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Space regainers in pediatric dentistry: From biological basis to contemporary biomechanics and clinical innovations—A narrative review

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Abstract
Premature loss of primary teeth may disturb the developing dentition and result in migration, tipping, rotation or bodily displacement of adjacent teeth, thereby reducing the space available for an unerupted permanent successor. The magnitude and pattern of space loss are variable and depend on the tooth lost, arch involved, dental age, eruption status of the permanent teeth, existing crowding, molar relationship and time elapsed after tooth loss. When intervention is undertaken before clinically significant space loss, a space maintainer may preserve the residual space; once space has already been lost, active space regaining may be indicated. [123] This narrative review integrates the biological basis of space loss, Kronfeld's concept of space closure, determinants and timing of space loss, diagnosis and space analysis, indications and contraindications, biomechanical principles, conventional fixed and removable space regainers, molar-distalization approaches, NiTi-based systems and contemporary multifunctional designs. The evidence base remains limited: a systematic review identified only two studies specifically evaluating space regainers and judged the evidence very low certainty. [1] Recent innovations are largely supported by case reports and technical descriptions rather than comparative trials. Accordingly, appliance selection should be individualized according to the tooth movement required, anchorage, eruption stage, overall occlusion and patient cooperation. The ultimate objective is not merely to increase a measured space but to restore a favorable eruption pathway, establish appropriate tooth position and maintain the recovered space until the permanent successor establishes a stable occlusion.

Keywords: Space regainer, space loss, premature primary tooth loss, mixed dentition, space management, interceptive orthodontics, molar distalization, nickel-titanium, NiTi open-coil spring, pediatric dentistry

Introduction

The primary dentition contributes to arch integrity, occlusal development and guidance of the permanent dentition. Premature loss of a primary tooth may permit adjacent teeth to drift into the extraction space and may alter the eruption environment of the permanent successor [23456]. The magnitude of space change is not uniform. It is influenced by the tooth lost, the maxillary or mandibular arch, dental age, eruption stage of the permanent first molar and successor, existing crowding, molar relationship and the interval following tooth loss [3457]. Recent quantitative evidence reinforces this variability: a 2026 systematic review and meta-analysis found measurable space loss after premature extraction of primary first molars, with greater mean loss in the mandible than the maxilla [8]. This is clinically important because measurable space loss is not synonymous with a need for active orthodontic treatment.

Space maintenance and space regaining are distinct interventions. A space maintainer attempts to preserve space that remains after premature tooth loss, whereas a space regainer is an active orthodontic appliance intended to recover space that has already been lost through migration or displacement [19]. Space regaining should therefore be considered only after confirming that localized space has actually been lost, that the permanent successor requires that space, and that recovering it is compatible with the overall occlusal objectives of the child. The purpose of this review is to provide a clinically oriented synthesis of the biological basis, diagnosis, timing, biomechanics, appliance designs, evidence base and future directions of space regaining in pediatric dentistry.

Definition and terminology

A space regainer is an active orthodontic appliance used to recover previously lost dental arch space by repositioning teeth that have migrated, tipped or rotated into the deficient region. Space supervision refers to observation of the developing dentition; space maintenance preserves existing space; and space regaining actively restores lost space.

The distinction is clinically relevant because the treatment objectives, force systems and risks differ. Space maintenance is fundamentally preventive, whereas space regaining is corrective and requires controlled tooth movement followed by stabilization.

Biological basis of space loss

Neutral-zone concept

The position of teeth reflects a dynamic equilibrium among eruptive forces, occlusal contacts, periodontal tissues and the surrounding musculature. The neutral zone describes the region in which the inward forces of the lips and cheeks are balanced by the outward force of the tongue. Following loss of a proximal contact, adjacent teeth may migrate toward the extraction site. The neutral-zone concept is useful for understanding arch stability but should not be interpreted as the sole mechanism responsible for post-extraction space closure.

Kronfeld's theory and mechanisms of space closure

Kronfeld's classical concept described closure of an extraction space through movement of teeth on both sides of the space. Posterior teeth may move mesially, while anterior teeth may drift distally; the relative contribution varies with tooth type, eruption stage, occlusion and individual anatomy [1011]. Thus, space closure should be viewed as a coordinated three-dimensional change rather than movement of one tooth in isolation.

The practical implication is important: the clinician should identify the component of movement responsible for the deficiency before selecting an appliance. A deficiency caused predominantly by mesial tipping of a permanent first molar requires different mechanics from a deficiency produced by displacement of a premolar or canine.

Clinical pattern and determinants of space loss

Tooth lost

Premature loss of the primary second molar is particularly important because mesial migration of the permanent first molar can reduce the space required for the developing second premolar. Longitudinal studies have demonstrated greater and more persistent space changes after premature loss of primary second molars than after first-molar loss [34, 56, 12].

Maxillary versus mandibular arch

Space loss after premature primary first-molar extraction tends to be greater in the mandible. A 2023 split-mouth systematic review found approximately 0.65 mm loss in maxillary D+E space and 1.24 mm in mandibular D+E space over 6–24 months; the mandibular D space loss was approximately 1.47 mm [7]. A newer 2026 meta-analysis reported mean losses of 0.52 mm in the maxilla and 1.78 mm in the mandible in longitudinal split-mouth studies [8].

Dental age and eruption stage

The stage of dental development at the time of tooth loss is a major determinant. Eruption of the permanent first molar and the developing position of the succedaneous tooth modify the direction and magnitude of migration [3, 5, 12].

Existing crowding and molar relationship

Pre-existing crowding can magnify the clinical consequences of localized space loss. Conversely, a child with adequate arch capacity may accommodate a modest reduction without clinically important eruption disturbance. Molar relationship also affects the amount of mesial migration possible and whether distalization would be compatible with the final occlusion.

Time since tooth loss

Space loss is progressive and is generally greatest during the earlier period after extraction. The exact rate is variable, and the clinical significance depends on arch, tooth lost and developmental stage. The 2026 meta-analysis emphasizes that most measurable change after first-primary-molar extraction occurs within the first year, supporting timely assessment when space maintenance or regaining is being considered [8].

Magnitude, timing and clinical significance of space loss

Space loss should be evaluated quantitatively and qualitatively. Quantitative assessment includes available space, required space and the resulting discrepancy. Qualitative assessment includes tooth angulation, rotation, root position, eruption pathway and molar relationship.

The clinician should avoid treating a numerical space discrepancy in isolation. The 2023 and 2026 systematic reviews demonstrate that measurable space loss after premature first-primary-molar loss may be modest and may not necessarily alter total arch length, width or perimeter [78]. Therefore, the indication for space regaining should be based on the effect of the localized deficiency on the developing permanent dentition rather than on measurement alone.

Consequences of untreated space loss

Clinically significant space loss may reduce the eruption space of the permanent successor and contribute to ectopic eruption, impaction, rotation, localized crowding, altered molar relationship and increased orthodontic treatment complexity [5612]. However, these outcomes should not be assumed to occur after every premature extraction; risk varies with the developmental and occlusal context.

Space loss versus generalized arch-length deficiency

A central treatment-planning question is whether the deficiency represents localized loss of previously available space or generalized arch-length deficiency. A child with generalized crowding may not benefit from isolated space regaining if the total arch lacks sufficient capacity. Conversely, a child with adequate overall arch capacity and localized post-extraction migration may be an excellent candidate.

Space analysis should therefore determine: (1) space currently available, (2) space required by the successor and (3) the resulting discrepancy. The clinician should then decide whether restoring the lost space contributes positively to the overall occlusal objective.

Diagnosis and treatment planning

Clinical assessment

Clinical examination should document the site and cause of premature tooth loss, teeth bordering the space, direction and amount of migration, tipping or rotation, molar relationship, existing crowding, eruption status, oral hygiene, caries activity, periodontal condition, anticipated cooperation and anchorage availability.

Radiographic assessment

Radiographs should establish the presence, position and developmental stage of the permanent successor and identify root proximity, ectopic eruption, abnormal development and the position of the second permanent molar. Radiographic assessment is particularly important before distalization of a permanent first molar.

Space analysis

Space analysis should compare the available mesiodistal space with the estimated requirement of the unerupted permanent tooth. Mixed-dentition analyses may assist estimation, but the result must be interpreted together with clinical and radiographic findings.

Digital assessment

Digital study models and intraoral scanning can provide three-dimensional measurements of space, tooth inclination

and treatment change. Emerging CAD/CAM workflows may permit customized appliance design, although evidence supporting digital space-regainer superiority is not yet available [13].

Indications for space regaining

Space regaining may be indicated when clinically significant localized space has already been lost and recovery is expected to improve eruption or alignment of a permanent successor. Common indications include premature loss of a primary second molar with mesial migration of the permanent first molar, localized premolar space deficiency, premolar eruption into an inappropriate space, selected ectopic molar migration and selected infraocclusion-associated space problems.

The permanent successor should have sufficient eruption potential and the planned movement should be compatible with the overall occlusion. Adequate anchorage must also be available.

Contraindications and limitations

Space regaining is inappropriate when the apparent deficiency is primarily generalized crowding, when adequate space already exists, when the successor is too close to eruption to justify active movement, when distalization would compromise another developing tooth, or when adequate anchorage cannot be achieved.

Other limitations include poor oral hygiene, uncontrolled caries, periodontal compromise, inability to maintain an appliance and treatment requirements exceeding the biological limits of the supporting structures. Most importantly, an increase in mesiodistal space does not prove successful orthodontic correction; uncontrolled tipping may create space while producing undesirable axial inclination or anchorage loss.

Timing of space regaining

Timing should be individualized according to dental age, amount and pattern of space loss, eruption stage of the permanent successor, position of the permanent first molar and remaining eruption potential. Early diagnosis is preferable because progressive migration can increase the complexity of movement. Conversely, unnecessary active movement should be avoided when the successor is already adequately positioned to erupt.

Biomechanical principles

Force magnitude and duration

Space regaining requires an appropriate force magnitude and a controlled activation interval. NiTi coil springs can provide relatively light continuous forces over a broad activation range because of their superelastic behavior [14, 15].

Point of force application and centre of resistance

A force applied away from the centre of resistance generates a moment and may produce tipping or rotation rather than bodily movement. Consequently, appliance design should consider the point of force application and the desired moment-to-force relationship.

Anchorage

Every active orthodontic force creates a reciprocal reaction. Anchorage may be derived from a single tooth, multiple teeth, lingual arches, Nance-type acrylic units, transpalatal arches or reinforced fixed frameworks. Double-banded and lingual-arch-supported designs distribute reciprocal forces over larger anchorage units.

Tipping versus bodily movement

Simple unilateral springs can produce rapid increases in mesiodistal space but may predominantly tip the target tooth. More sophisticated systems attempt to control rotation, angulation and root position. The clinician should therefore evaluate tooth movement in three dimensions rather than measuring only the space gained.

Classification of space regainers

Space regainers are appliances designed to recover arch space that has been lost following premature loss of primary teeth, mesial migration of permanent teeth, distal migration of adjacent teeth, ectopic eruption, or other localized disturbances in the normal eruption sequence. They may broadly be classified as fixed or removable appliances. Fixed space regainers include the Gerber space regainer, Hotz lingual arch, open-coil space regainer, lingual arch crossbow, double-banded space regainer, lip bumper, King appliance, unilateral spring space regainer, sectional arch regainer, pendulum appliance, distal jet and NiTi-based regainers. Removable space regainers include appliances incorporating helical springs, C-space regainers, jackscrews, split-saddle or split-block mechanisms, sling-shot elastics, free-end loops and removable distalizing screws [16]. [17],

A more clinically meaningful classification is based on the biomechanical objective of space recovery. Depending on the location and nature of the space loss, a regainer may be designed primarily to produce tipping or uprighting of a migrated tooth, bodily distalization of a molar, derotation of a displaced tooth, increase in arch perimeter, or coordinated movement of multiple teeth. Selection of the appliance should therefore be based not merely on the amount of space lost, but also on the tooth or teeth responsible for the space loss, the position and developmental stage of the unerupted successor, available anchorage, eruption status of the second permanent molar, existing molar and canine relationships, and the desired final occlusion.

Fixed space regainers

Gerber space regainer

The Gerber space regainer is a fixed, spring-assisted appliance primarily used for localized posterior space deficiency. It is particularly useful when a permanent molar has migrated mesially into a space required for eruption of a premolar or when a localized interdental space needs to be recovered. The appliance can be fabricated directly at the chairside or indirectly on a working cast, making it relatively simple compared with appliances requiring extensive laboratory procedures.

The principal components are a molar band or stainless-steel crown, a U-shaped tube or U-shaped assembly, an active U-shaped stainless-steel wire and a coil spring, usually a nickel-titanium open-coil spring in contemporary modifications. An occlusal rest may also be incorporated to reduce the cantilever effect and improve stability. The U-shaped wire is adapted so that it passes through the U-shaped assembly, while the compressed coil spring is positioned between the assembly and a stop on the active wire. After the appliance is cemented, release of the active component allows the spring to expand and exert a

distalizing or space-opening force on the migrated tooth [16]. [17],

The Gerber appliance is indicated primarily for localized space loss involving a single posterior tooth, particularly when the adjacent teeth can provide adequate anchorage. It is most useful when the tooth requiring movement is sufficiently erupted to receive the force and when the amount of space deficiency is limited. Because the appliance is fixed, it is especially useful in children in whom cooperation with a removable appliance is expected to be poor. The appliance is also useful when a relatively rapid chairside solution is desirable.

Its major advantage is that it is fixed and therefore does not depend on patient compliance. Its construction is relatively simple and can be accomplished with minimal laboratory involvement. The use of a coil spring allows continuous force delivery over a period of activation. However, the appliance provides relatively limited three-dimensional control of tooth movement. Depending on the position of the force relative to the centre of resistance, the tooth may undergo tipping rather than bodily movement. Anchorage loss may occur if the supporting tooth or teeth are unable to resist the reciprocal force. Band-related plaque accumulation, gingival inflammation and the possibility of decalcification or caries beneath the band are additional disadvantages. The amount and direction of activation must also be carefully controlled because excessive activation may produce undesirable tooth movement. The Gerber regainer has been described as a convenient fixed appliance because the U-shaped assembly and coil spring can be incorporated with relatively little laboratory work [16]. [17],

Hotz lingual arch

The Hotz lingual arch space regainer is a mandibular fixed appliance that uses the lingual arch as a broad anchorage unit for distalization of a mesially migrated permanent first molar. Its important feature is that the appliance does not depend on a single tooth for anchorage; instead, the force is distributed across the mandibular posterior and anterior teeth contacted by the lingual arch.

The appliance consists principally of bands on the mandibular permanent first molars and a stainless-steel lingual arch. The lingual arch is adapted to the lingual surfaces of the mandibular teeth and incorporates an active loop or spring mechanism. A horizontal spur may be incorporated into the arch and positioned in relation to the premolar or canine region. The active loop is progressively opened or activated to produce a distalizing force on the permanent first molar. The developing second permanent molar is an important consideration because adequate posterior space must be available to accommodate distal movement of the first molar [16, 17], The Hotz lingual arch is particularly indicated when the mandibular permanent first molar has migrated mesially while the more anterior tooth has not migrated significantly, and radiographic examination demonstrates sufficient space distal to the first molar for its movement. It is therefore fundamentally different from appliances that attempt to push the mesially migrated anterior tooth distally. Adequate anchorage is essential because distalization of the first permanent molar requires resistance from the remaining teeth supported by the lingual arch.

The principal advantage of the Hotz design is its distributed anchorage, which reduces the reciprocal movement that would occur when only one tooth is used as the anchorage unit. It is fixed and therefore does not rely on patient cooperation. It is particularly useful in the mixed dentition when a mandibular lingual arch would otherwise be required for space maintenance. Its disadvantages include the possibility of undesirable effects on the mandibular incisors, difficulty in maintaining oral hygiene around the lingual arch and bands, and the possibility of molar tipping if the force system is not appropriately controlled. The appliance should not be selected when the second permanent molar occupies the posterior space required for distalization or when distal movement would compromise the developing occlusion.

Open-coil space regainer

The open-coil space regainer, sometimes described as the Herbst-type space regainer in the pediatric literature, is a fixed spring-based appliance used primarily for localized posterior space recovery. It is particularly useful when the tooth immediately anterior to a migrated molar has erupted sufficiently to receive a distalizing force or when the molar itself needs to be repositioned distally.

The appliance generally consists of a band or stainless-steel crown on the tooth used for anchorage, a molar tube, a stainless-steel active wire bent into a U-shaped configuration and an open-coil spring positioned between a stop on the wire and the tube. When the spring is compressed during activation, it attempts to return to its original length and consequently produces a continuous force against the tooth requiring movement. Nickel-titanium open-coil springs are particularly useful because their superelastic properties permit relatively continuous force delivery over a relatively broad activation range [16]. [17],

The appliance is indicated for localized space loss, particularly when a permanent first molar has migrated mesially and the premolar space needs to be recovered. It can also be used when the first premolar has erupted and sufficient anchorage is available. Its effectiveness depends greatly on the location of the spring relative to the centre of resistance of the tooth. If the force is applied away from the centre of resistance, the tooth may tip rather than move bodily.

The main advantage is its simple construction and continuous spring-generated force. Because it is fixed, cooperation is minimal. NiTi open-coil springs can maintain activation over a relatively large range, reducing the frequency with which the appliance has to be reactivated. However, the appliance does not inherently provide complete control of axial inclination or root position. Tipping of the moved tooth and reciprocal movement of the anchorage tooth may therefore occur. Band-related plaque accumulation and gingival irritation are additional concerns. A further limitation is that an open-coil appliance used without adequate anchorage may move both sides of the space rather than selectively moving the intended tooth.

Lingual arch crossbow

The lingual arch crossbow is a fixed mandibular space regainer developed specifically for selected eruption-sequence problems in the mixed dentition. It is particularly useful when a mandibular first premolar erupts mesially into the canine region before eruption of the canine, thereby occupying space that is required for the canine. Chalakkal *et al.* described the appliance as a means of distalizing the

prematurely erupted first premolar while using the lingual arch to reinforce anchorage [18].

The appliance consists of a mandibular lingual arch supported by bands on the permanent first molars, molar tubes, a curved stainless-steel wire and NiTi open-coil springs. The curved wire is positioned through the molar tubes and extends toward the premolar that requires distal movement. The NiTi open-coil spring is incorporated into the assembly and compressed so that its expansion generates the distalizing force. The lingual arch acts as the anchorage unit and minimizes unwanted movement of the posterior teeth. The name "crossbow" is derived from the configuration of the curved active wire and spring assembly.

The appliance is indicated specifically when a premolar has migrated or erupted mesially into the canine space, particularly when the canine has not yet erupted and sufficient posterior anchorage is available. It is advantageous because the force is directed at the tooth occupying the canine space rather than attempting to distalize a posterior molar. The lingual arch provides broad anchorage and therefore reduces reciprocal tooth movement.

Its major advantages are fixed anchorage, reduced dependence on cooperation, relatively continuous NiTi spring force and the ability to address a specific eruption-sequence problem. It is also useful when preservation of the canine eruption path is the principal treatment objective.

The disadvantages are the need for careful fabrication and activation, difficulty in maintaining oral hygiene around the lingual arch and bands, and limited control of root movement. Because the published description was based on a new appliance design rather than a large clinical trial, its evidence base remains considerably smaller than that of conventional space-management appliances [18].

Double-banded space regainer

The double-banded space regainer is a fixed appliance designed to improve anchorage and control compared with a single-banded spring regainer. It was introduced as one of the newer designs incorporating a NiTi open-coil spring and was originally described for conventional interdental space loss [18].

The appliance incorporates two orthodontic bands placed on adjacent teeth, an active wire or tube assembly connecting the bands and a NiTi open-coil spring. The two teeth act together as the anchorage unit, allowing the spring to generate movement of the tooth or teeth responsible for the space deficiency while reducing the reciprocal effect on an individual anchorage tooth. Modifications can permit movement of more than one tooth when the space deficiency involves multiple teeth.

It is indicated for localized or moderate space loss in the mixed dentition, particularly when greater anchorage than that provided by a single-banded regainer is desirable. It can be particularly useful when a permanent molar has migrated mesially after premature loss of a primary molar and space for the unerupted premolar must be recovered.

The principal advantage is improved anchorage because two teeth share the reaction force. The appliance is fixed, requires relatively little patient cooperation and uses the superelastic properties of NiTi coil springs. A clinical comparison published in 2022 evaluated 38 children with unilateral mandibular space deficiency following premature loss of the second primary molar. Both the double-banded appliance and a removable distalizing-screw appliance significantly increased available space; however, the double-banded appliance demonstrated a shorter treatment time and less incisor tipping [19].

Its disadvantages include the need for band placement on two teeth, potential plaque accumulation and gingival problems, and the possibility of undesirable tooth movement if the anchorage unit is inadequate. Although the clinical comparative evidence is stronger than that available for several newer case-report appliances, its use should still be based on the individual biomechanics of the case.

Lip bumper

The lip bumper is a fixed functional space-regaining appliance that modifies the relationship between the lower lip and the mandibular posterior teeth. Rather than relying primarily on a coil spring to move one tooth, it uses the pressure of the lower lip against an acrylic or wire shield to alter the forces acting on the mandibular dentition.

A conventional lip bumper consists of bands or molar attachments, a heavy stainless-steel archwire and an anterior acrylic, plastic or wire-covered bumper positioned away from the labial surfaces of the mandibular incisors. The bumper separates the lower lip and cheek musculature from the posterior teeth. The force generated by the lip is transmitted through the bumper to the molar region, which may result in distal tipping or uprighting of mandibular molars and, depending on the force system, increased arch perimeter.

The appliance is indicated when space loss is associated with mesial movement of mandibular molars and when an increase in arch perimeter or broader redistribution of space is desirable, rather than when a very small localized space deficiency requires highly controlled movement. It may be particularly useful in selected mixed-dentition patients in whom the lower lip musculature can provide the required force.

The major advantage of the lip bumper is that it can produce space gain without direct dependence on patient activation, and its effect can extend over several posterior teeth. It may increase arch perimeter and provide molar distalization or uprighting. However, because its action is relatively generalized, it does not provide the same degree of localized control as a spring-based regainer. Possible adverse effects include lower-incisor proclination, molar tipping and changes in arch form. The evidence specifically evaluating the lip bumper as a space-regaining appliance remains limited, and it should therefore be selected according to the overall orthodontic objectives rather than solely to recover a small localized space [1].

King appliance

The King appliance is a fixed mandibular space regainer based on the lingual-arch principle. It incorporates a lingual arch with a NiTi open-coil spring mechanism to produce distal movement of a mesially displaced posterior tooth. The appliance is therefore particularly useful when posterior space has been lost and the clinician wishes to regain it while maintaining anchorage through the mandibular arch.

The basic components include molar bands, a lingual arch and a NiTi open-coil spring mounted on an active wire assembly. The lingual arch provides anchorage while the spring produces the active force required for distal movement. The appliance may be modified according to the location and amount of space deficiency.

The King appliance is indicated for localized posterior space loss, particularly when mesial migration of a permanent molar has compromised the eruption path of a developing premolar. Its fixed design minimizes the requirement for patient cooperation. A 2021 case report described successful recovery of posterior mandibular space in an adolescent male using a King appliance, followed by eruption of the previously unerupted tooth; arch dimensions were reported to remain stable at one-year follow-up [20].

Its advantages include fixed anchorage, incorporation of a superelastic NiTi spring, relatively simple clinical management and the potential to combine space recovery with subsequent maintenance. Its disadvantages are similar to those of other banded appliances, including plaque retention, gingival irritation and the possibility of tipping or anchorage loss. Importantly, the clinical evidence for the King appliance consists predominantly of case-based reports rather than comparative trials; therefore, the reported success should not be interpreted as evidence of superiority over established space-regaining systems.

Unilateral spring space regainer

The unilateral spring space regainer is a fixed appliance specifically designed to produce unilateral molar distalization while minimizing the lateral and rotational effects associated with asymmetric headgear or conventional pendulum-type mechanics. It is particularly useful when space deficiency is localized to one side of the maxillary arch.

The appliance consists of a band on the permanent first molar requiring distalization, a lingual sheath or tube attached to the molar band, a band on an anterior anchorage tooth such as the contralateral canine or premolar, curved stainless-steel wires connecting the anchorage units and a spring fabricated from titanium-molybdenum alloy. The spring is positioned so that its force acts approximately parallel to the posterior dental arch. The design therefore attempts to achieve distalization while reducing the transverse component of force.

It is indicated when unilateral posterior space needs to be recovered by distal movement of a maxillary permanent molar, particularly when conventional unilateral headgear would be undesirable because of compliance requirements or unwanted lateral forces. The original case demonstrated approximately 7 mm of space gain after 3½ months, with near-translatory movement of the maxillary first molar [21].

The major advantages described for the appliance are constant and relatively parallel force application, minimal requirement for patient cooperation, three-dimensional molar control and the potential for bodily movement with limited tipping. It can also be used even when the second permanent molar has erupted, making it useful in situations in which some other distalizing appliances become less effective. The reported appliance generated approximately 200 g of force and achieved a distalization rate of approximately 2 mm per month in the reported case [21].

The disadvantages include laboratory fabrication, relatively difficult activation, the possibility of food retention around the acrylic anchorage component and the need for strict follow-up. Because the evidence comes principally from a clinical case rather than a pediatric comparative trial, the results should be regarded as proof of clinical feasibility rather than definitive evidence of superiority [21].

Sectional arch space regainer

The sectional arch regainer uses localized fixed orthodontic mechanics rather than a conventional removable plate or a single spring assembly. It is particularly useful when the permanent second molar has erupted and the clinician requires greater control over the direction of movement, tooth angulation and rotation.

The appliance is constructed using a section of stainless-steel or NiTi archwire attached to brackets or tubes on selected teeth, with an auxiliary coil spring, loop or other active component incorporated according to the required movement. Rectangular wires can be used when greater control of crown-root inclination is required, whereas round wires and open-coil springs may be selected for simpler tipping or space-opening movements.

It is indicated when space loss is localized but the clinician requires more control than that provided by a simple spring regainer, particularly after eruption of the permanent second molar. It can be useful for regaining approximately 4 mm of localized arch space in selected cases [16]. [17],

Its main advantage is its greater flexibility in controlling tooth position, including angulation and rotation. It can be customized according to the exact biomechanics required. The disadvantages are increased technique sensitivity, the need for bracket or tube placement and greater dependence on precise activation. Poorly controlled sectional mechanics may produce unwanted tipping, rotation or extrusion.

Pendulum appliance

The pendulum appliance is primarily a maxillary molar-distalization appliance that can be adapted for space regaining when mesial migration of the permanent first molar has contributed to posterior space loss. It is a fixed appliance and therefore provides non-compliance distalization.

Its components include an acrylic palatal button, molar bands or attachments and one or more spring arms, commonly made from TMA wire, extending from the palatal acrylic toward the molars. When the springs are activated, they generate a distal and palatal force on the molars.

The pendulum is indicated when maxillary posterior space needs to be recovered by distalizing the permanent first molars, provided that the overall molar relationship and facial growth pattern make distalization appropriate. It is particularly useful when patient compliance with headgear is poor.

Its principal advantage is compliance-independent molar distalization with relatively simple activation. However, the pendulum has a recognized tendency to produce molar tipping, molar rotation and palatal displacement, particularly when the force vector is not well controlled. It may also produce reciprocal anterior effects through the palatal anchorage unit. Therefore, although it can recover space effectively, additional mechanics may be necessary to upright the molars or reinforce anchorage.

Distal jet

The distal jet is another fixed maxillary molar-distalization appliance that can be used for space recovery following mesial migration of permanent molars. Unlike the pendulum, the distal jet is designed to apply a force more directly through the molar tube and can provide improved control of the line of force.

The appliance consists of an acrylic palatal button for anchorage, molar bands, bilateral or unilateral molar tubes and compressed NiTi coil springs mounted on stainless-steel or other rigid guiding components. The spring is compressed between the palatal anchorage unit and the molar assembly. Activation of the spring produces distal movement of the molar.

It is indicated when maxillary molar distalization is required to recover posterior space, especially when the molar has moved mesially after premature loss of a primary tooth. Its fixed nature makes it useful in patients who are unlikely to comply with removable distalization appliances or extraoral traction.

The principal advantages are continuous spring force, fixed anchorage and reduced dependence on cooperation. Because the force is delivered through a guided assembly, the distal jet can offer better control than some simpler spring appliances. Its disadvantages include laboratory fabrication, palatal acrylic coverage, difficulty in maintaining hygiene, potential molar tipping or rotation and reciprocal movement of the anchorage unit. Careful post-distalization stabilization is essential because the recovered space may otherwise be lost again.

Removable space regainers

Helical-spring regainer

The helical-spring space regainer is a removable acrylic appliance incorporating an active helical spring to move a tooth into a space that has been reduced. The appliance is essentially a modified removable orthodontic plate in which the spring is positioned so that its active arm contacts the tooth requiring movement.

Its components include an acrylic baseplate, retentive clasps such as Adams or circumferential clasps, and a helical spring with an active arm directed against the tooth to be moved. The spring is activated by adjusting its active arm, allowing a controlled force to be delivered to the tooth.

It is indicated for small, localized space deficiencies, particularly when the tooth requiring movement is sufficiently erupted and the child is capable of wearing the appliance consistently. The removable design permits the appliance to be removed for cleaning and allows activation outside the mouth.

Its advantages are ease of insertion and removal, relatively simple activation, improved access for oral hygiene and the possibility of modifying the appliance as treatment progresses. Its principal disadvantage is dependence on patient cooperation. Inadequate wear reduces the effectiveness of the appliance, while excessive or inappropriate activation may produce tipping rather than controlled movement. Removable appliances may also become distorted or fractured.

C-space regainer

The C-space regainer is a removable acrylic space-regaining appliance that uses a specially designed spring mechanism to produce movement of a posterior tooth while attempting to limit unwanted anterior effects.

It consists of an acrylic baseplate with suitable retentive components and a C-shaped active spring or spring assembly positioned to contact the tooth requiring distal movement. Activation of the spring generates the force required to recover the lost space. The acrylic component provides the anchorage against which the spring acts.

The appliance is indicated for selected localized posterior space deficiencies of mild to moderate severity, particularly when a removable appliance is acceptable to the patient. It is more suitable when the tooth to be moved is adequately erupted and the required movement is relatively limited.

Its advantages include adjustability, removability for oral hygiene and relatively simple construction. The major limitation is the need for consistent patient cooperation. Because the appliance is removable, loss, breakage or inadequate wear can compromise treatment. In addition, control of three-dimensional tooth movement is limited compared with fixed orthodontic mechanics.

Jackscrew regainer

The jackscrew space regainer is a removable split-acrylic appliance in which mechanical activation of a screw separates portions of the acrylic base and produces movement of the tooth or segment adjacent to the space deficiency.

The appliance consists of a split acrylic baseplate, retentive clasps and a jackscrew positioned across the split portion of the appliance. Activation of the screw produces gradual separation of the acrylic segments, transmitting the force to the teeth and allowing controlled space recovery.

It is indicated when small to moderate amounts of localized space need to be regained and the teeth involved can be effectively incorporated into the acrylic segments. It is particularly useful when a screw-based activation is preferred over repeated bending of a spring.

Its advantages include predictable incremental activation and the ability to control the amount of expansion or separation mechanically. Its disadvantages include bulkiness, dependence on cooperation, potential discomfort and the possibility of unwanted movement of teeth incorporated into the anchorage segment. It is less appropriate when the required movement is highly localized to a single tooth and greater three-dimensional control is necessary.

Split-saddle or split-block appliance

The split-saddle or split-block space regainer is a removable appliance in which the acrylic base is divided into separate segments connected by an active wire mechanism. The split permits one segment to move relative to the other when the active component is activated.

The appliance consists of two acrylic saddle or block segments, retentive components and an active bent-wire connector or spring mechanism joining the segments. Activation is achieved by progressively altering the shape of the connecting wire, thereby producing separation of the acrylic segments and distal movement of the intended tooth or tooth segment. The reported distal movement is generally limited, approximately 1–2 mm, making the appliance more suitable for minor space deficiencies [17].

It is indicated when a relatively small amount of posterior space needs to be recovered, particularly in the mandibular arch. Its advantages include simple mechanical activation and removability for hygiene. However, the amount of movement that can be achieved is limited, and the appliance is highly dependent on patient compliance. The unilateral form has additional safety concerns in children and is generally avoided because of the possibility of accidental displacement or swallowing [17].

Sling-shot regainer

The sling-shot space regainer is a removable appliance that uses an elastic element to generate distalizing force. It is designed around the principle that an elastic stretched between buccal and lingual components can exert a force on the tooth occupying the reduced space.

Its components include a removable acrylic plate, retentive components, buccal and lingual hooks and an elastic element connecting the hooks. The elastic is stretched across the appliance and produces a distalizing force on the involved tooth. As the elastic loses its elasticity, it must be replaced.

It is indicated for selected localized space deficiencies in cooperative children, particularly when a simple removable mechanism is preferred. Its advantages are low cost, relatively simple construction and easy replacement of the active elastic component. Its disadvantages include variable force delivery as the elastic loses elasticity, the need for frequent replacement, possible distortion and, most importantly, dependence on patient cooperation.

Free-end-loop regainer

The free-end-loop space regainer is a removable acrylic appliance that incorporates an active wire loop to produce relatively light force against the tooth requiring movement.

Its components include an acrylic baseplate, a labial archwire for stability and retention, and a free-end or back-action loop fabricated from stainless-steel wire. The free end of the loop is positioned against the tooth requiring movement and is periodically activated by adjusting the loop [17].

The appliance is indicated when small amounts of space need to be recovered using relatively light orthodontic forces, particularly when the tooth is sufficiently erupted and a removable appliance can be worn reliably. The principal advantage is that the force can be adjusted gradually and the appliance can be removed for oral hygiene. However, the active loop is susceptible to distortion during insertion and removal, and force levels may change with repeated activation. The appliance is also entirely dependent on patient cooperation [17].

Removable distalizing-screw appliance

The removable distalizing-screw appliance is an acrylic plate incorporating a screw mechanism specifically oriented to produce distal movement of a posterior tooth. It is particularly useful for unilateral mandibular space deficiency.

The appliance consists of a removable acrylic baseplate, retentive clasps, an appropriately positioned distalizing screw and acrylic segments designed to transmit the screw-generated force to the molar or posterior tooth. Activation of the screw progressively displaces the relevant acrylic segment and produces distal movement of the involved tooth.

It is indicated for mild-to-moderate unilateral posterior space loss, particularly after premature loss of a mandibular second primary molar. Because it is removable, the appliance can be cleaned easily and can be modified during treatment. However, its effectiveness depends on adequate wear and correct activation.

The 2022 comparative study by Enteghad *et al*. evaluated this appliance against a fixed double-banded space regainer in 38 children with unilateral mandibular space deficiency following premature loss of the second primary molar. Both appliances significantly increased available space. The distalizing-screw group demonstrated greater changes in mandibular incisor inclination, whereas the fixed double-banded group required significantly less treatment time [19]. The removable appliance is therefore a useful alternative in cooperative patients, but its principal disadvantages remain compliance dependence, possible appliance displacement or breakage, soft-tissue irritation and less favourable control of unwanted incisor movement.

Molar distalization as a space-regaining strategy

When space loss is primarily caused by mesial migration of a permanent first molar, recovery of the space may require distalization of the molar rather than distal movement of the anterior tooth. The choice of appliance should be based on the amount and location of space loss, the eruption status of the second permanent molar, the position of the unerupted premolar, the existing molar relationship and the availability of posterior space. Appliances that may be used for this purpose include open-coil spring systems, lingual-arch-supported regainers, unilateral spring regainers, pendulum appliances, distal jets, sectional mechanics and removable distalizing screws.

Before attempting permanent molar distalization, the clinician should establish whether distal movement is biologically and orthodontically feasible. The position of the second permanent molar is particularly important, because the developing tooth may restrict distal movement of the first molar. The clinician should also evaluate the available posterior space, molar root position, skeletal and dental relationships and the desired final occlusion. Distalization should therefore not be undertaken merely because a space deficiency is present; it should form part of a comprehensive space-management plan.

A further consideration is stabilization after space recovery. Once the required space has been obtained, the tooth should be stabilized until the erupting permanent successor occupies the recovered space. Without adequate stabilization, the previously migrated tooth may move mesially again, resulting in recurrence of the space deficiency. Recent literature addressing molar distalization as a space-regaining strategy has emphasized the importance of retention and stabilization following active space recovery [22].

Niti-based space regainers

Nickel-titanium alloys have become increasingly important in space-regaining appliances because of their shape-memory and superelastic properties. A NiTi spring can undergo substantial activation while continuing to deliver a relatively continuous force, thereby reducing the frequency of adjustments required during treatment [14]. [15], This property has encouraged the development of both NiTi coil-spring appliances and bonded NiTi space regainers for use in the developing dentition.

NiTi-bonded space regainer

The NiTi-bonded space regainer is a fixed, minimally invasive space-regaining appliance that uses the superelastic properties of a NiTi wire rather than a conventional soldered spring assembly. It was described as a chairside alternative to conventional banded space regainers [23].

The appliance consists of bonded composite attachments or dimples placed on the teeth adjacent to the space, together with a NiTi wire that functions as the active spring. In the described design, a composite dimple is bonded to the buccal surface of the involved teeth and a tunnel or slot is created in the attachment. A NiTi wire, approximately 0.016 inch in the reported design, is engaged between the attachments so that its shape-memory properties generate the required force [23].

The appliance is indicated for localized space loss in patients in whom the involved teeth are sufficiently erupted to receive bonded attachments and where a chairside, minimally laboratory-dependent appliance is desirable. It is particularly attractive in pediatric patients because it can be fabricated in a single visit without the need for conventional band-and-loop laboratory procedures.

Its major advantages include chairside fabrication, reduced laboratory work, relatively simple construction and the continuous force characteristics of NiTi. It also avoids some of the bulk associated with acrylic removable appliances. However, its effectiveness depends on reliable bonding. Moisture contamination, poor enamel preparation or excessive force may result in debonding. In addition, three-dimensional control of tooth movement is limited, and the appliance is less suitable when substantial bodily movement or precise root control is required [23].

Modified NiTi open-coil space regainer

The modified NiTi space regainer described by Shan *et al*. in 2024 is a contemporary modification that combines a NiTi wire with an open-coil spring to provide continuous force over an extended activation range [24].

The appliance uses a NiTi wire, an open-coil spring and bonded orthodontic attachments. In the reported pediatric case, the active assembly was positioned between the maxillary right permanent first molar and the primary canine. Because the primary first molar carried a stainless-steel crown and could not receive a bonded attachment, the canine was selected as the anterior attachment site. A 0.014-inch NiTi wire was used with the open-coil spring, and the spring was extended by approximately 2 mm to increase its activation range and reduce the frequency of adjustments [24].

The appliance was used in a five-year-old child with early loss of the maxillary right primary molar and mandibular left primary molar. Huckaba analysis demonstrated approximately 3 mm of space loss in the region of the upper primary second molar and 0.7 mm in the lower region. The case was associated with mesial tilting of adjacent permanent teeth and a unilateral posterior crossbite. Following placement of the modified NiTi assembly, approximately 2 mm of space was regained during the first two weeks, with a total reported gain of approximately 6 mm during treatment [24].

The major advantage of the modification is the extended activation range of the NiTi open-coil spring, potentially reducing the number of appointments and adjustments. The appliance is relatively simple, minimally invasive and can be fabricated chairside. Its disadvantages include bonding sensitivity, limited control of root movement and the possibility of discomfort during the initial phase of activation. Most importantly, the evidence is based on a single case report; therefore, the reported clinical success should be regarded as a demonstration of feasibility rather than proof that the modified design is superior to conventional regainers [24].

Contemporary and multifunctional space-regaining appliances

Lingual-arch-supported open-coil space regainer

The lingual-arch-supported open-coil space regainer combines two established concepts—a mandibular lingual arch for anchorage and an open-coil spring for active space recovery—into a single fixed appliance. It was described by Chalakkal *et al*. in 2024 as a design intended to overcome the reciprocal anchorage loss that may occur when an open-coil spring is used alone [25].

The appliance consists of a mandibular lingual arch supported by permanent first molar bands, an active wire assembly and NiTi open-coil springs positioned between the molar anchorage and the tooth requiring movement. The lingual arch provides a rigid anchorage unit, while the compressed open-coil spring produces the active force. The critical biomechanical feature is that the lingual arch prevents distal displacement of the molar; consequently, the reciprocal force generated by the spring is directed toward mesial movement of the tooth anterior to the space rather than reciprocal distal movement of the molar [25].

The appliance was described in a 10-year-old child with 3.8 mm of space deficiency for eruption of the mandibular second premolar. The required space was regained in approximately eight weeks. Once adequate space had been achieved, further activation was stopped by placing self-cure acrylic over the springs, converting the active regainer into a passive space-maintaining configuration [25].

The principal indication is therefore localized mandibular posterior space loss in which the clinician wants to move the anterior tooth into the lost space while preventing reciprocal movement of the molar. Its major advantages are fixed anchorage, reduced dependence on cooperation, continuous NiTi spring force and the ability to function subsequently as a space maintainer. Its principal disadvantages are those associated with banded lingual arches, including plaque accumulation and gingival irritation, as well as the limited control of axial inclination of the moving tooth. Since the published evidence is currently based on a clinical case, its long-term effectiveness and superiority over other regainers remain to be established [25].

Junaidi two-in-one space regainer

The Junaidi space regainer is a contemporary chairside appliance introduced in 2024 with the specific objective of combining space regaining and subsequent space maintenance in a single appliance [26]. It was developed to simplify the conventional workflow in which a space regainer is fabricated and then replaced by a separate space-maintaining appliance after the required space has been recovered.

The appliance consists primarily of a molar band, a segment of orthodontic archwire and an open-coil spring. The appliance can be fabricated chairside without conventional impressions and without a separate laboratory phase. The archwire and open-coil spring are arranged so that the spring initially produces active space recovery. Once the desired space is obtained, the active component can be stabilized so that the appliance functions as a passive space maintainer [26].

The reported clinical case involved a 12-year-old boy with inadequate space for eruption of the second premolar. The pretreatment radiograph demonstrated approximately 4.3 mm of available space deficiency. The Junaidi appliance was placed and successfully regained the required space, following which the second premolar began erupting into the recovered space [26].

The appliance is particularly indicated when a localized posterior space deficiency is present and the clinician wishes to avoid a separate laboratory-fabricated space maintainer after active treatment. Its major advantages are chairside fabrication, avoidance of impressions and laboratory procedures, reduced treatment complexity, minimal patient cooperation and the two-in-one function of regainer followed by maintainer. Its limitations include the relatively simple nature of its force system, limited three-dimensional control and the need for careful stabilization after active space recovery. Since its evidence consists of an individual clinical report, the appliance should currently be considered a promising simplified design rather than an evidence-proven replacement for conventional space-regaining appliances [26].

SV appliance

The SV appliance is a customized multifunctional space-management appliance reported in 2025. It was developed with the objective of combining active space recovery with subsequent space maintenance while allowing the appliance to be adapted to the individual clinical situation [27].

The appliance is constructed as a customized fixed space-management device incorporating banded components and an active spring/wire mechanism designed according to the site of space loss and the position of the unerupted successor. Its design allows the appliance to be used initially for active recovery of the deficient space and subsequently maintained in position after the desired space has been obtained. The emphasis of the appliance is therefore not on a single standardized spring configuration but on customization according to the clinical requirement.

The reported case involved a child with posterior space deficiency associated with premature loss and root resorption of primary molars. The appliance was fabricated and cemented, with follow-up at one and three weeks and radiographic confirmation of space recovery [27].

The SV appliance may be indicated when space recovery and subsequent maintenance are both required and when a customized fixed design is desirable. Its principal advantage is the multifunctional nature of the appliance and its ability to be adapted to the individual space-management problem. It may also reduce the need for fabrication of a separate maintenance appliance. Its disadvantages include technique sensitivity, dependence on accurate fabrication and the possibility of the same band-related hygiene problems seen with other fixed appliances. As the published evidence is currently case-based, the clinical effectiveness and superiority of the SV appliance cannot yet be established [27].

Multifunctional regainer-maintainer with temporary tooth replacement

A further contemporary approach is the development of multifunctional appliances that combine space regaining, subsequent space maintenance and temporary replacement of a missing tooth. Such appliances are particularly attractive when a child has both a space deficiency and an immediate functional or esthetic requirement caused by premature tooth loss.

These appliances may incorporate a fixed or removable anchorage component, an active spring or screw mechanism for space recovery, a passive component for maintaining the recovered space and an acrylic or composite pontic for temporary tooth replacement. During the active phase, the spring or screw is activated to recover the lost space. Once the required space has been obtained, the active component is stabilized and the appliance is converted into a passive space maintainer, while the pontic continues to provide temporary tooth replacement.

The indication is primarily premature tooth loss associated with simultaneous space deficiency and a need for temporary functional or esthetic replacement. The principal advantage is that several treatment objectives can be addressed with one appliance, potentially reducing the number of appliance changes and clinical appointments. However, these designs are technique sensitive and require careful planning to ensure that the temporary replacement does not interfere with eruption of the permanent successor. Their evidence remains limited, and they should currently be regarded as individualized clinical solutions rather than established superior alternatives.

Clinical selection of a space regainer

The selection of a space regainer should ultimately be based on the cause, site and severity of space loss and the movement required to correct it. A simple localized space deficiency associated with mesial tipping of a single tooth may be managed effectively with a Gerber or open-coil spring regainer. When stronger anchorage is required, a lingual-arch-supported design or double-banded appliance may be preferable. When the permanent molar itself has migrated mesially and adequate posterior space is available, distalizing appliances such as the Hotz lingual arch, unilateral spring regainer, pendulum or distal jet may be considered according to the arch and required biomechanics. When the principal problem is anterior migration of a premolar into the canine eruption path, the lingual arch crossbow provides a more specific biomechanical solution. When patient cooperation is reliable and only a small amount of space needs to be recovered, removable appliances such as helical-spring, C-space, jackscrew, sling-shot, free-end-loop or distalizing-screw appliances may be selected. Conversely, in children with poor compliance, fixed appliances generally offer an advantage because the active force remains continuously engaged.

NiTi-based appliances offer the additional advantage of superelastic, relatively continuous force delivery, and newer chairside designs attempt to reduce laboratory procedures and adjustment frequency [14]. [15], Nevertheless, the presence of NiTi does not automatically confer superior clinical control. The direction and point of force application, anchorage design and eruption stage of the involved teeth remain more important determinants of the final tooth movement.

Finally, space regaining should always be followed by stabilization. Once the desired space has been recovered, the appliance should either be converted into a passive maintainer or replaced by an appropriate space-maintaining appliance until the permanent successor has erupted sufficiently to occupy the space. This is particularly

important following molar distalization because the corrected molar may have a strong tendency to relapse toward its original mesial position [22].

Space regaining followed by space maintenance

Space regaining and space maintenance should be regarded as sequential phases of one treatment strategy: diagnosis → space analysis → active space regaining → stabilization → space maintenance → eruption monitoring.

Once adequate space has been obtained, active force should be discontinued and the space stabilized until the permanent successor has erupted sufficiently to occupy it. Failure to provide retention may allow relapse. Contemporary dual-function appliances attempt to combine these phases [25, 26].

Special clinical situations

Infraoccluded or ankylosed primary molars

Infraoccluded primary molars may contribute to localized space deficiency and altered eruption pathways. Garcovich *et al*. described a NiTi-based space-regaining approach in a severely infraoccluded primary molar case, illustrating a minimally invasive option in a selected patient [28].

Premolar erupted into an inappropriate space

When a premolar erupts into space intended for another permanent tooth, treatment should be directed toward the specific eruption and positional problem. The lingual arch crossbow represents an example of appliance design based on eruption sequence rather than generic distalization [18].

Severe localized or multi-tooth space loss

When several teeth have migrated, simple unilateral springs may be inadequate. Reinforced anchorage, double-banded systems, lingual-arch-supported appliances or sectional fixed mechanics may be required.

Fixed versus removable space regainers

Feature	Fixed	Removable	Clinical implication
Cooperation	Low dependence	High dependence	Fixed preferred when compliance is uncertain
Force delivery	Usually continuous	Often intermittent	Continuous force may be advantageous for selected movements
Anchorage	Generally stronger	Variable	Fixed systems often preferred for larger movements
Oral hygiene	More difficult	Easier	Professional monitoring is important with fixed appliances
Small deficiencies	Suitable	Suitable	Choice depends on movement and cooperation
Large/controlled movement	Generally preferable	Less predictable	Reinforced anchorage often required
Appliance loss	Uncommon	Possible	Removable systems require reliable use
Adjustment	Clinician controlled	Patient-dependent in some designs	Follow-up is essential

No category is universally superior. Appliance choice should be based on the movement required, anchorage, eruption stage, oral hygiene and cooperation. A 2022 comparative study found that both fixed double-banded and removable distalizing-screw systems could recover mandibular space [19].

Evidence base and knowledge gaps

The central limitation of the literature is the mismatch between the large number of appliance designs and the small amount of high-quality comparative evidence. Khalaf *et al*. identified 11 eligible studies of space maintainers/regainers, but only two specifically evaluated space regainers; these involved a lip bumper and transpalatal arch and produced contradictory results. Overall evidence was very low certainty [1].

The newer NiTi and multifunctional appliances reported between 2024 and 2025 are predominantly case reports [24252627]. They should therefore be considered promising innovations rather than established replacements for conventional appliances.

Future trials should report standardized outcomes including space gained, tooth inclination, rotation, root position, anchorage loss, eruption success, treatment duration, relapse, adverse effects and patient-reported outcomes.

Clinical decision-making algorithm

1. Confirm premature tooth loss and determine the cause of space deficiency.
2. Establish whether clinically significant space has actually been lost.
3. Distinguish localized space loss from generalized arch-length deficiency.
4. Identify the tooth or teeth responsible for the loss.
5. Evaluate the permanent successor radiographically.
6. Quantify available and required space.
7. Determine the required movement: tipping, uprighting, derotation, bodily distalization or coordinated movement.
8. Assess anchorage requirements.
9. Select a fixed or removable appliance according to biomechanics and cooperation.
10. Monitor active space recovery.
11. Stop activation once the desired space is obtained.
12. Stabilize and maintain the recovered space.
13. Monitor eruption of the permanent successor.

Future directions

Future research should move from isolated appliance descriptions toward prospective comparative clinical trials. Conventional stainless-steel systems should be compared with NiTi-based systems using standardized three-dimensional outcomes. Digital models and intraoral scanning may permit precise assessment of tooth movement, while CAD/CAM may facilitate customized appliance fabrication [13].

Patient-centered outcomes are particularly relevant in pediatric dentistry, including discomfort, number of appointments, speech interference, eating difficulty, oral-hygiene burden, parental acceptance and treatment time. Novelty should not be equated with superiority until these outcomes are demonstrated in adequately powered comparative studies.

Clinical PEARLS

- Do not treat the millimeters alone; identify the tooth movement responsible for the deficiency.
- A 3-mm deficiency caused by simple tipping is biomechanically different from a 3-mm deficiency caused by bodily molar migration.
- Always evaluate the permanent successor before distalizing a permanent molar.
- Anchorage is fundamental to successful space regaining.
- Space gained is not synonymous with successful treatment.
- Assess tooth inclination, rotation and root position in addition to mesiodistal space.
- Fixed appliances reduce dependence on cooperation but increase hygiene demands.
- Removable appliances are useful when cooperation is reliable and the required movement is limited.
- NiTi systems provide attractive force characteristics but should not be assumed to be superior.
- Every active regainer should have a defined endpoint and a stabilization strategy.
- The final endpoint is favorable eruption and tooth position, not simply a measured increase in space.

Conclusion

Space regainers are an important component of interceptive orthodontic management when premature primary tooth loss has produced clinically significant localized space deficiency. Their use differs fundamentally from space maintenance because active orthodontic tooth movement is required.

Selection should be individualized according to the amount and pattern of space loss, dental age, eruption stage of the permanent successor, tooth position, occlusal relationship, anchorage, oral hygiene and cooperation. Conventional fixed and removable appliances remain clinically useful, while NiTi and multifunctional designs have expanded the available force systems and simplified some clinical procedures.

Nevertheless, the literature does not establish a universally superior appliance. The evidence base remains limited and contemporary innovations are supported mainly by case reports [1, 24, 25, 26, 27]. The future of space regaining should therefore emphasize accurate diagnosis, individualized biomechanics, controlled tooth movement, adequate anchorage, stabilization, digital assessment and long-term outcome evaluation. Ultimately, the objective is not simply to create space, but to restore the eruption environment and maintain it until the permanent dentition establishes a stable occlusion

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