

## A Review on Transverse Discrepancies

Mayithiri Balaji<sup>1</sup>, Ashith M.V<sup>1\*</sup>, Amoli Singh<sup>1</sup>, Siddarth Shetty<sup>1</sup>, Harshit Atul Kumar<sup>1</sup>

1. Department of Orthodontic and Dentofacial Orthopedics, Manipal College of Dental Sciences, Mangalore ,Manipal Academy of Higher Education, Manipal, India.

### Abstract

Transverse skeletal changes involving maxilla occurs first, followed by vertical and horizontal changes. Transverse changes present as solitary or in significance to other change and are of either skeletal or dentoalveolar in origin, but mainly are the results of a slight or severe constriction of the maxilla that leads to either unilateral, bilateral or unilateral functional crossbite and may be associated with Class III malocclusion or Class II malocclusion.

The article highlights the development, types, diagnosis and assessment, treatment and correction of transverse discrepancies.

It is important for the practitioner to understand the diagnostic processes involved in evaluating a crossbite to arrive at a diagnosis for effective and efficient treatment.

Review (J Int Dent Med Res 2023; 16(3): 1302-1308)

**Keywords:** Crossbite, Transverse discrepancies, Diagnosis, Assessment, Treatment.

**Received date:** 15 April 2023

**Accept date:** 09 August 2023

### Introduction

Crossbite is defined - 'a transverse discrepancy in tooth relationship' – British Glossary of Dental Terms<sup>1</sup>

Prevalence Rate:<sup>1</sup>

1. Foster et al reports that crossbites affects 8-16% of the population

2. Negligible difference between race and gender

3. 80% linked to mandibular displacement  
Crossbite of buccal occlusion is manifested as transverse dimension that primarily accounts to posterior occlusion along with any discrepancy. It is interrelated to vertical and sagittal dimensions and accordingly may have skeletal/dental or both components. It will clinically present as a bilateral or unilateral crossbite involving single or multiple teeth.

Primary and mixed-dentition stages are where transverse problems of maxillary and mandibular arches occur most frequently<sup>2</sup>. Transverse discrepancy does not correct by itself

and studies have shown that correction of transverse discrepancy in early phase of mixed dentition is beneficial for patient in long run.

To achieve an ideal and perfect occlusion, the buccolingual inclinations of teeth in the posterior region is important. Dental casts and posteroanterior cephalograms are used to determine the inclinations but the methods have intrinsic limitations<sup>3</sup>.

Study casts, in an absolute transverse discrepancy, determine whether origin of discrepancy is dental or skeletal along with magnitude of discrepancy<sup>3</sup>.

PA cephalograms have restricted value when evaluating discrepancy without asymmetry due to superimposition of structures and teeth which thereby decreases reliability of the method. In recent times, cone beam computed tomography aids in assessing angulation and inclinations of the tooth precisely.

Diagnosis and treatment planning of transverse discrepancies deserves more attention, as facial growth in the transverse dimension is completed first<sup>4</sup>.

Development of a transverse problem:

Southard et al reported that etiologic factors of transverse discrepancies include:

- 1) Ectopic tooth eruption
- 2) Imbalance of soft tissue (ex: continued digit sucking)
- 3) The prolonged retention of the primary teeth
- 4) Asymmetrical growth of mandible

#### \*Corresponding author:

Dr. Ashith M.V,  
Professor, Department of Orthodontic and Dentofacial Orthopedics, Manipal College of Dental Sciences, Mangalore ,Manipal Academy of Higher Education, Manipal, India.  
E-mail: ashith.mv@manipal.edu

5) Deficiency or the excess of growth of maxilla or mandible antero-posteriorly

6) TMJ dysfunction related to skeletal asymmetries

7) Deficiency or excess of maxillary/ mandibular transverse growth.

Faber et al reported that supernumerary, congenitally missing, or ectopic eruptions of teeth are also causes for occlusal asymmetry development.

The types of transverse discrepancies:

A) Dental asymmetries: In one or both arches

Lewis et al stated that dental manifested transverse discrepancies are caused due to local factors (example: congenitally missing tooth/teeth, early loss of deciduous teeth or certain habits like thumb sucking or tongue thrusting).

1) Midline deviations:

Some common causes of midline deviations are:

- A Posterior cross-bite accompanying mandibular shift.
- Drifting and/or tipping of lower and/or upper anterior teeth.
- Lateral shift of mandible where cross-bite is absent.

Due to the multifactorial aetiology of midline discrepancies, a radical understanding of the components that may contribute to the problem is essential for a correct diagnosis.

2) Asymmetric posterior tooth occlusion

3) Arch form distortions:

Faber et al reported that the abnormal position of posterior teeth, either symmetrically or asymmetrically, with or without crossbite, buccally or lingually, results in deviation from the normal arch form configuration.

B) Skeletal transverse discrepancies<sup>5</sup>:

The skeletal type of transverse discrepancy involves maxilla or mandible or a mixture of both. The maxillary problems result from symmetric or asymmetric basal arch constriction and varies depending upon severity of condition. Rotational changes of maxilla/mandible can also produce asymmetric occlusal relationship and asymmetric positioning of glenoid fossa. Severe skeletal problems are produced by trauma, infection or congenital anomalies, like facial clefts.

C) Muscular asymmetries<sup>5</sup>:

Persson et al reported that deviation from normal muscle function leads to development of skeletal and dental transverse discrepancies.

Eubanks et al reported that due to disproportionate muscle size, facial transverse problems are limited to soft tissues, like in masseter hypertrophy.

D) Functional related transverse problem<sup>5</sup>:

Deflection of the mandible due to occlusal interferences are often caused. The abnormal tooth contact especially in centric relation leads to consequent lateral or antero-posterior mandibular displacement, resulting in an asymmetric maxillomandibular relationship.

Diagnosis of transverse problems:

Before diagnosing a transverse discrepancy, assessing the patient is first and of utmost importance<sup>6</sup>.

1) Clinical assessment:

Christensen et al reported that the clinical assessment of patient should involve temporomandibular joint examination along with related musculature since certain disorders that cause interferences during mandibular translation eventually leads to mandibular deviations<sup>6</sup>.

It is important for the clinician to record the extent to which the maxillary midline is deviated from the soft tissue midline, as goal of the treatment is to align and position the midlines.

Southard et al reported factors that ought to be considered for a transverse discrepancy so as to arrive at an appropriate treatment plan for patients. The factors are:

- Extent and magnitude
- The facial symmetry and asymmetry
- Incidence of lateral CR-CO shift
- Whether the discrepancy is relative or absolute: Haas et al stated that - Relative transverse discrepancy is when posterior teeth do not coordinate in centric relation, but coordinate when canines of models are seated in Class I occlusion. On the contrary, absolute discrepancy is when posterior teeth do not coordinate even when canines are seated into Class I relationship.

Extent and magnitude of buccal corridors

2) Radiographic examination: To assess

three things-

I. The transverse skeletal growth of the mandible and maxilla

II. The growth (transverse) of both mandibular and maxillary dental arches

III. Buccolingual inclination of molars: Wilson et al found that in these discrepancies, maxillary

molars inclined buccally and mandibular molars inclined lingually.

### 3) Posteroanterior cephalogram:

Valuable tool for assessing left and right structures of dentofacial complex.

- Determines any skeletal and dentoalveolar dimension of transverse discrepancy dimension and assess and quantify skeletal and dental inter-arch relation discrepancy
- Detects, localizes and quantifies any skeletal or dentoalveolar asymmetry

Grummons proposed a mid-sagittal reference plane that runs from crista galli vertically through the ANS till chin area <sup>7</sup>.

If maxillomandibular asymmetry is present the above figure is useful to obtain the area of asymmetry. Lines are drawn to expose dental compensations for any skeletal maxillomandibular imbalance.

### 4) CBCT evaluation:

Transverse dimension of structures can be measured with the help of cone beam computed tomography. The widths of basal bone of maxilla and mandible, the buccolingual inclination of tooth along with their root positions in the bone can be accurately analyzed as well.

Different methods to diagnose dental and skeletal transverse problems:

#### 1) Maxillomandibular Transverse Differential Index:

The use of Maxillomandibular Transverse Differential was proposed by Vanarsdall et al, as a diagnostic tool for diagnosing transverse skeletal problems. This index followed Rickett's norms of mandible as well as maxilla growth (which was initially measured from the PA cephalograms). Skeletal width of maxilla and mandible are measured on the PA cephalogram and are equated with Rickett's norms.

Maxillomandibular width difference of a patient and the difference of Rickett's norms were calculated and compared. If difference is definitely more than 5 mm, the transverse skeletal problem therefore exists.

#### 2) Yonsei's transverse index:

In Yonsei University, Koo et al introduced an index so which evaluates the transverse dimensions and maxillomandibular relationships between groups of Class III and untreated normal occlusion <sup>8</sup>. Using casts, the widths of dental arch were measured at tips of cusp and the width of basal arch were measured as distance

between the points of mucogingival junction above tips of cusp. Width of basal arch from CT scans were measured as predictable centers of resistance at either, one third of root length or at furcation. Therefore, maxillomandibular differences and dimensions were then analyzed <sup>8</sup>.

#### 3) Width of Transpalatal area:

Measured from lingual groove of the first molar to first molar of other side (at gingival margin area). Brudon et al has reported that from ages 7 till 15 lies mean normal values <sup>9</sup>. The transpalatal width of patient can be related to reported values so as to determine if the upper arch is normal or tapered.

#### 4) WALA Ridge:

Andrews et al suggested using the particular WALA Ridge as landmark for assessing the mandibular arch form (shape and size) as it provides as a template for the maxillary arch form <sup>10</sup>. WALA ridge is a band of soft tissue just coronal to mucogingival junction of mandible and is at or near the level of center of resistance of the teeth.

WALA ridge horizontal norms as per Andrews is as follows <sup>10</sup>:

- 0.8 mm - For the first premolar
- 1.3 mm - For the second premolar
- 2.0 mm - For the first molar
- 2.2 mm - For the second molar

#### Treatment planning considerations:

Depending upon nature, whether dental or skeletal in origin and the severity of the problem; treatment options are available to resolve the problem. A detailed study of various diagnostic records is mandatory to determine etiology, location and magnitude of transverse problem.

1) Importance of midpalatal suture in treating transverse malocclusions <sup>11</sup>: Timing of maturation of midpalatal suture is of importance as it determines the treatment modality for transverse discrepancies. Angelieri et al found that conventional rapid maxillary expansion or RME approach has interrupted forces which are less resistant along with having more skeletal effects when initiated at stages A and B. This is due to the plenty of areas of ossification centers present along midpalatal suture. Surgically assisted RME in initiated at stages D and E as the suture fuses partially or totally thus hampering the RME forces from opening the suture.

2) Age of patient is another factor

important for treatment planning: Kuten et al stated that for early resolution of dental or functional asymmetries, age should be considered as an important factor.

Treatment of dental transverse discrepancies:

Behrents et al suggested that depending on severity and whether the abnormality is skeletal or dental in nature, the treatment options available are broadly divided into three major treatment methods<sup>11</sup>:

1. The early correction of transverse discrepancies and orthopedic approach to correct developing imbalance - This involves eliminating functional shifts
2. Camouflage through orthodontic treatment - This is to address dental related problems
3. A combination of orthodontic and surgical treatment for severe discrepancies

Early resolution of transverse discrepancies:

Three main factors that have to be considered when deciding the initiation of maxillary expansion are<sup>11</sup>:

- The Functional shift: Due to maxillary transverse deficiency, lateral functional shift is present. Therefore, as soon as the diagnosis is made, maxilla should be expanded. Especially in young patients, if the functional shift is thereby not corrected, incessant lateral positioning of the mandible results in asymmetric growth along with facial asymmetry.
- Cooperation of the patient: When it comes to timing of expansion, the cooperation and age of patient are important factors. Expansion can begin from 5 to 6 years of age, and therefore, clinicians have to proceed cautiously considering personality development and maturity of these young patients.

Either fixed or removable appliance must be taken into consideration when considering skeletal and dental effects in clinical management of the young patients.

- Stability and need for dental against skeletal expansion: Amount of dental against the skeletal expansion is dependent on skeletal maturity and age as well as type of appliance used.

Importance of timing of expansion is essential especially since the skeletal expansion is required. The stability and degree of skeletal expansion thereby decreases with age. Hence, when a severe skeletal discrepancy does exist, early maxillary expansion is recommended (Figure 1).

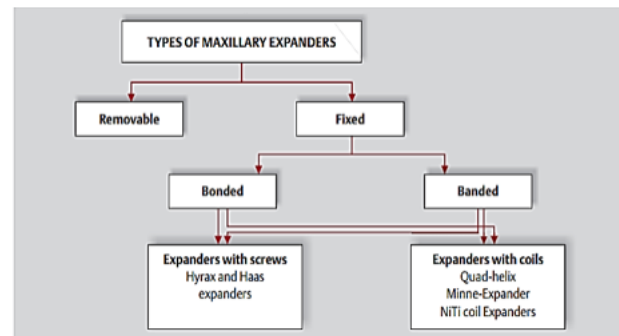


Figure 1. The types of expanders for maxilla<sup>12</sup>.

Maxillary Expanders (removable type): It is intended to produce slow type of expansion for localized or unilateral dental arch expansion. The uses include single tooth or bilateral crossbite correction. The screw activation produces heavy type of force that decays quickly. Hence, rapid reactivation should be avoided as it causes the dislodgement of appliance. The expansion rate should not surpass more than one turn per every 5 days<sup>12</sup>.

Maxillary Expanders (fixed type): It is intended to produce the rapid expansion for bilateral or unilateral or skeletal expansion. These are of two types, banded expander (retentive on bands) or bonded expander (on acrylic blocks). The stage of dental development determines design of appliance. The use of bonded expander in any stage of dentition is acceptable excluding the late mixed phase. If deciduous canines and molars have satisfactory length of root to provide necessary anchorage, bonded expander is used<sup>12</sup>.

Two types of force delivery systems<sup>12</sup>:

- Expanders with the screw expansion mechanism
- Expanders with the coil spring expansion mechanism

Expanders with Screw mechanism: Haas expander and Hyrax expander are most commonly used and involves the first premolar and molar banding. The Haas expander has pads (acrylic) on palatal side so as to provide

good bony anchorage. The lateral forces are directed indirectly onto the bone during early phases of expansion. The problem of mucosal irritation, inflammation and palatal gingival necrosis underneath palatal acrylic has been reported.

Expanders with Coils mechanism: The Ricketts quad-helix appliance is used in expansion of dental and even mild skeletal deficiencies. The quad helix can be used on acrylic blocks with occlusal coverage and even on molar bands.

The use and management of this appliance is simple as it does not rely on patient cooperation. The most positive results were indeed obtained with quad-helix appliance.

The Minne type Expander consists of a tube and sliding pin mechanism, that is loaded with heavy coil spring. The spring directs approximately 2 to 4 pounds of force. Its placement is horizontal between two hemi-maxillae, and therefore it uses more space than any other expander. To activate the expander, coil is re-compressed using a nut; as a result, force levels are kept relatively constant by the regular activation. Skeletal and dental effects with the banded and bonded Minne type expanders are comparable.

Erickson et al suggested that for a unilateral posterior crossbite, if a CR-CO shift is associated with it, the maxillary arch needs to be expanded to eliminate the mandibular shift.

When using growth modifying functional appliances to correct Class 2 malocclusions, working bite is taken in a forward mandibular position to redirect mandibular growth and produce both skeletal and dental changes.

Problems in transverse dimension are identified as either skeletal or dental and ranges in severity, in a prepubescent patient. Wertz et al reported that due to the skeletal maxillary constriction, it can indeed manifest as a dental posterior crossbite.

For a posterior crossbite, intercepting and corrective appliances such as quad helix and W arch are extensively used. As interdigitation of suture has not occurred, intermaxillary suture responds to the palatal expansion during this stage of development. Therefore, by interceptive treatment, the early correction of posterior crossbites results in a more stable, long-term occlusal correction.

Skeletal transverse problems in adults:

Aoshima and Kato et al reported that patients requiring surgical orthodontic treatment have severe skeletal asymmetry in mandible and maxilla together with substantial asymmetry in path of functional condylar movement<sup>13</sup>. Due to these asymmetries, dental asymmetry develops in the form of slanting of occlusal plane and unilateral crossbites.

Ackerman et al stated that the occlusal plane with a transverse cant, is seen in comparison to a skeletal relationship and is clearly pictured and described as the roll of esthetic plane<sup>14</sup>.

Proffit and Kim et al discussed that rotation of esthetic line and line of occlusion around a vertical axis towards one side or other described as yaw<sup>15</sup>. It was discussed that yawing or the Y-type asymmetry represents complex features of the dentoalveolar compensation. There is gross chin deviation, different mandibular body lengths and different distances from gonion to midsagittal plane<sup>15</sup>. Therefore, horizontal decompensation of distorted dental arch is important for maximum corrections of Y-type asymmetries.

The only treatment approach for patients with transverse skeletal problems that were not attended to at an early stage or if the patients have severe discrepancy is combined orthodontic and surgical correction. The rectification of these problems requires a team approach as well as skill starting from the treatment planning process to completion of treatment and post-treatment follow-ups.

Harry et al states that presurgical orthodontic treatment based on surgical goals must consist accomplishment of alignment, levelling, space closure, arch width compatibility and torque control<sup>16</sup>. The main goal of presurgical orthodontics is to eliminate existing dental compensations for skeletal deformity.

MARPE (Microimplant-assisted rapid palatal expansion)<sup>17</sup>: The expansion force in MARPE splits rigid midpalatal suture and therefore surgery is not needed. Costs and risks are nominal as compared to the SARPE approach. In comparison, this method is beneficial as it directs the expansion forces away from molars and towards midpalatal suture, thus resulting in a stable orthopedic correction with minimal tooth movement<sup>17</sup>.

Parts of MARPE expander<sup>17</sup>:

- 4 microimplants (1.5 \* 11 mm) inserted in

1.5 \* 2-mm slots of the appliance. Insertion slots ensure precision fit of microimplants in a perpendicular position.

- 11-mm length was chosen considering 2-mm height of the insertion slots, 1 to 2 mm of space between the appliance and palatal surface and 1 to 2 mm of gingival thickness
- Along with this, 5 to 6 mm of bone engagement is counted while choosing the length as it promotes bicortical engagement of microimplants into palate.
- Jackscrew size was chosen based on maximum screw size that would fit in palatal vault as well as close adaptation of appliance to tissue surface between maxillary first molars.

The position was designated to apply subsequent lateral forces against the pterygomaxillary buttress bone, which is a major resistance factor for maxillary expansion. Expansion rate was selected based on a protocol, that was developed by Dr Won Moon <sup>17</sup>.

SARME: Koudstaal et al states that a mixture of orthodontics and surgical procedures make up the surgically assisted rapid maxillary expansion in providing space in dental arch for teeth alignment <sup>18</sup>. There is a substantial enlargement of the palatal vault as well as apical base of maxilla, thus providing the necessary space for the tongue, for correct swallowing and less relapse. It is seen that there is significant improvement in nasal breathing due to enlargement of the nasal valves and an increase of nasal volume in all compartments. The indications of SARME as compared to MPMO include:

- 1) Requiring 10 mm or more expansions. In contrast, MPMO (multiple piece maxillary osteotomy) is chosen for expansions less than 10 mm.
- 2) When widening in transverse width is needed. In contrast, MPMO is chosen when the maxilla can be moved in directions such as setback, advancement, impaction or downgraft
- 3) When widening of maxillary intercanine width is significant needed

This procedure has minimal relapse rate, stable and overcorrection is generally unnecessary. In SARME, zygomaticomaxillary junction is considered as the major resistance site. Therefore, corticotomy through the zygomatic buttress from the piriform rim to the

maxillopterygoid junction is done.

Therefore, for correction of the transverse maxillary discrepancies, SARME is widely used. In Multiple piece maxillary osteotomy, a para sagittal osteotomy cut made, widens the maxilla by opening or also rotating the hemi-maxillae around central incisors. As a result, there is an intercanine width increase but is lesser than the increase in intermolar width. Two-piece type MPMOs are primarily for osteotomy cuts involving only one posterior segment.

In a three-piece type MPMO, the osteotomy cuts are therefore made distal to canines thereby maintaining intercanine width. It can be designed with osteotomy cuts distal to the premolars or without the need for widening posterior region so as to only correct significant anterior occlusal step.

Therefore, transverse discrepancies can be corrected through patient cooperation, proper diagnosis and a carefully executed treatment plan, so as to provide satisfactory results of treatment.

In all the above treatment modalities, retention and relapse are known to be the main challenges for clinicians post orthodontic treatment. The accountability of retainer wear to maintain treatment result is dependent on patients. Xian et al <sup>19</sup> revealed that the Modified Vacuum-Formed Retainer and also Hawley Retainer were similarly effective in preserving transverse dimension stability for expanded arches.

## Conclusions

Transverse dimension is indeed a critical element especially for the treatment of an orthognathic surgery patient. Patients with transverse discrepancies provide the doctor with unique diagnostic and biomechanical issues. Identification of underlying reasons of asymmetric or symmetric transverse condition is important in developing a decent treatment approach. Correction of transverse discrepancies may show to be problematic for orthodontists, therefore, the diagnosis of transverse discrepancies is extremely vital for the definitive satisfactory achievement of a stable and functional occlusion.

A balanced transverse relationship between the maxillary and mandibular dentition is indeed a requirement for establishing normal

occlusion no matter of patient's age. Early treatment of transverse discrepancies benefits patient by:

- An improved patient self-esteem along with parental satisfaction
- A comparatively better and more stable result
- Need for extensive therapy is not required later
- The reduced potential for iatrogenic caused tooth damage such as trauma, resorption of roots and decalcification.

To conclude, comprehension of the mechanism of transverse dental compensation is indeed pivotal for planning an appropriate camouflage treatment and even for presurgical treatment in patients.

#### Declaration of Interest

The authors report no conflict of interest.

#### References

1. Yu X, Zhang H, Sun L, Pan J, Liu Y, Chen L. Prevalence of malocclusion and occlusal traits in the early mixed dentition in Shanghai, China. *PeerJ*. 2019 Apr 2;7:e6630.
2. Asiry MA, AlShahrani I. Prevalence of malocclusion among school children of Southern Saudi Arabia. *J Orthod Sci*. 2019 Feb 20;8:2.
3. Southard TE, Marshall SD, Allareddy V, Shin K. Adult transverse diagnosis and treatment: A case-based review. *In Seminars in Orthodontics*. 2019 Mar 1;25(1):69-108.
4. Chung CH. Diagnosis of transverse problems. *In Seminars in Orthodontics*. 2019 Mar 1;25(1):16-23.
5. Lundström A. Some asymmetries of the dental arches, jaws, and skull, and their etiological significance. *American journal of orthodontics*. 1961 Feb 1;47(2):81-106.
6. Faber RD. The differential diagnosis and treatment of crossbites. *Dental Clinics of North America*. 1981 Jan 1;25(1):53-68.
7. DC G. Kappeyne van de Coppello MA. A Frontal asymmetry analysis. *J Clin Orthod*. 1987 Jul;21(7):448-65.
8. Koo YJ, Choi SH, Keum BT, Yu HS, Hwang CJ, Melsen B, Lee KJ. Maxillomandibular arch width differences at estimated centers of resistance: comparison between normal occlusion and skeletal Class III malocclusion. *The Korean Journal of Orthodontics*. 2017 May;47(3):167-75.
9. McNamara JA. Maxillary transverse deficiency. *American journal of orthodontics and dentofacial orthopedics*. 2000 May 1;117(5):567-70.
10. Andrews LF. The 6-elements orthodontic philosophy: Treatment goals, classification, and rules for treating. *American Journal of Orthodontics and Dentofacial Orthopedics*. 2015 Dec 1;148(6):883-7.
11. Baccetti T, Franchi L, Cameron CG, McNamara Jr JA. Treatment timing for rapid maxillary expansion. *The Angle Orthodontist*. 2001 Oct;71(5):343-50.
12. Rakosi T, Graber TM. Orthodontic and dentofacial orthopedic treatment. *European Journal of Orthodontics*. 2010 Sep 5;32(5):604.
13. Aoshima O. Investigation of the facial symmetry of cases with cross bites needing surgical orthodontic treatment using postero-anterior roentgenographic cephalometrics. *Nihon Kyosei Shika Gakkai Zasshi= The Journal of Japan Orthodontic Society*. 1990 Jun 1;49(3):256-62.
14. Ackerman JL, Proffit WR, Sarver DM, Ackerman MB, Kean MR. Pitch, roll, and yaw: describing the spatial orientation of dentofacial traits. *American Journal of Orthodontics and Dentofacial Orthopedics*. 2007 Mar 1;131(3):305-10.
15. Kim KA, Lee JW, Park JH, Kim BH, Ahn HW, Kim SJ. Targeted presurgical decompensation in patients with yaw-dependent facial asymmetry. *The Korean Journal of Orthodontics*. 2017 May;47(3):195-206.
16. Legan HL. Surgical correction of patients with asymmetries. *In Seminars in Orthodontics* 1998 Sep 1;4(3):189-198.
17. Carlson C, Sung J, McComb RW, Machado AW, Moon W. Microimplant-assisted rapid palatal expansion appliance to orthopedically correct transverse maxillary deficiency in an adult. *American Journal of Orthodontics and Dentofacial Orthopedics*. 2016 May 1;149(5):716-28.
18. Koudstaal MJ, Poort LJ, Van der Wal KG, Wolvius EB, Prah Andersen B, Schulten AJ. Surgically assisted rapid maxillary expansion (SARME): a review of the literature. *International journal of oral and maxillofacial surgery*. 2005 Oct 1;34(7):709-14.
19. Xian L, Ashari A, Mohamed AM, Wahab RM, Tata MD, Kit YC, Sinnasamy S. Relapse in modified vacuum-formed and Hawley retainers for transverse expansion a multicenter randomized control trial. *Journal of International Dental and Medical Research*. 2020 May 1;13(2):614-21.