Space Regainer's in Pediatric Dentistry: A Review Article on Conventional Appliances and Contemporary Digital Advances.

ABSTRACT: Background: **The deciduous dentition serves mastication, speech and appearance, and it also reserves arch space for the erupting permanent successors. When a primary tooth is lost before its normal exfoliation time, adjacent teeth tend to migrate, arch perimeter diminishes and the eruption path of the successor may be compromised. Space regainers are interceptive appliances that re-establish lost arch length and hold it until the permanent tooth erupts.**

Methods: This narrative review is based on information **gathered from relevant textbooks, published research articles, review papers and clinical reports on space regainer in pediatric dentistry. The literature was reviewed and organised to discuss the biological basis of space loss, diagnostic considerations, mixed-dentition space analysis, conventional and modified appliance designs, and contemporary developments in space management. No formal systematic search strategy, duplicate screening, risk of bias assessment or meta analysis was undertaken.**

Results: **Space loss is not uniform across the arch; it depends on which primary tooth is lost, the age at loss and the eruption stage of the permanent first molar. Early loss of a maxillary second primary molar may leave the second premolar impacted, while unilateral loss of a primary canine may shift the midline. Diagnosis combines dental and skeletal assessment, radiographs, study models, mixed dentition analysis and appraisal of anchorage.** Regaining is most favourable during the mid-mixed-dentition period, while much of the leeway space remains available and the permanent second molar has not yet erupted, and greater amounts can be recovered in the maxilla than in the mandible. **A wide range of fixed and removable appliances exists, several of which later serve as passive maintainers once the space has been recovered.**Conclusion: **Accurate diagnosis, appropriate appliance selection and sustained follow-up determine the outcome. Digital design and three-dimensional printing offer customisation and reduced chairside time, though long-term clinical evidence remains limited.**

Keywords: space regainer; premature loss of primary teeth; interceptive orthodontics; mixed dentition space analysis; space maintenance; molar distalization

1. INTRODUCTION

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Premature loss of a primary tooth disturbs a system already delicately balanced. The adjacent teeth drift toward the empty space, the opposing teeth over-erupt and the arch perimeter shrinks — modestly at first, but often enough to compromise the eruption of the successor. The causes are ordinary ones, caries and trauma above all, though loss may also be the presenting sign of a systemic condition and should prompt a wider look at the child's health (2). Interceptive orthodontics exists to interrupt this sequence, and the space regainer is among its more useful instruments: where a maintainer holds what remains, a regainer recovers what has gone, restoring arch length and occlusal harmony, simplifying later treatment and allowing the permanent tooth to erupt into place (4,10).The appliances range from a band and a simple spring to mini-screw-supported devices and, most recently, appliances designed on screen and printed in resin or metal. This range is a strength and a difficulty at once, since the clinician treating a seven-year-old with a tipped mandibular first molar must choose among several dozen designs, each with its own anchorage requirements, activation schedule and modes of failure. Much of the literature is descriptive and comparative evidence is thin. This review therefore gathers the conventional designs into one scheme, sets out the principles governing their selection and use, and considers where modifications and digital technology are taking the field.

2. HISTORICAL DEVELOPMENT AND DEFINITIONS

The earliest appliance described for minor space regaining was that of Paul E Jaffe in 1963 (4). King described an appliance for space regaining in both arches, a design still described as a modified lingual arch NiTi open coil regainer delivering 100–150 g (1,3,17), and Hitchcock in 1974 modified the lingual arch with U loops for distal molar movement, giving the Hotz lingual arch (7). Bench et al. introduced the Gerber space regainer in 1978 for regaining space for an erupting first premolar (8), Bayardo described an anterior regainer using direct bonding in 1986 (5), Hilgers reported the pendulum appliance in 1992, its U loop producing favourable mesiobuccal rotation as well as bodily molar movement (4), and Carano and Testa in 1996 designed an appliance for unilateral or bilateral Class II correction (4).The vocabulary was fixed rather earlier. The American Association of Orthodontists defined interceptive orthodontics in 1969 as the phase of orthodontics employed to recognise and eliminate potential irregularities in the developing dentofacial complex (3), while JC Brauer had coined the term space maintenance in 1941 for preserving a space previously occupied by a tooth or group of teeth (5). Boucher described the space maintainer as an appliance designed to preserve that space after premature loss, and Graber in 1966 defined preventive orthodontics as action taken to preserve the integrity of what appears to be normal occlusion at a given time (5). Space regainers recover a space already lost (4,10), while space management covers maintenance, regaining, supervision and serial extraction together (11).

3. ERUPTION, ARCH CHANGES AND THE BIOLOGICAL BASIS OF SPACE LOSS

The mixed dentition is a period of rapid change in which the arch must accommodate teeth considerably larger than those they replace, and the sequence in which the permanent teeth erupt determines whether the available reserve relieves crowding or is consumed by drifting (12). The leeway space between the primary canine and molar supplies much of that reserve. Loss of a primary molar before its successor is ready

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removes a boundary, and the response is predictable: mesial migration of the molar behind, distal migration of the tooth in front, and a measurable reduction in arch length, the extent depending on the tooth lost, the child's age and the stage of eruption (13).

Two clinical points follow. Timing matters more than the absolute amount lost, because an appliance used before the successor is due is doing preventive work, whereas one used afterwards is trying to undo established drift. And the tissues impose limits: a molar can be uprighted or distalized only if the surrounding bone and the erupting second molar allow it, the dentoalveolar complex responding most readily in the young, which is why distalization is best attempted before the permanent second molar erupts (16). Space regaining is thus a manipulation of growth with a timetable of its own.

4. DIAGNOSIS AND TREATMENT PLANNING

Space regaining begins with assessment rather than an appliance. The history of the loss, the state of the remaining dentition, the caries experience, oral hygiene and the child's behaviour all bear on what can be attempted, and radiographs are added where the presence or position of a successor is in doubt. Study models and intraoral assessment establish the amount of space lost, which must be quantified in millimetres rather than estimated, since the choice between a regainer and an alternative such as extraction turns on that figure.

Four questions structure the plan: how much space is missing, which tooth will be moved and in which direction, what anchorage opposes that movement, and whether the child will tolerate the appliance required. A tipped molar needing 2 mm of distal movement is a different problem from a quadrant that has lost 5 mm with the premolar already erupting. Where the requirement is minimal, proximal stripping may suffice (16); where it is substantial, the choice lies between distalization, extraction and a more elaborate appliance. Age and cooperation weigh heavily, since every removable appliance depends on compliance and every banded appliance on hygiene around the band (4).

5. MIXED DENTITON SPACE ANALYSIS

The size of a discrepancy can only be judged against an estimate of the space the permanent teeth will need. Mixed dentition analysis compares the measured arch perimeter with the predicted width of the unerupted premolars and canines, using regression equations from radiographs, tables derived from tooth width ratios, or the simpler methods based on the mesiodistal widths of the erupted mandibular incisors (14). Each approach carries error and none replaces the assessment of arch form and occlusion; their value lies in turning an impression of crowding into a figure that can be weighed against the millimetres a regainer is likely to deliver.

6. FIXED SPACE REGAINERS

Fixed regainers are anchored on the teeth and so do not depend on the child's cooperation. The designs most often described are the following, summarised in Table 1.**Table 1. Types of fixed space regainers**

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No.	Appliance	Principal design and mode of action	Reference
1	Jaffe	Sliding section or arch on buccal and lingual arms of molar bands; light spring pressure, reactivated at intervals	(4,6)
2	Gerber	Band with welded or soldered U loop seated in molar tube, occlusal rest reducing cantilever; open coil between stops; chairside	(4,9,15)
3	Hotz lingual arch	0.036" lingual arch on first molars, U loops expanded 2 mm per side; maintainer, regainer or leeway-space user	(7,11)
4	Lip bumper	Heavy labial arch with acrylic flange 5–6 mm from incisors; lip musculature distalizes molars; Denholtz in maxilla	(5,6,9)
5	King	Modified lingual arch NiTi open coil regainer, 100–150 g	(3,17,18)
6	Open coil	Reciprocal active appliance; solder stops buccal and lingual instead of occlusal stop; coil 2–3 mm longer than stop-to-tube distance	(4,5,11,26)
7	Sliding loop	0.036" loop through two buccal tubes with coil spring and occlusal stop; premolar mesial, molar distal	(4)
8	Gurin lock	Sliding bar with adjustable Gurin Lock and NiTi spring; jackscrew added when the opposite abutment must be held	(4)
9	Pendulum	Acrylic plate on first premolars, 0.6 mm arms with closed helix and U loop, 250 g per side, monthly reactivation	(4)
10	NiTi bonded	0.016" NiTi wire bonded to premolar and engaged in composite tunnel on first molar; shape memory	(4,9)
11	Lingual arch crossbow	Lingual arch anchorage, 0.9 mm wire through 1.1 mm × 10 mm molar tubes, NiTi open coil	(3,9)
12	Double banded	Both teeth adjacent to the space banded; buccal and palatal tubes with coil spring between stops	(4,9)
13	Anterior	2x4 appliance, finger springs and split labial bows, or Bayardo bonded open coil	(3,5,9,11)
14	Distal Jet	Piston and tube in Nance button; NiTi springs 150 g in children, 250 g in adults; converts to Nance retainer	(4,9,24)
15	Band and U loop	0.180 × 0.005 inch band material with 21 gauge U loop; serves as regainer then maintainer	(4)
16	Sectional arch	Sectional wire stopped against molar tube and anterior bracket, or compressed open coil; up to 4 mm	(6,11)
17	Kloehn headgear	Cervical face bow with inner bow in first molar tubes; worn 12–14 hrs/24 hrs	(11,21,22)
18	Jones Jig	0.030-inch sectional wire, nitinol coil spring, eyelet tube, Nance holding arch; 0.83 mm per month	(21,23)
19	Unilateral	0.036" × 0.072" lingual sheath, two 0.036" wires,	(3,25)

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	spring	Ni-Ti spring 5–6 mm apical to centre of resistance	
20	NiTi coil springs	Open coils 75–100 g over 7 mm; compression springs 15 mm to 6 mm, tension springs 3 mm to 6 mm	(4)
21	Regainer cum maintainer	Band with canine retractor of 22 or 23 gauge wire, or 21 gauge U loop opened for activation	(3)

Footnotes: Numbers in the final column refer to entries in the reference list. NiTi, nickel titanium; 2x4, two molar bands with four anterior brackets; hrs, hours. Design features and all dimensions are as reported in the cited sources.

1. Jaffe appliance: Described in 1963 for a limited range of minor tooth movements and reactivated at intervals so that the force on the banded teeth stays constant (4,6). Light spring pressure acts against a sliding section or arch carried on buccal and lingual arms of the molar bands, and the appliance suits drifting after ankylosis, early loss of a deciduous molar or extraction (4).

2. Gerber appliance: Built at the chairside in a short appointment with no laboratory work (4,15). A band is fitted and its mesial surface marked for the U loop, which is welded or soldered into place; the U assembly is seated in the molar tube and brought to contact the tooth mesial to the space, an occlusal rest added to the wire section reducing the cantilever effect. Sections of open coil spring are cut to fit over the wire between the stops and the ends of the U tube. To activate, the distance from the mesial contact to the point where the wire enters the tube is measured and the space to be regained plus 1–2 mm added; the springs are compressed, held with floss or a steel ligature through the eyelet, the assembly cemented and the ligature cut (4). The anchorage tooth must withstand the displacing force (9).

3. Hotz lingual arch: Hitchcock's 1974 modification (7): a versatile 0.036" stainless steel arch on the lingual aspect of the first molars, acting passively, actively or both as maintainer, regainer or means of using the leeway space (11). The U loop is expanded 2 mm per side, the patient is reviewed at 1 week and then every 4–6 weeks, and the arch is left as a passive maintainer under 6-monthly review; radiographs must show space between the first and developing second molar (11).

4. Lip bumper: A heavy labial arch with an anterior acrylic flange, semifixed and usable in both arches (5,6). Placed 5–6 mm from the anterior teeth, it uses the lip musculature to transmit a distalizing force to the molars, Ben Mohimd et al. reporting desirable results in 9 months (9); the maxillary counterpart is the Denholtz appliance (6).

5. King appliance: Described for both arches (3), it is a modified lingual arch NiTi open coil regainer delivering 100–150 g (17). A millimetre a month is satisfactory progress, and a conventional maintainer follows once a Class I or cusp-to-cusp relation is reached (3). Case reports record 5 mm regained in 5 months with three activations (17) and 4 mm in 2 months (18); gingival inflammation and secondary caries beneath the band are its limitations (17,18).

6. Open coil regainer: A reciprocal active fixed appliance used once the first premolar has erupted (4,5), fabricated like the sliding loop but with solder stops at the

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junction of the straight and curved parts, buccally and lingually, rather than an occlusal stop (4). It uses 0.036" wire and tubes and a spring 2–3 mm longer than the anterior stop-to-tube distance; the child is seen at 1 week and then every 4–6 weeks and the appliance removed once the premolar pierces the mucosa (11). Axial inclination cannot be controlled, so tipping may occur (4). A modified nickel titanium regainer using the same open coil principle has been reported in a pediatric patient (26).

7. Sliding loop regainer: For loss of the mandibular second primary molar with both adjacent teeth tipped: a constant force moves the premolar mesially while the molar reciprocates distally, using a 0.036" loop, two buccal tubes, a coil spring about 2 mm in excess of the space and an occlusal stop against rotation (4).

8. Gurin lock regainer: A unilateral fixed appliance where the bicuspid must come mesially without distal movement of other teeth; a nickel titanium spring is activated by an adjustable Gurin Lock turned with a box wrench, with a jackscrew and arch wires added where the opposite abutment must be held (4).

9. Pendulum appliance: Hilgers, 1992: an acrylic plate retained on the first premolars carries 0.6 mm distalization arms with a closed helix and a U loop, an activation of 60–70 generating 250 g per side with monthly reactivation (4). Nappee et al. later replaced the dental support with a single palatal mini-screw in the "Pendulis" (4).

10. NiTi bonded regainer: K.S Negi, 2007: a composite dimple with a mesially open tunnel on the first molar receives a 0.016" NiTi wire bonded to the primary molar or premolar, whose loop distalizes and uprights the molar by shape memory in a single visit without impressions, bands or soldering (4,9).

11. Lingual arch crossbow: Chalakkal et al. used the lingual arch as anchorage for a curved 0.9 mm wire passing through 1.1 mm, 10 mm molar tubes with NiTi open coil springs, compressed to half length and later deactivated with self-cure acrylic so that the appliance serves as a maintainer (3,9).

12. Double banded regainer: Banding both teeth adjacent to the space, with buccal and palatal tubes and wires carrying a coil spring between stops, avoids tipping (4,9). Chalakkal et al. gained 5.1 mm in 6 months maxillary and 4 mm in 5 months mandibular, bringing a canine space from 3.5 mm to 7 mm (4).

13. Anterior regainer: Used where anterior space is lost through tipping, migration, microdontia or a missing tooth (11), with a 2x4 appliance on 0.014" wires (11) or finger springs and split labial bows (9). Bayardo's 1986 bonded technique etched with 35% phosphoric acid and used a 0.036" × 0.009" open coil spring with a 2 mm distal bend, changing wire from 0.014" to 0.016" to 0.018" to 0.018 × 0.025 at 3-week intervals before adding an acrylic pontic (3,5).

14. Distal Jet: Carano and Testa, 1996: a piston and tube in a Nance button with NiTi springs of 150 g in children and 250 g in adults, activated monthly, giving 2–3 mm in 4 months and convertible to a Nance retainer (4,9). Treatment changes with this

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appliance have been compared with those of the Jones jig and the First Class appliance (24).

15. Band and U loop regainer: A fixed unilateral expander serving first as regainer and then as maintainer, built from 0.180 × 0.005 inch band material with a 21 gauge U loop, 22 or 23 gauge wire for a canine retractor and 23 gauge for two loops, the loop boxed in plaster during soldering (4).

16. Sectional arch technique: Used once the second molar has erupted, regaining up to 4 mm through a sectional wire or a compressed open coil spring (6,11).

17. Kloehn head gear: Kingsley first moved maxillary teeth backwards with headgear in 1892 (21); the Kloehn appliance restrains maxillary growth through a cervical face bow worn 12–14 hrs/24 hrs (11). Lima Filho et al. reported longitudinal anteroposterior and vertical maxillary changes in skeletal Class II patients treated with Kloehn cervical headgear (22).

18. Jones Jig: Jones and White, 1992 (21): a 0.030-inch sectional wire with nitinol coil spring and eyelet tube anchored by a Nance holding arch, distalizing at 0.83 mm a month with 1.0–5.0 mm of activation every 4 weeks (23). Anchorage loss gave 1.05 ± 0.87 mm of premolar mesial movement and a 1.10 ± 0.83 mm overjet increase, 2.0 mm and 4.76° of tipping, and only 46% of the space from molar distalization (23).

19. Unilateral spring regainer: Described as a smart way of driving the molar distally (25): a 0.036" × 0.072" lingual sheath with two 0.036" wires and a Ni-Ti spring 5–6 mm apical to the centre of resistance, plus a 0.010" × 0.030" spring compressed 10 mm buccally and opened 3–4 mm extra-orally for activation (3).

20. Coil springs: NiTi was proposed in 1975; open coils give slightly below the optimum 75–100 g, deliver force over 7 mm, and compress from 15 mm to 6 mm, while tension coils are distracted from 3 mm to 6 mm (4).

21. Regainer cum maintainer: A band with a canine retractor of 22 or 23 gauge wire or a 21 gauge U loop, activated by opening the loop or coil spring (3).

7. REMOVABLE SPACE REGAINERS

Goodale described three removable types — the free end loop spring, the split block and the fixed loop-spring appliance (3) — and further designs have since been added, classified in Table 2. All rely on clasp retention and on tissue-borne anchorage from the acrylic base, which is what allows a removable appliance to distribute force over a wide area (28).**Table 2. Types of removable space regainers**

No	Appliance	Principal design and mode of action	Reference
1	Free end loop spring	Labial archwire for retention, back-action loop spring of no. 0.025 wire, acrylic base; unilateral	(3,9,11,15)
2	Split block (split saddle)	Dumbbell of no. 0.025 wire with buccolingually split acrylic block joined by buccal and lingual loops	(3,9,15,16)

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3	Fixed loop-spring	0.025 or 0.030 wire embedded in acrylic, looped through edentulous space to a staple on the first molar	(3)
4	Slingshot	Wire elastic holder with buccal and lingual hooks on the molar; elastic stretched between them	(3,9,15,16)
5	C-space	0.036" labial framework with closed helices, 0.010" × 0.040" open coil soldered distally, 0.028" ball clasps	(4,27)
6	Upper Hawley with helical spring	Compressed helix at right angle to alveolar ridge, adjustable over 3–4 mm	(4)
7	Fixed-removable Hawley	Primary molar bands with 0.028 lingual loops incorporated into the acrylic	(4)
8	Lower Hawley with helical spring	Labial bow of 0.025 or 0.028 yellow Elgiloy; single or double helix against mesial of molar	(4)
9	Lower Hawley with split-acrylic spring	Split acrylic dumbbell, up to 2 mm by tipping the molar distally	(4)
10	Lower Hawley with slingshot elastic	Hooks on lingual and buccal molar surfaces with a daily-change elastic	(4)
11	Maxillary Cetlin plate	0.022 × 0.028 wire anterior screen, Adam's clasps, helical loops in palatal acrylic	(9)
12	Jackscrew regainer	Expansion screw between halves of a split acrylic plate, perpendicular to the midline	(6,9)
13	Finger or cantilever spring	Simple finger springs in acrylic, Adam's clasp retention	(9)

Footnotes: Numbers in the final column refer to entries in the reference list. All removable designs rely on clasp retention and on tissue-borne anchorage from the acrylic base. Dimensions as reported in the cited sources.

1. Free end loop spring regainer: A maxillary unilateral appliance with a labial archwire for stability and retention, a back-action loop spring of no. 0.025 wire and an acrylic base giving tissue-borne anchorage (3,9,11,15). The uprighting distal driving spring is bent from 0.025 or 0.020 inch round stainless steel wire and carries a helix activated close to the gingival margin (11). The free end of the loop is activated at intervals with a light force, reviewed often enough to keep that force light (3,9), reactivated every 2–3 weeks (11), with acrylic clearance ensured in the direction of movement (11). The lower version has a shorter loop that distorts less on insertion (3,9,15).

2. Split-block regainer: Also called the split saddle regainer (3): a dumbbell of no. 0.025 wire extending buccolingually with a buccolingually split acrylic block (3,9) joined by buccal and lingual wire loops (15). The block is split with a disc after processing (15) and activated by flattening the connecting wire (16) or spreading the loops at intervals (9,15). It is commonly used in the lower arch and can move the first molar distally by 1 to 2 mm (16); a unilateral adult version should not be used in a child's mouth because of the risk of swallowing (3).

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3. Fixed loop-spring regainer: Differing from the others only in spring activation (3): 0.025 or 0.030 wire embedded in acrylic, brought through the embrasure, bent to contact the teeth, looped out through the edentulous space and returned to the mesial surface of the first molar around a staple, with wire clasps for retention. The wire contacting the distal surface of the tooth mesial to the space prevents its distal drift, the spring loop must move freely on the staple, and afterwards the appliance becomes a maintainer by soldering the spring in its passive position or adding resin (3).

4. Slingshot regainer: A wire elastic holder with hooks replaces the spring (3): an elastic stretched between buccal and lingual hooks on the molar produces the distalizing force (9,15,16). The child places a fresh elastic outside the mouth and guides it into position after insertion (3,9), changing it once daily (15); movement is limited to 1 to 2 mm (16).

5. C-space regainer: Described by Chung et al. (27): a removable appliance giving bodily molar movement without incisor flaring, used to intrude teeth or move them distally or sagittally, in mild discrepancy treated by second or third molar extraction, and in open bite (4). A 0.036" stainless steel labial framework with a closed helix in each canine region extends distally to lie close to the buccal molar tubes, its ends polished for a loose fit; a 0.010" × 0.040" open coil spring is soldered distal to the helix and 0.028" ball clasps retain the appliance. Fabrication begins with the working cast on a large glass slab; once the frame and clasps are stabilized a separating medium is applied, acrylic is applied over all the anterior crowns, the cast is inverted immediately and the acrylic extended labially according to the anchorage needed, and after curing the plate is scalloped cervically but left thick enough to contact the mandibular incisors. To avoid anterior protrusion, 0.028" ball clasps are added between the lateral incisors and canines as hooks for Class II elastics or J hook traction. The patient is checked every three weeks, the helix squeezed with a heavy wire or three-pronged plier to reactivate, and the molar overcorrected at least 2 mm distal to Class I because of mesial relapse; a Nance button is placed immediately on removal, though the literature on the appliance remains sparse (4).

6. Upper Hawley with helical spring: A compressed helical spring formed at right angles to the alveolar ridge next to the mesial surface of the upper 6-year molar, adjustable to maintain distal pressure over 3 to 4 mm, in 0.028 yellow Elgiloy or 0.020 Australian wire adjusted every 2 weeks (4).

7. Fixed-removable Hawley: Two bands on the primary first or second molars with 0.028 loops soldered lingually are incorporated into the acrylic, converting the removable Hawley into a fixed-removable device with better anchorage and retention; a bandable primary molar without excessive root resorption is required on each side (4).

8. Lower Hawley with helical spring: A labial bow of 0.025 or 0.028 yellow Elgiloy with adjustment loops labial to the cuspids passes over the ridge so that the lower anterior teeth and the whole arch act as an anchorage unit; the helical spring is of 0.028 Elgiloy or 0.020 Australian wire, and the double helix is slower to bend but kinder to the periodontium. Little or no distal pressure is applied in the first week, thereafter a slight distal pressure every 2 weeks, and 2 mm of movement takes 2 to 4 months (4).

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9. Lower Hawley with split-acrylic spring: A split acrylic dumbbell spring regains up to 2 mm by tipping a 6-year molar distally, adjusted twice a month with about 0.5 mm of opening each time, since larger adjustments prevent the appliance from seating (4).

10. Lower Hawley with slingshot elastic: Hooks on the lingual and buccal surfaces of the molar with an elastic between them, the child fitting a new elastic outside the mouth and changing it daily (4).

11. Maxillary Cetlin plate: For distalization of one or two maxillary molars: 0.022 × 0.028 wire covered with acrylic as an anterior screen, Adam's clasps on the first molars or primary teeth, and a wire with helical loops in the palatal acrylic ending at the mesial aspect of the permanent molars, with a separator inserted if interproximal room is insufficient (9).

12. Jackscrew regainer: An expansion screw between the halves of a split acrylic plate, positioned perpendicular to the midline in relation to the edentulous space (9), activated regularly against the banded teeth (6) and expanded to gain arch width (9); a bilateral version adds a coil-loaded lingual arch through lingually soldered tubes for rapid results (6).

13. Finger or cantilever spring regainer: Simple finger springs in an acrylic appliance retained by Adam's clasps, whose activation can distalize the molars (9).

8. OTHER METHODS OF SPACE REGAINING

Space may also be recovered without a regainer, by proximal stripping, expansion, extraction, distalization, derotation of posteriors, uprighting of molars and proclination of anteriors (16).

Proximal strippingalso called slenderisation, disking or proximal slicing, is indicated only where the space required is minimal, where extraction can be avoided, and in the lower anterior region as an aid to retention; it is contraindicated in very young patients because of pulpal exposure, and in those with a high caries index or sensitivity. Metallic abrasive strips, safe-sided carborundum discs or long thin tapered fissure burs are used, followed by fluoride, with no more than 50% of the tooth sliced and its morphology unchanged (16).

Uprighting of molars: Loss of the deciduous second molar or extraction of the second premolar tips the first molar mesially, and a tipped molar occupies more space than an upright one, so uprighting with springs or regainers returns some space (16).

Derotation of posteriors: Rotated molars occupy more space than normally placed ones, and derotation releases some of it; fixed appliances with springs or elastics achieve it best (16).

Proclination of anteriorsregains space in retroclined teeth, where the profile allows (16).

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Distalizationmoves molars backwards, ideally before the permanent second molar erupts (16), and the extraoral and intraoral approaches have been reviewed at length (20,21). Extraorally, a headgear takes cervical or cranial anchorage through a face bow, its outer bow attached to a headcap or neck strap and its inner bow to molar buccal tubes. Intraorally, repelling magnets are placed one on the molar and one on an anterior tooth with a Nance holding arch reinforcing anchorage; extraction of one premolar per quadrant is one of the commonest methods, molars and incisors being rarely extracted; and expansion, skeletal or dento-alveolar, is non-invasive, rapid maxillary expansion splitting the midpalatal suture up to 16 years in girls and 18 in boys with a removable split plate and midline screw or fixed Haas, Issacson, Hyrax or Derichsweiler appliances, while slow expansion uses jackscrews, the Coffin spring or a quad helix (16).

9. MODIFICATIONS AND INNOVATIVE APPLIANCES

Some studies have adapted space maintainers to serve as regainers, the aim being a balance between effectiveness and compliance (6). Romano et al. treated two cases of ectopic eruption of the permanent maxillary first molars with a modified Nance palatal arch, the wire soldered to the band and positioned distally to carry an elastic chain to a bonded occlusal button; the molars were corrected within a few months, the adjacent primary teeth preserved and function restored, the mechanism being distalization (6). Nevant et al. in 1991 and Raucci et al. in 2015 concluded that the lip bumper produced more significant space regain than the transpalatal arch, the lower lip muscles applying continuous distalizing force to the mandibular first molars while the tongue opposes labially on the incisors, and prefabricated bumpers with thicker shields were more efficient than stainless steel round wire through their greater contact area with the lip musculature (6). In a 13-year-old with a Class II division 1 malocclusion on a Class II skeletal base, expansion was the only viable option among distalization, proclination, stripping, extraction and expansion, an estimated 0.5–0.7 mm of space being gained for every 1 mm of posterior arch expansion; a twin block created the space used to adjust for the missing central incisor, showing that a functional appliance can expand the maxilla while correcting the sagittal relationship (6).

The **Kamatuday regainer** bands the mandibular right first molar with 0.006 × 0.180 in material carrying 1.1 mm diameter, 10 mm molar tubes welded buccally and lingually, and the peg-shaped canine and retained deciduous canine (83) with 0.004 × 0.150 in material; two 0.017 × 0.025 inch wires soldered to these bands run into the molar tubes, and NiTi open coil springs (GAC International Inc., Central Islip, NY; 0.012 in diameter, 0.045 in lumen, 13 mm length) sit between anteriorly soldered stoppers. Springs are held compressed to half length during cementation; 2.0 mm was gained at 2 months and 3.5 mm at 4 months, and the appliance was removed once the premolar had erupted to its mesial and distal heights of contour (19).

The **banded helical regainer** bands the first deciduous molar and the first permanent molar, the active component being a 4 mm helix and 10 mm active arm of 23-gauge wire on the mesial surface of the first molar with its open end in the buccal tube; the arm length was the measured distance from the distal of the helix to the end of the tube, calculated as 10 mm, with 2.5 mm added for alignment, and the retentive arm was soldered buccally to avoid soft tissue laceration. Cemented with type 1 HY-Bond

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Glass Ionomer CX-Smart and activated by opening the coil, the space was regained within 3 weeks of weekly review (29).

The **Junaidi regainer** needs only a molar band, an archwire and an open coil spring: a large rectangular wire, for example 0.018 × 0.025 inches, is cut to the distance between first premolar and first molar plus the space required plus the length needed to bend around the distal of the premolar, with 2 mm added for a composite ball distal to the molar tube, and the NiTi open coil measured from the mesial opening of the tube to the end of the arm plus 2–3 mm for activation. Nothing is soldered, since the soldered joint is a common site of failure accounting, after cement loss, for 15% to 36% of failures; the heavy-gauge wire resists deformation, anchors the spring and is replaced chairside, and the design becomes a maintainer by omitting the coil and placing a stopper mesial to the tube (30).

The **SV appliance** was devised because no existing appliance addressed regaining and maintenance at once. Both permanent mandibular molars were banded, a lingual sheath welded lingually on the right side where space was lost, and the bands transferred with an alginate impression and stabilized with needles before the cast was poured in dental stone. The lingual arch maintainer was fabricated from 0.8 mm stainless steel wire, the erupted permanent incisors contacting it at the cingulum, its posterior part lying 2 mm below the gingival margin or edentulous ridge to prevent distortion in mastication and 1–2 mm lingual to the posterior teeth so that the bicuspids could erupt adequately buccolingually. A U-clasp of 0.7 mm wire gave retention, the coil spring lay between it and the lower right molar, and the appliance was trimmed and polished. The patient brushed twice daily by the modified Bass technique, was recalled at 1 week then every 3 weeks until the crown tip appeared, and 4.5 mm was regained in three months; the NiTi springs deliver 100 to 150 gm, load rising linearly up to 3 mm of movement and nonlinearly to 11 mm, and banding may harm the gingiva or allow caries behind the band (31).

10. MAINTENANCE AND FOLLOW-UP

Removable appliances need periodic checking to establish whether the patient is wearing the appliance at all, whether it has distorted or broken, and whether the soft tissues are being irritated; where teeth are erupting beneath the appliance, the corresponding acrylic is cut away to let them come into position. Fixed appliances are checked for breakage at the soldered joints or in the band material, and for looseness from dissolution of cement, which allows food lodgement and caries (4).Base metal appliances release nickel and chromium. Bhaskar and Subba Reddy (2010) observed that release was at a minimum on the 28th day after insertion and increased proportionally with the number of space maintainers inserted; Mohammad et al. (2013) found more salivary Ni-Cr after maintainer insertion than with stainless steel crowns; and Ashish Anand et al. (2015) explained that the release was well below the average dietary intake of nickel, 300–500 ppm/day, and of chromium, 50 to 200 ppm/day, and so was not capable of causing toxic effects (5).The appliance is removed every 6 months or 1 year depending on the situation, the abutment tooth examined for caries or decalcification, polished and given a fluoride application, and the appliance recemented, with regular radiographic examination of the developing permanent teeth (4). It may be removed or discarded once the succedaneous teeth have erupted into proper position in the oral cavity (4).

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11. FUTURE TRENDS IN SPACE MANAGEMENT

Three-dimensional printing, or desktop fabrication, has recently entered pediatric dentistry, resting on computer-aided design and computer-aided manufacturing and building customized objects layer by layer from standardized materials (6). One case study used 3D-printed bands and loop maintainers, CAD/CAM allowing patient-specific prostheses to guide eruption in an autistic child with high precision and rapid production, reduced chairside time also minimizing aerosol exposure; the cast was scanned with a 3D digital dental scanner and the band and loop designed in 3Shape dental software (Copenhagen, Denmark: 3Shape) (6). Ceramics, hydrogels, thermoplastics and polymer-based materials are available alongside metals, with titanium and Co-Cr alloys preferred for corrosion resistance, hardness and bonding capacity (6). Guo et al. used scanning and laser medical image reconstruction to build a digital model of dentition defects and compared polyetheretherketone with conventional fabrication: conventional maintainers suffer from complicated manufacturing, technique sensitivity, individual variation and shrinkage of self-curing resin, whereas PEEK maintainers were more accurate, the mean distance and standard deviation of the PEEK group significantly smaller than those of the conventional group (6). The tube and loop, or Nikhil, maintainer eliminates impression making, band transfer and soldering (6), and preformed bands reduce chairside time in children whose fear and anxiety make longer appointments difficult (6). Aksoy et al. examined AI chatbots for delivering space maintainer information to patients and parents and considered them a valuable tool for assisting treatment planning (6). Digitization has shortened treatment while improving diagnostic accuracy, but long-term studies are still needed on the success of conventional and innovative appliances, on new designs and materials, and on the integration of AI into the care of young children (6).

12.DISCUSSION

Premature loss of primary teeth during the mixed dentition period may lead to reduction in arch length and disturbances in the eruption of permanent successors. The extent of space loss depends on the tooth involved, the child's age and the eruption status of adjacent teeth. Padma Kumari and Retnakumari, in their longitudinal study, reported measurable space reduction following premature loss of a mandibular primary molar, emphasising the importance of early diagnosis and timely intervention (13).Accurate diagnosis and mixed dentition space analysis are essential before selecting a space regainer. Clinical examination, radiographs and study models help determine the amount of space lost and the type of tooth movement required (6,14,16). Several fixed and removable appliances have been described, each with specific indications and biomechanical characteristics.Fixed appliances such as the Gerber, Hotz lingual arch, King appliance and open coil regainer provide continuous force application and do not rely on patient compliance (3,4,7,8,17). However, they require regular monitoring to prevent plaque accumulation, gingival inflammation and decalcification around the bands. Removable appliances, including free-end loop springs, split-block appliances and Hawley-type regainers, offer easier oral hygiene and relatively simple adjustment, but their effectiveness depends largely on patient cooperation and consistent wear (3,9,15,16).Anchorage control and the type of tooth movement are important determinants of successful treatment. Appliances designed for molar distalization may produce unwanted movement of anchorage teeth if the

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reciprocal forces are not adequately controlled. Clinical findings associated with the Jones Jig highlight the importance of considering anchorage loss while evaluating the effectiveness of distalization appliances (21,23). Other approaches, including proximal stripping, expansion, derotation and molar uprighting, may also be considered according to the amount of space required and the existing occlusal relationship (16,20).Recent modifications, including the Kamatuday, banded helical, Junaidi and SV appliances, aim to simplify fabrication and improve clinical efficiency (19,29–31). Digital technologies such as CAD/CAM and three-dimensional printing have further introduced possibilities for customised appliance fabrication and reduced chairside procedures (6). Nevertheless, evidence supporting many newer designs remains limited, and further clinical studies are required to establish their long-term effectiveness and stability.Overall, the literature suggests that no single appliance is suitable for every clinical situation. Successful space regaining depends on early diagnosis, appropriate appliance selection, adequate anchorage, patient cooperation and regular follow-up. Once the required space has been recovered, it should be maintained until the permanent successor erupts into its appropriate position.

13.CONCLUSION

Space regainers remain indispensable in the interceptive management of children who lose primary teeth prematurely, since regaining space in good time maintains arch integrity, allows the permanent teeth to erupt properly and prevents a malocclusion from progressing; success depends on accurate diagnosis, appropriate appliance selection, sound biomechanical principles and diligent follow-up. Conventional regainers are reliable in routine practice, while modified designs, prefabricated systems, digital workflows, advanced biomaterials and three-dimensional printing have improved precision, efficiency, comfort and compliance and reduce chairside time — a particular advantage with young, anxious or special needs patients. Selection must nonetheless remain individual, weighing age, growth pattern, dental and skeletal relationships, the extent of space loss and long-term orthodontic requirements, and further longitudinal evidence is needed to establish standardized protocols and confirm the stability of digitally fabricated appliances. A timely, well-planned interceptive approach simplifies later orthodontic treatment, reduces its duration and cost, and contributes to optimal functional and esthetic outcomes.

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