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Effects of total arch distalization on cephalometric and arch dimensions

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Abstract:

Despite the rising therapeutic use of IZC implants, existing literature largely focuses on sagittal dental movements while overlooking vertical skeletal and transverse arch alterations following total arch distalization. Therefore it is of interest to report the cephalometric changes and arch dimensional modifications following total arch distalization with infrazygomatic crest implants in skeletal Class I and Class II patients. A comprehensive understanding of these dimensional changes is critical for accurate case selection, optimal biomechanical planning and predicting treatment outcomes. Pre-treatment and post-treatment lateral cephalograms were compared after en-masse maxillary arch distalization with bilateral IZC implants. There were significant improvements in cephalometric measurements related to the nasolabial angle, mandibular plane angle, lower facial height and PTV, with no significant vertical changes in the positions of the maxillary incisors and molars relative to the palatal plane, indicating effective vertical control.

Keywords: Infrazygomatic crest (IZC) implant, total arch distalization, skeletal anchorage, cephalometric analysis, Class II malocclusion

Background:

The concept of total arch-distalization has garnered significant attention due to developments in orthodontic biomechanics and anchorage methods. Total arch distalization entails the concurrent distal displacement of the entire maxillary dentition, comprising molars, premolars, canines and anterior teeth. This technique enables orthodontists to correct Class II dental malocclusion, reduce severe overjet and relieve mild to moderate crowding without the need for tooth extraction [1]. Another important advantage of total arch-distalization is the better control of the dental and skeletal relationships during the therapy. Properly planned and carried out distal movement of the entire maxillary arch may correct molar relationships, improve incisor position and improve facial balance. This technique is very helpful for patients with mild to moderate skeletal deformities that are unlikely to require surgery [2]. Interest in non-extraction orthodontic treatment methods has increased in contemporary orthodontics and this has led to the emergence of total arch distalization as a key approach [3]. A complete understanding of the biomechanical principles, indications, advantages and limitations of this therapy is necessary for good treatment results. Further studies and clinical evaluations are required to determine the effectiveness, efficiency and permanency of the maxillary arch distalization techniques [4]. Infrazygomatic crest (IZC) anchorage for distalization of the maxillary arch is associated with various dentoalveolar and vertical changes which aid in correction of Class II malocclusion. The mechanics of distalization could potentially influence the dimensional features of the maxillary arch [5]. As posterior teeth drift distally, an increase in space within the dental arch is frequently observed and changes in arch length and arch perimeter are often noted. This newly created space can be utilized to help align the crowded teeth and treat protrusion of incisors without extraction therapy [6]. In addition, minor changes in arch width may occur depending on the design of the archwire and the amount of transverse control during treatment. The stability of the arch form is a significant factor to minimize the recurrence after orthodontic treatment [7]. Competent treatment planning and biomechanical regulation of

IZC-assisted maxillary arch distalization require knowledge of changes in incisor inclination, molar angulation, arch dimensional features and vertical dimension. Close monitoring during treatment allows the clinician to encourage controlled tooth movement and to minimize adverse effects, thus improving functional and aesthetic outcomes [8]. There is increasing therapeutic application of IZC implants, but there is a lack of literature evaluating cephalometric vertical changes and arch dimensions after total arch distalization. The majority of the published studies have mainly focused on sagittal dental movements with relatively less attention paid to vertical skeletal consequences and transverse arch alterations [1]. Therefore, it is of interest to report the cephalometric changes and arch dimensional modifications following total arch distalization with infrazygomatic crest implants in skeletal Class I and Class II patients.

Materials and Methods:

The study design was to evaluate the cephalometric parameters and maxillary arch dimensional changes after total arch-distalization using Infrazygomatic crest implants in skeletal class 1 and 2 patients. Lateral cephalograms and maxillary casts were obtained from the patients who reported to the Department of Orthodontics & Dentofacial Orthopaedics, P. S. M College of Dental Science & Research, Akkikavu, Kerala. The study commenced after obtaining a certificate of approval from the institutional Ethics Committee (704/Ethics/PSMCD SR/2023). Sample size was calculated using $N = 2((Z_{\alpha/2} + Z_{\beta})^2 / \Delta^2)$. A total minimum calculated sample size of 16 (8 in each group) would be required to yield 80% power to detect a significant difference, with an effect size of 1.35 and a significance level of 0.05 (5%). The inclusion criteria were: patients with a mean age of 18–30 years, those with Angle's class I or class II malocclusion without any distal appliance other than miniscrews used during distalization phase, a full complement of permanent teeth and good patient compliance during the treatment with good oral hygiene. The exclusion criteria were patients indicated for extraction treatment, patients showing symptoms of temporomandibular disorders, periodontal diseases, skeletal

facial asymmetry or bruxism. Based on convenience sampling, 16 lateral cephalograms (pre-treatment and post-treatment) and study models (pre-treatment and post-treatment) of orthodontic patients who reported to PSM Dental College and satisfied the inclusion & exclusion criteria were selected. Lateral cephalograms had obtained before (T0) and after (T1) maxillary arch distalization using the NewTom GiANO HR machine. The radiographic magnification of the cephalograms was standardized to 100% of the actual size, with a 100-mm metal ruler included in the digital image as a reference. Vertical dimensional changes were assessed by tracing the pre- and post-distalization lateral cephalograms. Study models were analyzed to evaluate arch width changes following total arch distalization. All selected patients underwent comprehensive pre-treatment record collection, including lateral cephalograms and maxillary study models (T0). Fixed orthodontic appliances with MBT prescription (0.022" slot) were bonded in the maxillary arch. Initial leveling and alignment were carried out using a sequence of nickel-titanium archwires, followed by rectangular stainless steel archwires (0.017" × 0.025") to achieve adequate torque control before distalization. Subsequently, infrazygomatic crest (IZC) implants (diameter: 2 mm; length: 12 mm) were placed under local anaesthesia in the infrazygomatic crest region, usually above the maxillary first molar area, with an angulation of approximately 55°–70° to the occlusal plane to obtain optimal engagement of cortical bone. Immediate loading of implants was carried out following placement. En-masse distalization of the maxillary arch was then initiated using nickel-titanium coil springs attached between the IZC implant and archwire hook. A force of approximately 200–250 grams on each side was applied and measured using a Dontrix gauge. IZC implants provided absolute anchorage, thereby reducing unwanted reciprocal tooth movement to a minimum. Patients were reviewed at monthly intervals for reactivation of distalizing force and regular monitoring of treatment progress. Distalization was continued until a Class I molar relationship or desired amount of distal movement had been achieved. Following completion of distalization, post-treatment records (T1), including lateral cephalograms and maxillary study models, were obtained. These records were subsequently used to assess changes in cephalometric parameters as well as maxillary arch dimensions after total arch distalization. Skeletal changes will be determined by the following cephalometric parameters: mandibular plane (Gonion to Gnathion) to SN plane, lower facial height (Anterior Nasal Spine to Menton), pterygomaxillary fissure vertical line (PTV) to most prominent distal surface of the upper first molar, PTV to point A, palatal plane to edge of upper incisor, palatal

plane to distal cusp tip of upper first molar, nasolabial angle. Arch width changes will be determined by the following study model measurements: according to James A. McNamara Jr., intercanine width was evaluated by measuring the linear distance from the cusp tip of the left and right canines on study models. According to Pont, Intermolar width is measured as the linear distance between the central fossae (central grooves) of the right and left maxillary first permanent molars.

Statistical analysis:

All collected data were systematically entered into Microsoft Excel and subsequently analyzed using IBM SPSS Statistics Version 24.0. The paired t-test was used to contrast the pre-treatment and post-treatment results in the same subjects at 5% level of significance.

Results:

In the present investigation, some cephalometric parameters showed significant alterations after treatment. There was significant improvement in the nasolabial angle from 101.31° to 105.5° ($p < 0.001$) with significant improvement in the soft tissue profile and facial esthetics. There was a significant decrease in the mandibular plane to SN angle from 32.5° to 30.5° ($p < 0.001$). Likewise, the lower facial height decreased from 60.000 mm to 58.63 mm ($p < 0.001$), indicating improved vertical facial proportions and skeletal harmony. Additionally, there have been substantial changes to the maxilla's position. There was a decrease in the distance from the vertical line of the pterygomaxillary fissure (PTV) to point A, from 48.13 mm to 46.38 mm ($p < 0.001$), indicating good anterior maxillary retraction. Significant reduction was observed in the distance between PTV and distal cusp of upper molar from 18.88 mm to 16.75 mm ($p < 0.001$), indicating successful molar distalization and efficient space management. No statistically significant changes in vertical dental measurements were found. Distance from palatal plane to upper incisor decreased from 27.5 to 26.13 ($p=0.231$). Distance from palatal plane to upper molar decreased slightly from 19.56 to 19.38 ($p=0.535$). The results showed that the treatment was relatively stable in the vertical dental positions without significant undesirable vertical changes (**Table 1**). In respect of dental arch dimensions, there was significant transverse expansion. There was an increase in intercanine width from 33.63 mm to 34.88 mm ($p < 0.001$) and intermolar width from 46.63 mm to 47.69 mm ($p < 0.001$). These results indicate an improvement in the arch width and dental alignment and in the overall transverse development (**Table 2**).

Table 1: Summary of lateral cephalometric variables employed in the study

Variable	Pre-treatment (Mean±SD)	Post-treatment (Mean±SD)	Mean Diff.	95% CI	t-value	p-value
Nasolabial Angle (°)	101.31±6.55	105.50±6.09	+4.19	(3.51,4.87)	13.12	<0.001*
Mandibular Plane to SN (°)	32.50±3.61	30.50±3.31	-2	(-2.95,-1.05)	-4.47	<0.001*
Lower Facial Height (mm)	60.00±7.73	58.63±8.28	-1.37	(-1.99,-0.76)	-4.79	<0.001*
PTV to Point A (mm)	48.13±2.85	46.38±2.53	-1.75	(-1.99,-1.51)	-15.65	<0.001*
Palatal Plane to U1 (mm)	27.50±7.21	26.13±5.07	-1.37	(-3.72,0.97)	-1.25	0.231
Palatal Plane to U6 (mm)	19.56±2.47	19.38±2.14	-0.18	(-0.82,0.44)	-0.63	0.535
PTV to U6 Distal (mm)	18.88±3.32	16.75±2.97	-2.13	(-2.62,-1.63)	-9.22	<0.001*

$p < 0.01$ – statistically highly significant

Table 2: Statistical analysis of maxillary arch expansion

Variables	Pre-Treatment (Mean ± SD)	Post-Treatment (Mean ± SD)	Mean difference	95% CI	t-value	p-value
Inter canine Distance (mm)	33.63±1.69	34.88±1.48	+1.25	(0.65,1.85)	4.44	<0.001**
Inter molar Distance (mm)	46.63±2.59	47.69±2.16	+1.06	(0.69,1.44)	6.04	<0.001**

Discussion:

This prospective study evaluated the cephalometric changes after total arch distalization with infrazygomatic crest (IZC) implants in skeletal class I and class II patients. The results showed a significant sagittal correction, good soft tissue change and vertical control was effective too. These findings are in agreement with the growing evidence that extra-alveolar skeletal anchorage is a predictable non-extraction treatment modality for mild to moderate Class I and Class II malocclusions in adult patients [9]. The primary benefits of IZC implants are their absolute anchorage, which is not dependent on the dentition. Traditional distalizing appliances need patient cooperation or dental anchorage. On the contrary, IZC implants allow for en-masse distalisation of the whole maxillary arch with minimal anchorage loss [10]. Due to their position in dense cortical bone, they are suitable for immediate loading and efficient transmission of orthodontic forces, thus allowing greater distal movement with minimal unwanted reciprocal effects [8, 11]. In this study, the significant reduction of the PTV-upper molar distance suggests an effective distalization of the maxillary dentition, which is in line with prior findings indicating the efficiency of IZC-supported mechanics [12, 13]. There was a significant reduction in the distance between PTV and Point A, suggesting that distalization can induce some skeletal adaptation in addition to dentoalveolar movement. The main effect of orthodontic distalization is tooth movement, but the alveolar bone remodelling around the anterior maxilla may have a role in a minor posterior repositioning of point A. Similar results were reported by a prior study [8] with little skeletal modification with total arch distalization with infrazygomatic crest anchorage. These skeletal adaptations improve sagittal relationships without orthognathic surgery. Controlling the vertical dimension is one of the most difficult problems in maxillary distalization, as conventional distalizing appliances tend to cause molar extrusion, clockwise mandibular rotation and an increase in lower facial height [14]. In the present study, however, no statistically significant change was observed in the vertical position of the upper incisors or molars relative to the palatal plane, which shows excellent vertical control during treatment. These results validate the biomechanical principle of the possibility for the distalizing force to bypass the center of resistance of the maxillary dentition with extra-alveolar anchorage, thus reducing the extrusion and uncontrolled tipping. Similar results were also reported in the literature, which pointed out that skeletal anchorage systems provide better vertical control than conventional distalization methods [15]. The large reduction of the mandibular plane angle in the present study supports the effectiveness of the IZC-supported distalization in controlling the vertical skeletal dimension. The treatment produced a slight counterclockwise rotation of the mandible, rather than the clockwise mandibular rotation usually desired in patients with increased vertical dimensions. This is in

agreement with the results of Wani *et al.* [16] and Shaikh *et al.* [12], who have shown that IZC mechanics can simultaneously achieve distalization and slight intrusion of posterior teeth, which leads to reduction in mandible plane angle and improvement in facial proportions. The lower facial height was also significantly reduced after treatment. Excessive vertical growth is undesirable because it may unfavourably affect facial esthetics and occlusal stability. Maintenance or reduction of lower facial height is desirable clinically. The use of extra-alveolar skeletal anchorage is an effective technique to reduce the vertical side effects of distalization avoiding posterior dental extrusion [17]. Therefore, these present results further support the use of IZC implants in patients who need combined sagittal correction and vertical control. An important soft tissue finding was revealed in the present study, *i.e.* a statistically significant increase in the nasolabial angle. The change was a posteriorly moved maxillary anterior teeth and resultant decrease in the upper lip prominence with an improved facial profile. The improvement of the esthetics of the face is one of the main goals of orthodontic treatment, especially in adult patients who want to undergo a non-extraction therapy. Similar improvements in nasolabial angle and upper lip position have been reported following total arch distalisation with skeletal anchorage [18]. The results showed that distalization with IZC are effective in improving soft tissue balance without affecting lip competence. The lack of detectable vertical changes in the position of the upper incisors also indicates that good torque control was maintained throughout treatment. Rectangular stainless steel archwires were used in the present study before distalization for the controlled bodily movement of the anterior teeth. Chang *et al.* [19] reported that the accurate torque expression with skeletal anchorage can reduce the uncontrolled tipping of incisors during en-masse distalization thereby improving the treatment efficiency and long-term stability. The main objective of the present study was, however, a cephalometric evaluation and total arch distalization can also affect maxillary arch dimensions. Previous 3D studies have demonstrated that distalization using IZC implants and coordinated archwires produced only minor alterations in intercanine and intermolar widths, indicating maintenance of the transverse arch shape [8, 12 and 20]. The recognition that excessive transverse constriction may predispose to relapse after treatment further underscores the importance of maintaining arch dimensions [21]. Future studies with combined analysis of digital models and imaging with CBCT may shed more light on the association between the cephalometric changes and arch dimensional stability after IZC-supported distalisation. The present study has important clinical implications. IZC is an effective non-extraction alternative for total arch distalization in adult patients with skeletal Class I bimaxillary protrusion and mild to moderate skeletal Class II malocclusion. The technique offers excellent anchorage control and predictable tooth movement without the need for patient

compliance associated with headgear or removable distalization appliances. In addition, the positive vertical changes observed suggest that the use of IZC implants could be particularly beneficial for patients with borderline hyperdivergent growth patterns where vertical control is critical. The study has certain limitations. A small sample size and the absence of a control group limit the generalizability of the findings. Furthermore, the assessment of the cephalometric analysis was limited to two-dimensional analysis, which cannot analyse the transverse skeletal changes, root position or alveolar remodelling. More randomized controlled trials with larger sample sizes, long-term follow-ups and three-dimensional CBCT assessments are required to evaluate the treatment stability, root integrity and maxillary arch dimension changes following distalization with the support of IZC.

Conclusion:

Total arch distalization by infrazygomatic crest (IZC) implants is an effective and predictable modality of treatment of skeletal Class I and Class II malocclusions. The technique resulted in evident distalization of the maxillary dentition with favorable sagittal skeletal changes and improved soft tissue profile as evidenced by increased nasolabial angle. Excellent vertical control was maintained throughout treatment with no significant extrusion of maxillary incisors or molars and favorable decreases in mandibular plane angle and lower facial height.

Advancement to knowledge:

Total arch distalization using infrazygomatic crest implants is a predictable and effective treatment for skeletal Class I and II malocclusions. It produces significant maxillary distalization, favorable sagittal skeletal changes and improved soft tissue profile, with increased nasolabial angle. Vertical control remains stable, with minimal extrusion and slight reductions in mandibular plane angle and lower facial height. Overall, IZC anchorage enables controlled en-masse movement with fewer unwanted vertical effects than conventional mechanics.

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