch for single step intrusion and retraction of maxillary incisors.

2. To evaluate the amount of retraction (in mm) of the maxillary incisors achieved per unit time using the three piece intrusion arch.

3. To analyze whether the three piece intrusion arch can reduce treatment duration by the simultaneous intrusion and retraction of incisors.

MATERIALS & METHODS:
Sample Characteristics:
The present study was conducted on ten patients who reported to the Department of Orthodontics, M.R. Ambedkar Dental College seeking orthodontic treatment. The sample consisted of six females and four males with age ranging between 18-25 years.

Criteria for selection used:
- The patients were selected such that they would benefit from intrusion and retraction of the maxillary incisors during the process of their orthodontic treatment. Simple randomization was not followed and no control group was selected.
- The patients had pseudo dento-alveolar deep bite due to supra eruption of upper incisors > 3 mm with pronclination upper anterior teeth and overjet > 4 mm.
- All patients selected had an average or vertical growth pattern.
- The patient had class I or class II malocclusions with spacing or mild crowding.
- The patients had the upper incisal margins below the functional occlusal plane.
- They had fully erupted first and second molars.
- All the patients had a curve of spee > 2 mm and
- The patients had sufficient amount of alveolar bone trough in the maxillary anterior region.

Treatment sequencing used:
- The cases selected were both, first premolar extraction as well as non-extraction cases, provided that they benefited from intrusion and retraction of their maxillary incisors.
- All the cases were started using MBT bracket system with triple tubes on maxillary molars and double
tubes on mandibular molars and had a slot dimension of .022” x .028”.
- All the teeth including the second molars were strapped up.
- After initial alignment, individual canine retraction was done in all cases using sliding mechanics with active tie backs extending from the hook on the maxillary first molar tube to the distal hook of the maxillary canine.
- After the individual canine retraction was achieved, the canines were consolidated with the rest of the posterior teeth bilaterally.
- A lateral cephalogram was taken on a standardized cephalostat (EC Praline 00 machine) and center of resistance of the anterior segment was located. This cephalogram was later on used to compare the results with the post intrusion and retraction cephalograms. Pre and Post intrusion clinical photographic records were also taken.

The Three piece intrusion arch:
The Three piece intrusion arch was introduced in 1995 by Shroff, Lindauer, Burstone and Leiss for the purpose of simultaneous intrusion and retraction of flared anterior teeth as well as correction of their axial inclinations with good anchorage control. The premise on which the force application was based was that if intrusion along the long axis of the tooth is required, the intrusive force can be redirected lingually by the application of a mild distal force. An intrusive force alone produces proclination. A mild distal force along with the intrusive force results in the retraction of the anterior segment as well. (Fig.1, 2 & 3)

Components of three piece intrusion arch:
(Fig 5 – 5.4)
The three piece intrusion arch consisted of an anterior segment of .019” x .025” stainless steel wire and two bilateral .017” x .025” TMA tip back springs.

1. Anterior segment:
The rigid anterior segment consisted of a .019” x .025” stainless steel wire from 3M Unitek placed into the brackets of the incisors and stepped up gingivally distal to the brackets on the lateral segment. The wire was again bent to 90 degree slightly below the center of resistance and further angled downwards to end 2-3mm distal to the
center of resistance of the anterior segment. The angled posterior extension of the anterior segment allows the intrusive force to be applied along the axis of the teeth. The anterior portion of the anterior segment was contoured according to the arch form. The posterior extensions were adapted such that no soft tissue impingement was created.

2. The posterior segments:
The posterior segments were consolidated bilaterally from canine to second molar using a passive stabilizing wire of .019" x .025" stainless steel. They were further consolidated transversely using a .9mm hard temper stainless steel transpalatal arch (Fig. 4).

3. The intrusion springs:
The bilateral intrusion springs were made of .017" x .025" TMA wire. The tip back bends were incorporated mesial to the auxiliary tube on the maxillary first molars and the springs were inserted into the tube. The hooks which indicate the point of intrusive force application were bent at right angles and curved inwards and engaged on the posterior extension of the anterior segment at a point distal to the estimated position of the center of resistance of the anterior segment (i.e., distal to the lateral incisor).

4. Distal force component (elastic chain): An elastic chain is extended bilaterally from the molar hook to the posterior hook of the anterior segment. This small distal force directs the intrusive force so its line of action is lingual and parallel to the long axis of the incisors. A tip back moment is generated on the posterior segment. The anterior segment will be retracted as a result of small tip back moment created.

Fig. 4: Anchorage preparation: Double trans palatal arch with rigid consolidation of the posterior segments using .019" x .025" stainless steel wire.

Fig. 5.2: Anterior segment

Fig. 5.3: TMA intrusion springs
Anchorage Consideration:
The posterior segments of the maxillary arch comprising of the canine, premolar, first and second molars were consolidated firmly using .010" stainless steel ligature wires and a passive stabilizing wire segment of .019"x .025" stainless steel were from 3M Unitek was engaged in each posterior segment which offered adequate antero-posterior anchorage. The two segments were connected transversely by a single or double transpalatal arch of .9mm hard temper stainless steel extending from the palatal sheath of the maxillary first and second molar to the opposite side and this provided anchorage in the vertical plane.

Location of the center of resistance & determining the point of intrusive force application:
The center of resistance of the anterior segment was determined from the standardized lateral cephalogram taken after individual canine retraction. The center of resistance of the four incisors is usually estimated to be halfway between the crest of the alveolar bone and the apex of the lateral incisor root in the sagittal plane. This information was used clinically to establish the point of force application during intrusion mechanics.

For retracting and intruding flared anterior teeth, the intrusive force must be passed slightly lingual to the center of resistance and a mild distal component of force must be added to orient the force such that the intrusion occurs along the long axis of the incisors. This redirection of the force produces a clockwise moment created around the center of resistance of the anterior segment and results in retraction of the anterior teeth.

Engagement of the three piece intrusion arch & force calibration:
A calibrated Correx gauge was used to measure the amount of intrusive force being applied (Fig. 7). After the intrusion springs were inserted in the auxiliary tube and distal ends of the wire were cut such that 1mm of wire was projecting distally. The amount of force delivered was measured with a Correx gauge, about 30gms of intrusive force delivered per side i.e., a total of 60gms of intrusive force for the four maxillary incisors.

Dependent upon the distance, the same amount of force in grams was employed for the distal component on both sides after mildly pre-stretching the elastic chain (Fig. 8, 9).

The assembly was inserted and secured in place and a class I elastic chain was engaged to produce a mild
distal component of the force. The amount of space present between the height of Contour of the distal surface of the lateral incisor and the mesial surface of the height of contour of the canine as measured in millimeters using a calibrated Vernier Caliper (Fig. 10).

The patient was recalled after every 4 weeks and the distance between the lateral incisor and the canine was measured bilaterally using a Vernier Caliper and the elastic chain was changed when required by pre-stretching it first to deliver the required force.

At the end of the phase of intrusion another lateral cephalogram was taken on the standardized cephalostat and compared to the pre-intrusion cephalogram to evaluate cephalometrically the amount of intrusion that had been achieved. Any reciprocal extrusions of the posterior segment were also evaluated by comparing the pre and post intrusion cephalograms.

Treatment duration & treatment changes evaluation protocol:
The mean treatment duration was 6 months during which the patient was reevaluated every 4 weeks. The force levels were evaluated at every visit and the elastic chain replaced on occasions if the force levels had decayed significantly. The amount of space present between the height of contour of the lateral incisor and the canine was measured on every visit using the calibrated Vernier Caliper. At the end of the intrusion and retraction phase, post treatment records were taken.

Methods of evaluating treatment changes:
A total of five cephalometric variables which represented the treatment changes were analyzed on pre and post treatment cephalograms. The rate of intrusion was derived by dividing the mean amount of intrusion of the anterior segment by the mean treatment time recorded in millimeter per month.
Cephalometric landmarks

IE - The most incisal point on the crown of the most prominent central incisor
IA - Root apex of the most prominent maxillary central incisor
MBC - Mesiobuccal cusp tip of maxillary first molar
MBR - Root apex of the Mesiobuccal root of the maxillary first molar
ANS - Tip of the anterior nasal spine of the maxilla
PNS - Tip of the posterior nasal spine of the maxilla
N - Nasion point
HP - Constructed horizontal plane (7° to S-N plane)
N- - Perpendicular plane to the constructed horizontal plane through Nasion
UL₁ - Long axis of the maxillary central incisor
UL₆ - Long axis of the maxillary upper first molar

Superimposition technique

Cephalometric tracings were made on pre and post intrusion retraction cephalograms and were superimposed using position 3 of the Rickets 4 step position analysis. ANS – PNS were superimposed (palatal plane) and registered at ANS. The position of the maxillary molar was assessed to find out if intrusion and retraction of the incisors and extrusion and any distal tipping of the molars had occurred.

Assessment of treatment changes:

All angular measurement were made to the nearest 0.5°, horizontal and vertical measurement was made to nearest 0.1mm with a Vernier Caliper. The following variables were measured.

1. Maxillary incisor vertical movement \( U₁ \), Vertical / \( U₁ \) VER
2. Maxillary incisor horizontal movement \( U₁ \), horizontal / \( U₁ \) HOR
3. Maxillary incisor angular movement - \( U₁ \), angular / \( U₁ \) ANG
4. Maxillary molar vertical movement – \( U₆ \), vertical / \( U₆ \) VER
5. Maxillary molar angular movement – \( U₆ \), angular / \( U₆ \) ANG

Maxillary anterior segment changes:

\( U₁ \) VER = in millimeters represents the perpendicular distance between the incisal edge of the maxillary central incisor and the palatal plane (X axis). \( U₁ \) HOR = in millimeter represents the perpendicular distance between the incisal edges of the upper central incisors, to the perpendicular through nasion to the constructed horizontal plane (Na-) (Y axis). \( U₁ \) ANG = in degrees represents the angle between the long axis of the upper central incisor and the palatal plane.

Maxillary posterior segment changes:

\( U₆ \) VER = in millimeters represents the perpendicular distance between the mesiobuccal cusp tip of the upper first molar and the palatal plane. \( U₆ \) ANG = represents in degrees the angle formed by a line passing through the mesiobuccal root apex of the first molar with the palatal plane.

Statistical analysis:

1. All - Amount of anterior intrusion
2. AIR - Amount of incisor retraction
3. AME - Amount of molar extrusion
4. TI - Degree of incisal retraction
5. TM - Degree of molar distal tipping
6. T2-T1 - Time taken for incisor intrusion and retraction.

The mentioned variables were assessed from the cephalometric measurements. The amount of time taken for space closure was also tabulated. The data was analyzed using descriptive statistics such as mean, standard deviation (SD) and inferential statistics such as paired 't' test.

RESULTS:
The data obtained were analyzed using the SPSS version XI. The paired 't' test at 5% level of significance or 95% confidence limit was used to measure the changes that occurred in the variable due to treatment. The result obtained were demonstrated in the tables and plotted in graphs and were elicited below.

<table>
<thead>
<tr>
<th>Table I</th>
<th>Amount of incisor intrusion (All) (Mean value in millimeters)</th>
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<tbody>
<tr>
<td></td>
<td>Pre-treatment</td>
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<tr>
<td>Variable 1</td>
<td>29.97 ± 4.9</td>
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<table>
<thead>
<tr>
<th>Table II</th>
<th>Amount of incisor retraction (AIR) (millimeters)</th>
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<tbody>
<tr>
<td></td>
<td>Pre-treatment</td>
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<tr>
<td>Variable 2</td>
<td>9.8 ± 3.7</td>
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<thead>
<tr>
<th>Table III</th>
<th>Amount of molar extrusion (AME) (millimeters)</th>
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<tr>
<td>Variable 3</td>
<td>21.3 ± 3.9</td>
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</table>

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<tr>
<th>Table IV</th>
<th>Degree of incisor retraction (TI) (degrees)</th>
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<tr>
<td>Variable 4</td>
<td>125.6 ± 8.38</td>
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<tr>
<th>Table V</th>
<th>Degree of molar distal crown tipping (TM) (degrees)</th>
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</thead>
<tbody>
<tr>
<td>Variable 5</td>
<td>93.2 ± 6.1</td>
</tr>
</tbody>
</table>

The mean rate intrusion in millimeters per month was 0.5 ± 0.14 mm/month. The mean rate of retraction was 0.752 mm/month. The mean rate of molar extrusion was found to be 0.095 mm/month. The average rate of retraction (angular) of maxillary incisor measured in degrees was 1.09°/month. The mean rate of angular change showing the distal crown tipping of maxillary first molar was .23°/month.
DISCUSSION:
Smiling is a social requirement. The quality of smile greatly depends on the amount of display and protrusion of maxillary incisor

Deep bite which is aptly described as a sign and not the cause of a malocclusion is often a great challenge that an orthodontist has to overcome. When the deep bite is present in a patient with a vertical growth pattern with increased maxillary incisor display, intrusion mechanics is ideally instituted.

The result of the present study is discussed in terms of the various parameters i.e., incisor intrusion, incisor retraction, molar tip back and molar extrusion.

**Incisor intrusion:**
In this study, the maxillary incisors were intruded to a mean value of 2.73mm. The amount of intrusion achieved was considered highly statistically as well as clinically significant. The least value obtained in this study was 2mm which could be attributed to presence of a reduced amount of alveolar bone trough in this patient. The maximum amount of intrusion of 3.3mm could have been produced because of the favorable amount of alveolar bone trough existing in the patient and due to the low magnitude of forces used.

**Incisor Retraction:**
In this study, the average value of retraction was 4.17mm which was highly statistically as well as clinically significant.

The mean amount of angular retraction of incisors was 6.2 degree. In all the cases, retraction was terminated once the long axis of the maxillary incisor was parallel to the facial axis. The reason for achieving such a significant amount of retraction in the study could be due to the application of the force distal to the center of resistance of the anterior segment and its redirection along the long axis of the incisors using a mild distal force.

No flaring of the teeth occurred in this study as the intrusion springs were not engaged directly into the bracket slots and a single point of force application was utilized, thus minimizing the counter clockwise moment that tends to flare the anterior teeth. In single arch extraction cases-the residual space can be handled by:-

1. Adding 15°-20° palatal route torque to the upper incisors.
2. Stripping and retraction of the lower incisors with addition of 15° of labial route torque (Finishing and detailing of the occlusion in the MBT technique).

**Molar extrusion:**
The mean amount of extrusion was .52mm which though statistically significant is found to be clinically insignificant. The maximum amount of molar extrusion (0.7mm) seen in one patient may be attributed to her vertical growth pattern, and weak facial musculature that could not resist the reactionary extrusive forces. But this amount of extrusion was not large enough to cause any clinically visible amount of increase in the mandibular plane angle or a backward rotation or the mandible. The inclinations of canines bilaterally into the posterior segments have helped in reducing the reciprocal effect of extrusion on the buccal segments.

**Molar tip back:**
The reciprocal counter clockwise moments generated due to the intrusion arch normally tend to tip the crowns of the molars distally. In this study, a mean value of 1.2 degree molar tip back was found to occur. This value was considered statistically significant but is clinically insignificant. This also could have been minimized by the use of a more rigid stainless steel stabilizing wire.

In our study, we achieved significant amounts of intrusion and retraction. Though the reciprocal effects on the posterior segments were statistically significant, they were not clinically significant. Skeletal anchorage devices can be utilized to reduce the reactionary forces. Subsequently they have been shown as units for force delivery. In our study, the intrusive and retractive parameters were assessed based on the movement of the incisal edge of the maxillary incisors rather than the more stable point like the centroid of the maxillary incisor. Consequently, any loss of torque or tipping of the incisors, if it did occur, would have given us misleading figures regarding the net effective intrusion and retraction. Subsequent studies may be conducted where comparison of the amount of intrusion achieved with three piece intrusion arch and other modified intrusion arches could be made.

**SUMMARY AND CONCLUSION:**
From the results obtained in this study it was concluded that:

1. The treatment protocol formulated in this study for simultaneous intrusion and retraction was efficient and effective.
2. The amount of incisor intrusion was statistically as well as clinically highly significant.
3. The amount of incisor retraction (angular as well as linear) was highly significant statistically as well as clinically.
4. The amount of molar extrusion was statistically significant but clinically insignificant.
5. The amount of molar distal tip back was statistically significant but clinically insignificant.
6. The mean rate of intrusion was .5mm / month.
7. The mean rate of retraction was .75mm / month.

The three piece intrusion arch is a simple, cost effective and time saving appliance, the integration of which into the routine orthodontic practice offers benefits aplenty to an orthodontist. The beginner will know the realistic expectations of this appliance from this study.

Case-I: EXTRA ORAL, PRE-INTRUSION & RETRACTION PHOTOGRAPHS

Patient A presented with a Class II skeletal base, an average growth pattern and Angle's Class II Division I malocclusion with supra erupted maxillary incisors. Extraction of upper first pre- molars was followed by the use of three piece intrusion arch for simultaneous intrusion and retraction of maxillary incisors.

Frontal View

Lateral View

Pre-Intrusion & Retraction Cephalogram

Pre-intrusion & Retraction Photographs

Intra Oral Photographs at the time of Initial Placement Of Three Piece Intrusion Arch.

Intra Oral Photographs Post Intrusion & Retraction

Extra Oral Photographs-Post Intrusion & Retraction
Case-II: EXTRA ORAL PRE-INTRUSION AND RETRACTION PHOTOGRAPHS

Patient B presented with a mild Class II skeletal base and a vertical growth pattern having Angle's Class II division I malocclusion and supra-erupted maxillary incisors, but presenting with Class-I molar relation because of missing lower central incisor. Extraction of the upper first premolars was followed by simultaneous intrusion and retraction of maxillary incisors using the three-piece intrusion arch.

Frontal View  Lateral View  Pre-Intrusion & Retrusion Cephalogram

Pre-intrusion & Retraction Photographs

Intra Oral Photographs at the time of Initial Placement of Three Piece Intrusion Arch

Extra Oral Photographs-Post Intrusion & Retraction
Case-III: EXTRA ORAL PRE-INTRUSION AND RETRACTION PHOTOGRAPHS

Patient C presented with class I skeletal bases with an average growth pattern and had class I molar relation, spacing in the anterior region and supra-erupted maxillary incisors. Non-extraction therapy was followed utilizing three piece intrusion arch for simultaneous intrusion and retraction of maxillary incisors.

BIBLIOGRAPHY: