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Evolution of the Matrix for Class 2 Restorations

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Evolution of the Matrix for Class 2 Restorations

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Evolution of the Matrix for Class 2 Restorations

INTRODUCTION

In the late 1800s the need for a matrix became apparent when dentists recognized that the best way to treat a tooth affected by dental caries on the approximal surfaces was by restoring its anatomical contour and contact with the adjacent tooth. The matrix was needed to provide the missing wall or walls and thus contain the restorative material during the filling of the prepared cavity. Until the late 1800s, the rationale for treating carious lesions on the approximal surfaces of teeth was based on either a restorative or a prophylactic concept.

EARLY CONCEPTS OF TREATING APPROXIMAL CARIES

Restorative Concept

The rationale for restorative treatment was to remove the caries and fill the cavity with a suitable material (Harris, 1848). At this time, however, restoration of the tooth to form and function was not of general concern.

Prophylactic Concept

The rationale for prophylactic treatment was premised on an early theory of caries, which taught that caries began at the point of contact between the teeth where pressure damaged the enamel — the lesion being caused by the action of external corrosive agents — and on observation of animal prototypes and human tribal and cultural customs (Harris, 1848; Jack, 1887). In these groups, the cone-shaped configuration of teeth, whether biologically present or mechanically produced, demonstrated a remarkable absence of caries.

The method advocated the creation of a self-cleansing space by removing diseased or healthy tooth structure from the approximal surfaces, thereby achieving total and permanent separation of the teeth (Fig 1) (Harris, 1848). The self-cleansing space was indicated

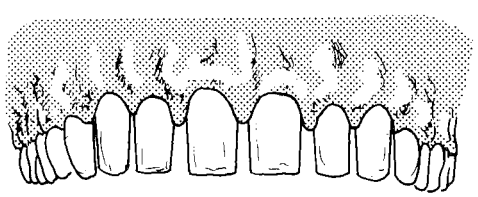

FIG 1. *Total and permanent separation of approximating teeth to achieve self-cleansing spaces (after Harris)*

for the prevention of caries, for the treatment of superficial caries, and to provide access to deep caries.

The procedure was accomplished by the use

of a file, the oldest method of removing tooth structure (Harris, 1848). Chisels (Taft, 1859), small corundum points, and engine burs (Harris, 1848) were also used, after which the teeth were polished to a smooth, rounded surface (Harris, 1848). Later, disks of various substances, including diamonds, were also employed in separating teeth (Taft, 1877; Harris, 1885). The corundum disks introduced by Robert Arthur in 1872 (Hoffman-Axthelm, 1981) eventually superseded the use of the file.

The procedure as described by Harris (1848) required the removal of one-third or more of the tooth and created a shoulder at the cervical margin to maintain contact in this area and prevent the teeth from drifting. In the posterior region, the separation was referred to as a "V-shaped" space (Fig 2). If the teeth required restorations, these were designed so as not to encroach on the space created. Later, Harris (1858) reduced the amount of tooth to be removed to a minimum of one-fourth.

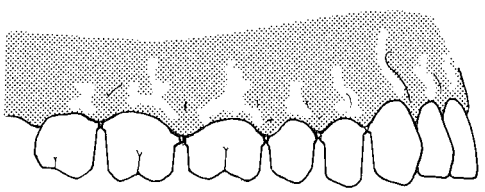

FIG 2. *The shoulder and V-shaped embrasure advocated by the prophylactic rationale (after Harris)*

In 1870 the prophylactic rationale was again popularized by Robert Arthur, who, along with W G A Bonwill and T F Chupein, was its most prominent advocate (Flagg, 1878; Harris, 1885; Guilford, 1897). They too made improvements in the procedure.

Even with these improvements, however, the results observed by the general practitioner led to condemnation of the procedure by the profession at large. The main criticism of this technique, voiced by practitioners and patients alike, concerned the disfigurement of teeth (Harris, 1885). Not only did patients complain of disfigured teeth, they also complained of impaction of food on the gingivae and sensitivity of teeth due to exposed dentin. Practitioners criticized the procedure for periodontal complications, namely, recession and injury to the gingivae, and noted recurrence and actual promotion of caries as well as problems with the occlusion from the drifting of teeth (Jack, 1887; Cox, 1890; Guilford, 1897; Marshall, 1901). By 1887, the technique was contraindicated (Jack, 1887; Marshall, 1901).

Contoured Fillings

Around 1890 practitioners changed the way they restored teeth that had approximal lesions (Black, 1890; Guilford, 1897; Newkirk, 1908b). The concept was premised on a new theory of caries, which taught that caries began below, not at the contact point of the teeth as with the early theory of caries (Miller, 1904), and advocated the restoration of the natural, or original, contour and contact of the tooth. As such, a contoured filling would re-establish the proper form of the interproximal space, maintain the function of the teeth, ensure no breach in the continuity of the occlusal aspect of the dentition, maintain the length of the arch, prevent impaction of food, and maintain and promote the health of the gingivae as well as the comfort of the patient (Black, 1890; Jack, 1897), principles later endorsed by Fee (1940). Thus Black (1890) brought a new and different meaning to the "V-shaped" space. An additional concept introduced concurrently prescribed extending the margins of the approximal part of the cavity onto the facial and lingual surfaces of the tooth (Guilford, 1886, 1897; Newkirk, 1908b). This concept not only facilitated the placement of contoured fillings, but also placed the cavity margins within the range of protective influences, reducing the possibility of recurrent caries.

EARLY MATRICES

The early advocates of contoured fillings included W H Atkinson, M H Webb, and S H Guilford (Talbot, 1882; Guilford, 1897; Flagg, 1878). They recognized that to fill a prepared cavity and produce a contoured filling the practitioner required assistance in containing the filling material. Without such assistance, overcontour at the cervical level and undercontour at the occlusal level resulted. The assistance came in the form of a matrix, which provided for the missing wall or walls of the prepared tooth and transformed a cavity of two, three, or more

surfaces into a simple one (Bennett, 1885). In addition, the matrix could be molded to assist in re-establishing the natural contours of the tooth (Brophy, 1886; Jack, 1887; Bödecker, 1887).

Early in its use the matrix was subject to criticism (Taft, 1877). Some believed that when a tooth was to be restored with direct filling gold, the matrix did not allow for enough contour of gold to compensate for the subsequent polishing and adapted too closely to the margins, thus providing the potential for inadequate condensation of gold in these areas, especially at the cervical level (Ottolengui, 1891; Marshall, 1901; Newkirk, 1908a). The matrix was thought to be more useful in filling disto-occlusal than mesio-occlusal cavities because in mesio-occlusal cavities it obstructed vision and limited access for instruments and the placement of gold over the cervical margin; yet the possibility of using the matrix in mesio-occlusal cavities was accepted (Guilford, 1886; Jack, 1871).

Although the early matrices were intended for use with direct filling golds, these matrices were also recommended for use with amalgam, which had been introduced to America in the 1830s (Ottolengui, 1891; Burchard, 1897). Because of its plasticity, amalgam required a matrix for the condensation and development of proper physical properties, contour, and interproximal contact.

SEPARATION

Originally, separating devices were introduced to gain access to the lesion and place the filling material (Harris, 1848). Separation by pressure was first introduced by E Parmly (Harris, 1848), and was accomplished over a period of 3 to 5 days (Jack, 1887) or 10 to 12 days (Taft, 1855). It was later referred to as gradual, or indirect, wedging (Harris, 1885; Marshall, 1901). Rapid wedging (Harris, 1885), or immediate (direct) wedging as it was later called (Marshall, 1901), was introduced and first described by C Palmer (Taft, 1877; Jack, 1887). The technique included placing a wooden wedge cervically between the necks of the teeth to achieve the minimum separation required. Prior to this first wedge, a "shield" wedge was placed to protect the gingivae. A second wedge was then forced between the contact points of the teeth achieving the maximum separation required. Afterward, the first wedge was seated further to complete the procedure and the second wedge removed. For restorative procedures, separating devices included two general types, the mechanical separator and the wedge.

Mechanical Separators

In 1874 Jarvis introduced the first recorded mechanical separators (Fig 3) (McGehee, True & Inskipp, 1956), one for the anterior and the other for the molar teeth (Taft, 1877).

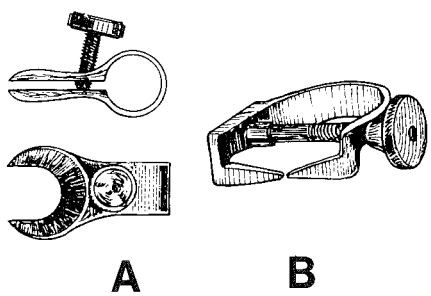

FIG 3. *Jarvis separators (after Taft):*
A - *For anterior teeth*
B - *For posterior teeth*

This was followed by the Perry separator (Harris, 1889), which was considered an improvement (Fig 4) (Jack, 1887).

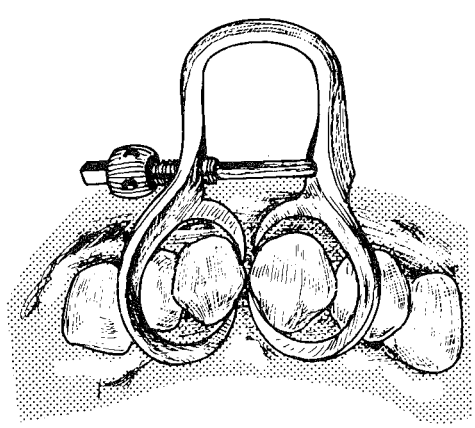

FIG 4. *Perry separator applied to teeth (after Jack)*

Later, Perry introduced other separators (Black, 1908) which included the Perry two-bar separator (Fig 5), an improvement on the original (Jack, 1887; Fillebrown, 1889; Marshall, 1901).

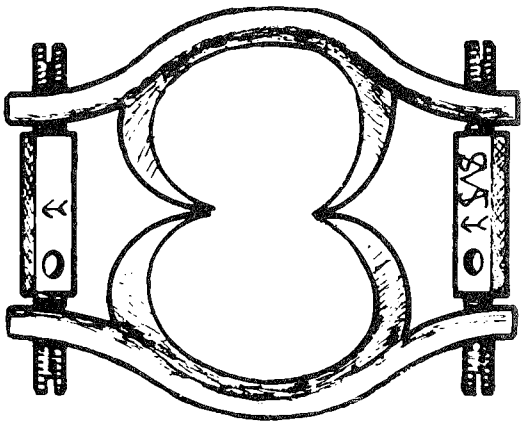

FIG 5. *Perry two-bar separator (after Jack)*

Other mechanical separators included the Woodward (1886) (Fig 6), Parr's universal (Fig 7) (Perry, 1886; Fillebrown, 1889), Elliott (Fig 8), Ivory double bow (Fig 9), and Ivory adjustable separators (Fig 10) (Gabel, 1940). Ferrier redesigned the Perry separator (Gabel, 1940) to remove interferences caused by the parts of the separator and to give more access for the use of instruments (Fig 11) (Black, 1936; Ferrier, 1959).

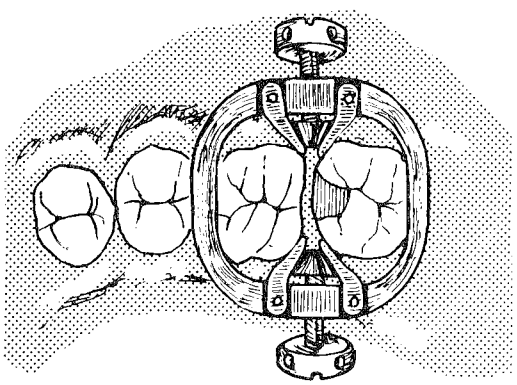

FIG 6. *Woodward separator applied to teeth (after Jack)*

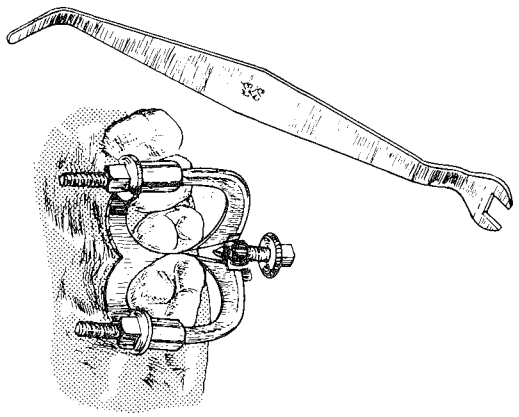

FIG 7. *Parr universal separator and wrench. Separator applied to teeth (after Fillebrown)*

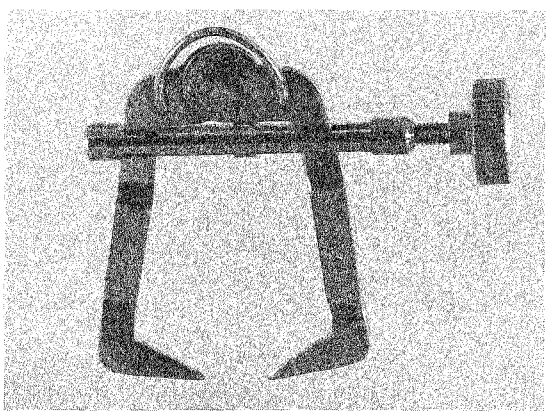

FIG 8. *Elliott separator*

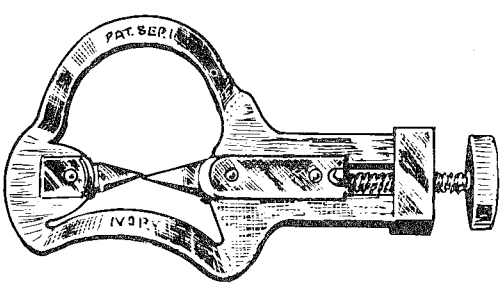

FIG 9. *Ivory universal double-bow separator (after Columbus Dental Mfg Co)*

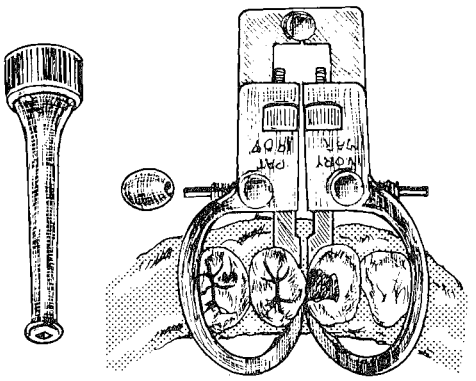

FIG 10. *Ivory adjustable separator and wrench. Separator applied to teeth (after Columbus Dental Mfg Co)*

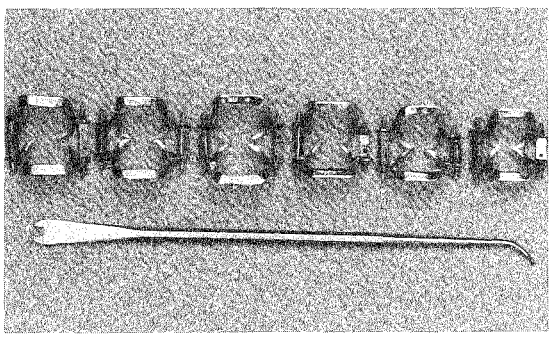

FIG 11. *Ferrier separator, in various sizes, and wrench*

Later mechanical separators included the True and the Dentatus-Nyström (Gabel, 1940; McGehee and others, 1956; Nyström, 1963). Introduced in 1943, the True separator (Fig 12)

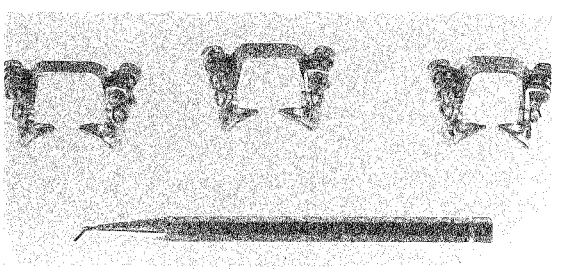

FIG 12. *True separator, in various sizes, and wrench*

was considered an improvement because, having a single bow, there was less to interfere with the operator during restorative procedures.

Wedges

The wooden wedge had been in use for separating teeth before the advent of the matrix. The materials that had been selected for use were boxwood, orangewood, balsam wood, and soft pine (Taft, 1883). They ranged from hard, close-grained wood to medium, fine-grained wood. As an alternative to the wooden wedge, the metal wedge was introduced, the first being the Ottolengui (1891) steel wedge in the late 1800s. It was V-shaped, consisting of two arms that were squeezed together for placement, then sprung apart to retain the wedge in the embrasure (Fig 13). Much later,

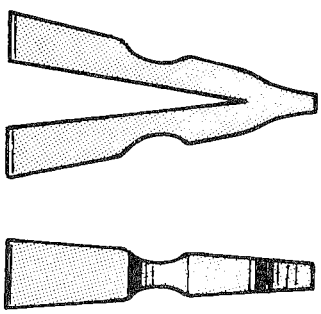

FIG 13. *Ottolengui steel wedge, occlusal and lateral views (after Ottolengui)*

Messing (1960) introduced a wedge made of silver, which was sterilizable and could be bent to the desired shape. The Messing wedge had a concave side to give contour to the restoration and a flat side to provide frictional resistance against the adjacent tooth. The end was grooved to the fit the beaks of dressing forceps for easy insertion and withdrawal. Today wedges are available in wood, celluloid, or plastic (Eccles & Green, 1973), and may include the Stimudent and wedges of medicated wood (McGehee & others, 1956; Simon, 1956; Messing, 1960). The wedges may be purchased precontoured or may be shaped by the dentist to better accommodate their placement and adaptation to the band.

Early on, instruments used to assist in placing and contouring the wedge were developed. To place the wedge, Chase's dental wedge forceps (Fig 14), the Jarvis separator, and the

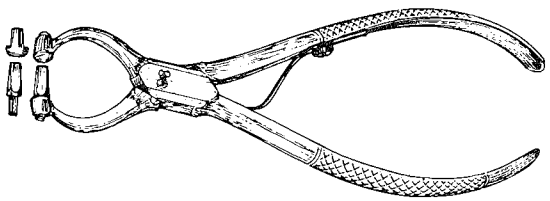

FIG 14. *Chase dental wood forceps (after Taft)*

hand mallet were used (Taft, 1883; Harris, 1885). The Palmer pliers and college pliers were used for placing and removing the wedge (Jack, 1887). To remove projecting portions of the wedge, Miller wedge-cutting pliers (Fig 15)

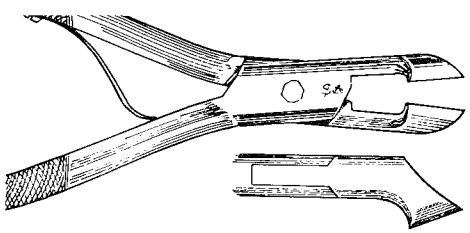

FIG 15. *Miller wedge-cutting pliers (after Jack)*

were used (Harris, 1885; Jack, 1887). Early on, Jack (1871) suggested gum sandarac or mastic to support and retain the wedge; much later, modeling compound was recommended (Brown, 1955; Miller, 1959).

THE ORIGINAL MATRIX

The first recorded use of a matrix is of that introduced by Dwinelle (1855). The matrix consisted of a band made from a broad, thin piece of dense gold. The band was wedged firmly against the tooth. However, it was open at the cervical margin of the cavity preparation to allow space for the condensation of excess gold. Although his own personal testimony and that of his peers (Brophy, 1886; Jack, 1887) point to Dwinelle as the originator of the matrix, he was not necessarily so designated later (Guilford, 1886; Fillebrown, 1889; Green, Shellman & Simon, 1943). Later, the original matrix was described as a metal band that was wedged against and supported by the adjacent tooth, but was not attributed to any one inventor (Fillebrown, 1889; Green & others, 1943; Simon, 1956). Subsequent imitations of the band consisted of blank ends of files or pieces of silver (Cooke, 1871; Jack, 1887).

IMPROVEMENTS ON THE ORIGINAL MATRIX

With the new concept of contoured fillings, the matrix took on added significance. The earliest matrices incorporating the new concepts appeared in the late 1800s and included the Jack, Huey, Perry, and Brunton matrices. As a group, these matrices used various materials of unspecified thickness for the band. The materials included steel, platinum plate or foil, brass, copper, phosphor-bronze, German silver, and tin. Few of the bands were precontoured or shaped prior to placement, nor were they wedged or stabilized with a luting agent.

Jack Matrix

The Jack matrix, introduced in 1871, was accepted as the first matrix to satisfy the concept of contoured fillings. The matrix consisted of a slightly wedge-shaped piece of steel hollowed out to create a depression on its face to correspond to the desired contour (Jack, 1871). The band was made in assorted sizes and shapes and was put into place with forceps, the adjacent tooth being used for retention (Fig 16a).

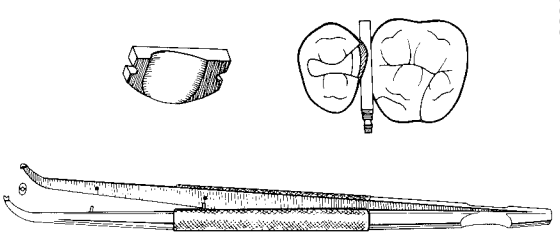

FIG 16a. *The original Jack matrix showing its placement to the prepared tooth, its band and placement forceps (after Harris)*

The band was then wedged with a boxwood wedge. Jack occasionally used boxwood or silver for the band, sometimes a double-faced matrix to allow two cavities to be filled, and sometimes a circular band of silver for large cavities in isolated teeth.

Later, an improved version called the Depressed matrix was introduced (Jack, 1885). The band of this matrix was thinner at the cervical aspect and curved from end to end to provide more access to the cavity (Fig 16b).

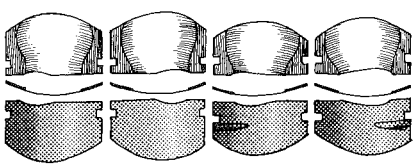

FIG 16b. *Bands for the Depressed matrix*

The matrix was wedged with two wedges of orangewood, one from the facial and one from the lingual, the wedges first being dipped in sandarac to aid in retention during the condensation of the filling material.

Shortly after its introduction, the Jack matrix declined in popularity. Practitioners generally considered the design too complicated, and too laborious and time consuming, to make. It required an adjacent tooth to retain the band, which was difficult to hold in position. Also the band needed to be wedged tightly against the margins of the cavity, which made condensation of direct filling golds at the margins uncertain (Guilford, 1886; Brophy, 1886).

Huey Matrix

The Huey matrix (Fig 17) was introduced about 1874 as an improvement on the Jack matrix (Guilford, 1886). The design included a circumferential band and thus the matrix could be used for both two-surface and three-surface restorations. The matrix consisted of a band of flat, platinum plate, No 28 American gauge, which encircled the tooth. The free ends of the band were bent at right angles on the facial side, after which the ends were reinforced with heavier pieces of the same metal soldered to

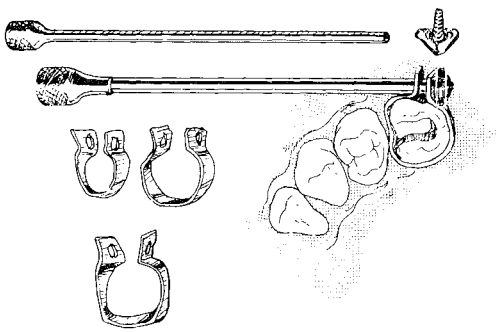

FIG 17. *Huey matrix — components and placement on a tooth (after Goodhugh)*

them. Holes were then drilled in the ends to accommodate a screw with a nut that was used to tighten the band around the tooth. Unlike the Jack matrix, this design of matrix did not require an adjacent tooth to retain the band. According to Guilford (1886), when the band was adapted to the tooth the tension was distributed evenly so that the band did not bind more heavily on the friable margins of the cavity than on any other portion of the tooth.

Perry Matrix

The Perry matrix (Fig 18), introduced in the late 1800s, was used for two-surface restorations and depended on a mechanical separator, the Perry separator, which improved the amount and method of separation (Brophy, 1886). The matrix consisted of a band of thin, narrow brass or phospor-bronze. The band could be shaped before placement and was burnished to the adjacent tooth for re-establishment of the tooth's contour and contact. The separator held the band in place. Black (1899) modified this

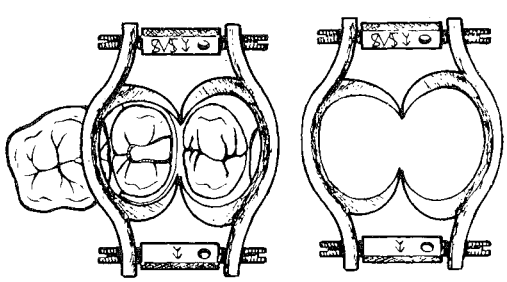

FIG 18. *Perry separator and matrix (after Jack)*

design of matrix by using bands of copper, German silver, or steel. He also placed a wedge of softwood into the lingual embrasure if close adaptation at the cervical margin were required (Reade & Kirkwood, 1965). A later modification of the Perry matrix consisted of a band 0.002 in (51 μm) thick and modeling compound to secure the separator (Green & others, 1943; Simon, 1956).

Brunton Matrix

The Brunton matrix (Fig 19), which also was

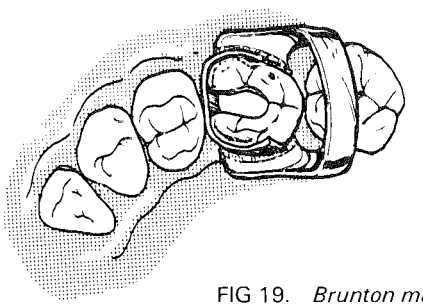

FIG 19. *Brunton matrix*

introduced in the late 1800s, occupied one interdental space but did not require the adjacent tooth for retention. This matrix consisted of a band made of a short piece of clock spring with the temper taken out of the ends (Hutchinson, 1885). The ends of the band were bent sharply on themselves. The band was kept in place on the tooth by a rubber dam clamp placed at the cervical aspect with clamp forceps. Cunningham (1885) modified this matrix by using a band of platinum foil secured with a rubber dam clamp. H P Booth suggested an additional modification, namely, a flexible band of tin, brass, or copper held firmly at the cervical level with a matrix holder or clamp designed by him (Palmer, 1890).

DISCUSSION OF EARLY IMPROVEMENTS

These early improvements of the original matrix did not, however, result in the acceptance of one design of matrix but led to various modifications, trends, and improvements of the early matrices. The Jack matrix, for instance, led, through modifications and improvements, to the custom matrices, the predecessors of those in current use. Similarly, the Huey matrix, which consisted of a band encircling the tooth and was held by a screw or retainer, became the predecessor of the matrices with mechanical retainers. The Perry matrix led to modifications known as band-mechanical separator matrices and, finally, the modifications of the Brunton matrix led to the spring-clamp matrices.

CUSTOM MATRICES

The custom matrices consist of a band in conjunction with some type of separating device other than a mechanical separator. Three types of custom matrix are used currently: the anatomic matrix, the tie-band matrix, and the continuous-loop matrix. All three were preceded by early custom matrices introduced in the late 1800s. The band of the early custom matrices was of an unspecified thickness and made of steel, gold, platinum, German silver, copper, or brass. Few were precontoured, that is, contoured before placement on the tooth, or wedged or shaped after placement. The later custom matrices used bands ranging in thickness from 0.001 to 0.002 in (25-51 μm) and were made of German silver, copper, and, in addition, nickel, aluminum, and steel, either carbon or stainless. Most bands were precontoured and then shaped further after the matrix was placed. They were wedged and stabilized with compound.

Anatomic Matrices

SHELLAC MATRIX

One of the early custom matrices was the shellac matrix (Fig 20). This matrix was formed

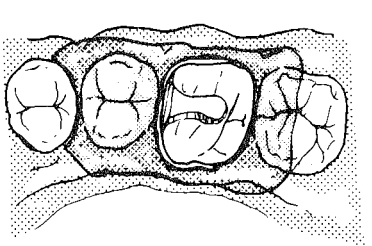

FIG 20. *Shellac matrix*

by the use of shellac to encompass the tooth being operated and two or three adjoining teeth (Jack, 1887). The shellac covered the occlusal surfaces of the adjacent teeth and was placed in the embrasures for support. Because direct filling gold became contaminated when in contact with shellac, the technique was later modified by Brunton (Bennett, 1885). This modification added to the shellac matrix a band made of a clock spring or platinum foil that was placed in the interproximal area to prevent contamination of the gold during condensation.

HERBST MATRIX

A piece of clock spring was also used in the Herbst matrix introduced in the late 1800s (Bennett, 1885). The piece of clock spring extended around half the tooth, covering and reaching beyond all the margins of the cavity (Bödecker, 1887). Modifications of this matrix included adding one wedge secured with two pins and using two wedges (Bennett, 1885). Other modifications included the use of bands of different metals and a wooden wedge, both secured with shellac. The band could be made of steel, Brown's polishing metal, or thin German silver (Bödecker, 1887).

HUTCHINSON MATRIX

The Hutchinson matrix, unlike the clock-spring matrix, consisted of a short length of a small blade of a penknife (Hutchinson, 1885). This blade had a thick back, which could be bent by heating. Because the blade was like a wedge and adapted well to the walls of the cavity, no auxiliary wedge was required.

HAND MATRIX

The Hand matrix also consisted of a thin blade, which was attached to and continuous with a shank and handle (Newkirk, 1908a). The blade was placed into the interproximal area and held firmly against the tooth at the cervical level. The opposite edge of the blade was placed against the crown of the adjacent tooth. The handle of the blade was held in the operator's left hand and, with a twist, separation resulted.

WOODWARD MATRIX

Woodward (1885) introduced the clasp matrix (Fig 21), which consisted of a polished band of steel blank secured with contoured wedges (Jack, 1887). The band had a lug, which rested on the marginal ridge of the approximal tooth and was grooved on its reverse side. The grooves were pitched away from the cervical edge of the band to hold the wedge and stabilize the matrix.

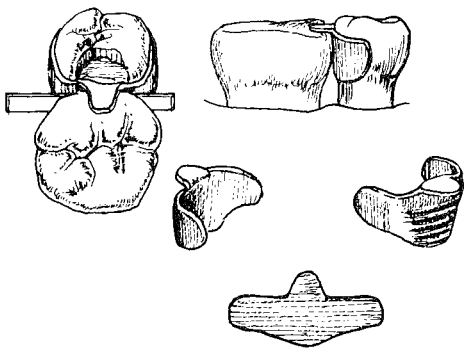

FIG 21. *Woodward clasp matrix (after Jack)*

RUBBER MATRICES

Other custom matrices consisted of a rubber material. For the matrix made of vulcanized rubber, the rubber was shaped on a model, making a matrix that surrounded the prepared tooth and replaced the missing wall. Thus the matrix did not require the support of the adjacent tooth (Brophy, 1886).

Danforth matrix: A variation of the vulcanized rubber matrix was the Danforth matrix. This consisted of a piece of rubber dam drawn taut around the adjacent tooth (Danforth, 1908).

Adapto matrix: Much later, rubber was again used in a matrix, the Adapto matrix, introduced by F C Munch in 1937. Here the rubber was used to achieve separation. This matrix proved unsatisfactory, however, because the elasticity of the matrix inhibited approximal adaptation of the filling material during condensation (Green & others, 1943).

SWEENEY MATRIX

The successor to these custom matrices was the Sweeney (1940) matrix. This matrix consisted of a steel or brass band 0.003 in (76 μm) thick (McGehee & others, 1956), or a thinner, untempered steel band 5/16 x 0.002 in (8 mm x 51 μm) (Nyström, 1963; Strickland, 1968), supported by compound facially and lingually. In addition, a wooden wedge was used with the Sweeney matrix and it was further stabilized with the jaws of an Ivory No 1 retainer warmed and inserted into the compound on the facial and lingual sides (Fig 22) (Green & others, 1943; Stibbs, 1958; Reade & Kirkwood, 1965). A suggested improvement was to burnish the contour into the band (Phillips & others, 1956; Strickland, 1968). The faciolingual contour of the contact area was established with contouring pliers. For this purpose, pliers with leaded beaks were introduced by Miller (1947). An ovoid burnisher was used to establish the occlusocervical contour (Strickland, 1968).

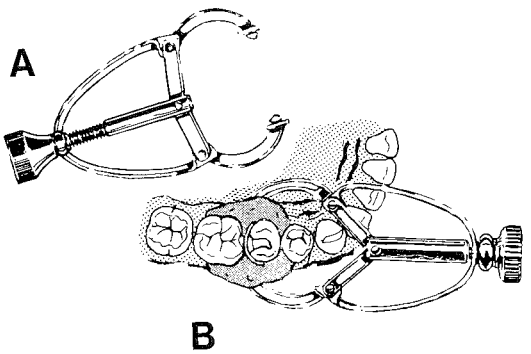

FIG 22. *Sweeney matrix:*
A - *Ivory No 1 retainer*
B - *Matrix on tooth*

INGRAHAM-KOSER MATRIX

Ingraham and Koser (1955) redesigned the Sweeney matrix, using a contoured band of stainless steel 3/8 x 0.002 in (9.5 mm x 51 μm) (Hampson, 1961) and a U-shaped staple, instead of the Ivory No 1 retainer, for support (Fig 23). Contouring pliers were used to recreate the natural, anatomic contours of the tooth before the matrix was placed. Additionally, stainless steel provided a smoother surface than untempered steel against which to condense the amalgam. As with the Sweeney matrix, a wooden wedge and green compound placed facially and lingually were used. The staple secured the compound and facilitated the placement of multiple matrices (Hampson, 1961; Gilmore, 1967; Tocchini, 1967).

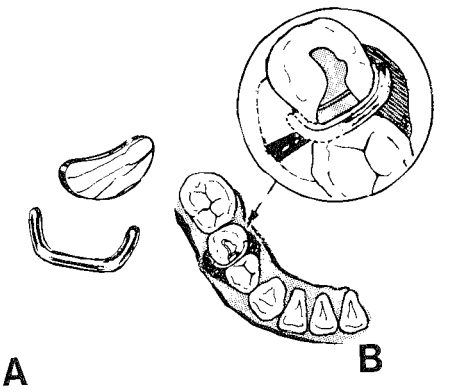

FIG 23. *Ingraham-Koser matrix:*
A - *Band and staple*
B - *Band wedged to the tooth and stabilized with green compound secured with a staple*

SECTIONAL MATRIX WITH BI TINE RING

The sectional matrix with Bi Tine ring (Palodent, Portola Valley, CA 94025, USA), invented by Meyer (1957), can be used to place both two-surface and three-surface restorations. The matrix consists of a precontoured band of stainless steel, 0.0015 in (38 μm) thick, which is wedged and stabilized by the Bi Tine ring with compound applied to its tined tips. The Bi Tine ring also provides additional separation. In addition, Meyer advocates the sterilization of the band prior to its initial use, especially for medically compromised patients, to prevent systemic introduction of bacteria through the sulcular area (Meyer, 1986, personal communication). After placement, the band is burnished with a ball burnisher to perfect the contour and contact area.

OPEN-FACE MATRIX

Another matrix, the Open-face matrix, was introduced about the same time. It consisted of

a band that was wedged and then stabilized with the index finger (Sweet, 1958). The matrix did not follow the concepts of the anatomic matrix and was not as widely known or popular.

Tie-band Matrix

The early custom matrices that preceded the Tie-band matrix were the Perry, Clapp, and Fillebrown matrices, all introduced in the late 1800s.

PERRY MATRIX

Among the several designs of matrix suggested by Perry, one consisted of a very thin band of steel that extended around half the tooth (Fig 24) (Harris, 1889). The bands were made in an assortment of sizes and shapes. Small pieces of metal were soldered to the ends of the band, and holes then drilled through these thickened ends at their cervical aspect. A cord of floss or silk was threaded through these holes, tightened around the tooth, and secured by a double or triple knot. The purpose of thickening the band was to prevent the steel from cutting the cord. If necessary, a wedge dipped in sandarac was used.

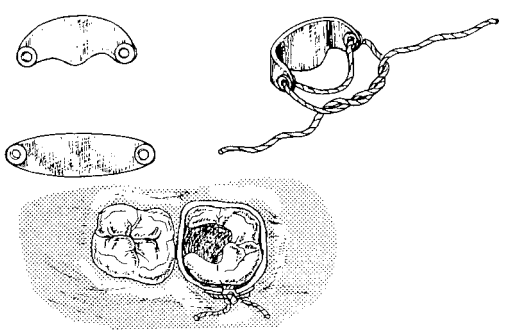

FIG 24. *Perry tie-band matrix (after Harris)*

CLAPP MATRIX

Clapp (1897) introduced a matrix of similar design but used a band of German silver, 35-38 gauge (Herbert & Vale, 1962). When annealed, the band could be adapted better to the shape of the tooth. The band was polished, thus illuminating the approximal area of the cavity for improved visibility. The size required was only enough to extend beyond all the margins of the cavity. Holes were made in the ends of the band and floss was inserted. After it was placed on the tooth the band was secured with the floss tied around the tooth twice. The band was then contoured with a burnishing instrument. Unlike the Perry matrix, the Clapp design required the floss to be wound further around the tooth and matrix until both were totally covered (Fig 25). The ligature was then saturated with sandarac or other varnish to prevent slippage.

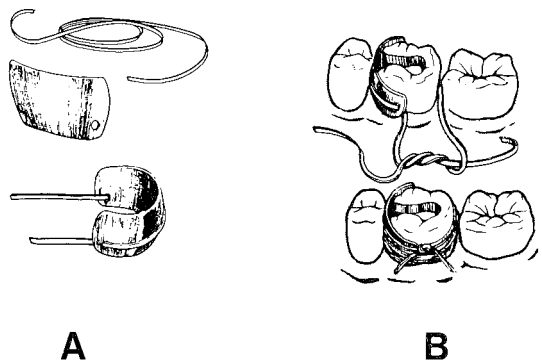

FIG 25. *Clapp tie-band matrix (after Clapp):*
A - *Band and ligature of floss*
B - *Matrix stabilized to the tooth by wrapping the ligature completely around the tooth and band*

FILLEBROWN MATRIX

Fillebrown (1889) also introduced a matrix the design of which was similar to but differed from these early tie-band matrices. This matrix consisted of a preformed, thin metal band with projections at the edges instead of holes at the ends (Fig 26). The projections at the

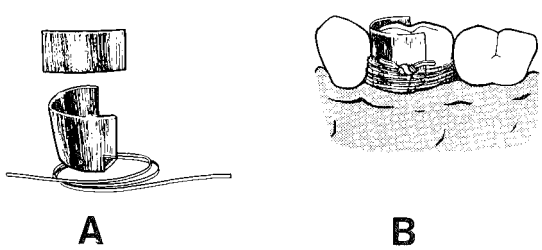

FIG 26. *Fillebrown ligated matrix (after Black):*
A - *Band and ligature*
B - *Matrix affixed to the tooth by tightening the ligature and wedging*

cervical edge of the band held a ligature that secured the band; those at the occlusal edge rested on the adjacent tooth and prevented the band from slipping cervically. Wedges were placed interproximally.

BLACK MATRIX

The ligated matrix introduced by Black (1899) similarly consisted of a band that extended around half the tooth and beyond all the margins of the cavity. The band was a thin plate of copper, brass, German silver, or steel with the cervical corners turned up to accommodate a ligature which, when the band was placed, was tied around the tooth two or three times. A Perry separator was then used for separation. If necessary, a soft wooden wedge was inserted into the lingual embrasure, adapting the band closer to the cervical margin of the cavity.

Some modifications included a 0.001 in (25 μm) thick band of steel (Miller, 1952) or stainless steel, which could be burnished to contour after the matrix had been placed (Black, 1936; Gilmore, 1967). The ligature could be wrapped three or four times around the tooth for additional security and wedged with an orangewood wedge. To reinforce the matrix, guttapercha or modeling compound was placed facially and lingually and also carried over the occlusal surface (Black, 1899; Black, 1908; Gabel, 1954; Blackwell, 1955). Another modification replaced the Perry separator with the Ferrier separator (Black, 1936) or the True separator (McGehee & others, 1956). Yet others did not feel the need for a separator. For cavities involving both approximal surfaces, a band that encircled the entire tooth was used (Fig 27) (Green & others, 1943; Gabel, 1954).

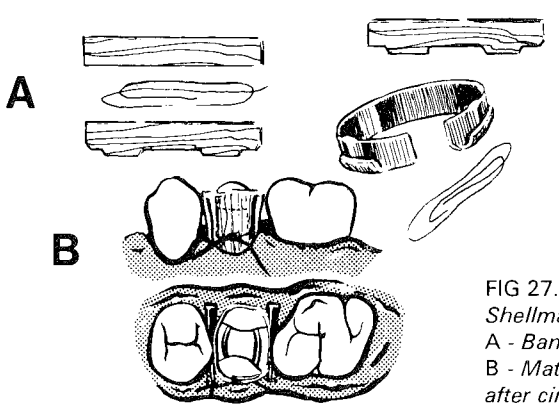

FIG 27. *Circumferential ligated matrix (after Green, Shellman & Simon):*
A - *Band and ligature*
B - *Matrix wedged and stabilized with compound after cinching the ligature to the band*

This band could also be cut on a curve to give a bell-crown, or arcuate, shape (Black, 1908; Black, 1936).

ANDREWS MATRIX

The Andrews matrix consisted of a thin strip of copper nearly encircling the tooth and affixed with a ligature of floss silk wrapped around the matrix four or five times (Andrews, 1886).

BAKER MATRIX

Baker, in his matrix, used silver-plated copper for increased illumination into the cavity (Baker, 1886).

ABERNETHY MATRIX

Abernethy (1937) modified the matrix by using a small ligature wire instead of floss to secure the band. Compound or shellac held in a bridge tray was applied to the matrix and the tooth. The tray had a hole cut in the top to provide access into the cavity (Fig 28).

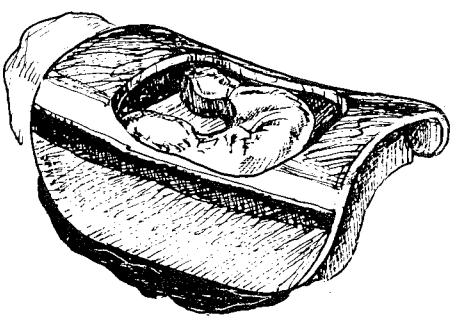

FIG 28. *Abernethy matrix (after Abernethy)*

HOLLENBACK MATRIX

Hollenback (1937a,b) redesigned and reintroduced the early tie-band matrix. The new matrix consisted of a stainless steel band 0.002 in (51 μm) thick with a hole in each end. A ligature was passed through the holes and around the tooth two or three times. The matrix was then secured with low-fusing compound. A suggested modification was to burnish the band to contour after the matrix had been placed (Hollenback, 1937b). The main criticism of the design had to do with the lack of wedging, which potentiated cervical extrusion of the restorative material during condensation (Phillips & others, 1956).

MARKLEY MODIFICATION

Markley (1951) modified the tie-band matrix with a thinner band and wedging — a stainless steel band 0.0015 in (38 μm) thick precontoured with an ovoid burnisher. The holes in the band were cut with a rubber dam punch (McGehee & others, 1956; Gilmore, 1967). After placement and ligation of the band, a hardwood wedge was used (Fig 29). Additionally, the band was burnished after the matrix had been placed (Miller, 1959; Phillips & others, 1956; Reade & Kirkwood, 1965).

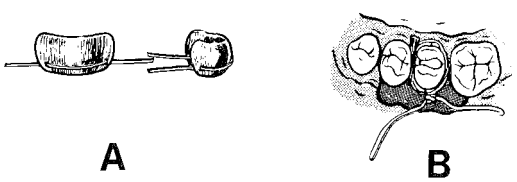

FIG 29. *Tie-band matrix:*
A - *Contoured band threaded with a ligature of floss*
B - *Matrix secured by the ligature, wedge, and green compound*

HAMPSON MODIFICATION

Hampson (1961) also suggested using a wedge to improve the Hollenback matrix. He further suggested the use of the Ivory No 1 retainer to stabilize the compound, an idea originating with Sweeney.

OTHER MODIFICATIONS

Other later modifications included the use of a stainless steel band, 0.001 in (25 μm) thick (Simon, 1956; Gilmore, 1967). The band could be precontoured with No 112 ball-and-socket pliers or No 114 contouring pliers (Miller, 1959) and cut to produce a hole in the area of the contact, thus reducing the amount of separation required.

Continuous-loop Matrix

From its inception the continuous-loop matrix differed from the anatomic and tie-band matrices. It was introduced for cavities involving three or more surfaces. The early matrices of this group include the Herbst continuous loop, collar, or band and the Weirich matrix of a single band of metal alloy.

HERBST MATRIX

The Herbst matrix consisted of a circumferential band and a wooden wedge (Fig 30)

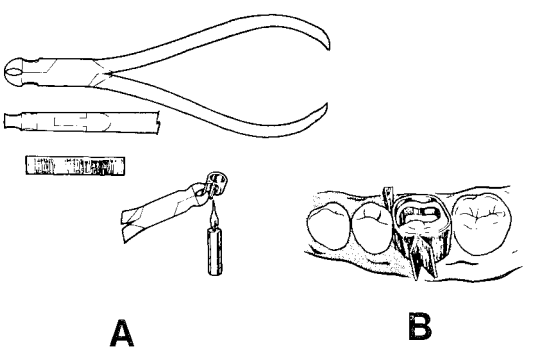

FIG 30. *Herbst matrix (after Bödecker):*
A - *Band cinched to the tooth and soldered*
B - *Band wedged after placement*

(Bödecker, 1887; Marshall, 1901). The band was made of German silver 32-33 gauge and was wide enough to extend beyond all the margins of the cavity. The band was drawn taut around the tooth with Herbst pliers and the ends pinched, forming a seam. The band was then removed and soldered along the seam before replacement and stabilization.

Newkirk modification: Newkirk (1908a) modified the matrix by using different materials for the band and different methods of adapta-

tion. He suggested thin sheet steel, tinned copper, or German silver rolled thin for the band. After placement the band was drawn taut around the tooth and binding wire wound several times around the seam and twisted tight. If closer adaptation at the cervical margin were needed, the cervical edge of the band could be pinched with pliers.

Soldered matrix: The Herbst continuous-loop matrix was reintroduced and redesigned when the soldered matrix appeared (Biales, 1944). The soldered matrix consisted of a continuous band of carbon steel, 36-gauge copper (McGehee & others, 1956), or stainless steel, 0.002 in (51 μm) thick, which was wedged with a wooden wedge. The band was contoured with pliers, placed on the tooth, and drawn taut with flat-nosed pliers, after which the band was removed and soldered along the seam (Sweet, 1958; Gustafsson & Magnusson, 1977).

Spot-welded matrix: This matrix consisted of a band of stainless steel, 1/4 x 0.0015 to 5/16 x 0.002 in (6.4 mm x 38 μm to 8 mm x 51 μm), which was drawn around the tooth and wedged in much the same way as the soldered matrix except that the seam was fixed by a welded joint (Fig 31) (Sweet, 1958; Tocchini, 1959; Strickland, 1968; Gustafsson & Magnusson, 1977).

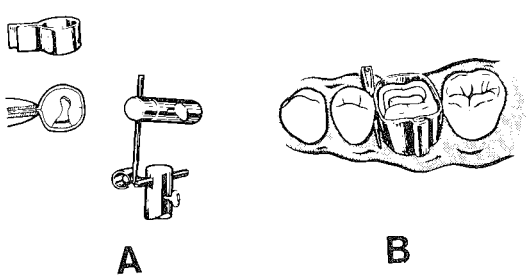

FIG 31. *Spot-welded matrix (after Harrison):*
A - *Matrix is cinched to the tooth and welded along the seam*
B - *Band wedged to the tooth*

Tinner's-joint matrix: Instead of a welded joint, a tinner's joint — the folding of the band upon itself — has been suggested (Fig 32) along with the use of a McKean master separator (Fig 33) in place of a wooden wedge (Tocchini, 1967; Strickland, 1968; Gustafsson & Magnusson, 1977). Tocchini has also suggested contouring the band with a ball burnisher after placement on the tooth, or making a hole in the area of the contact to reduce the amount of separation needed.

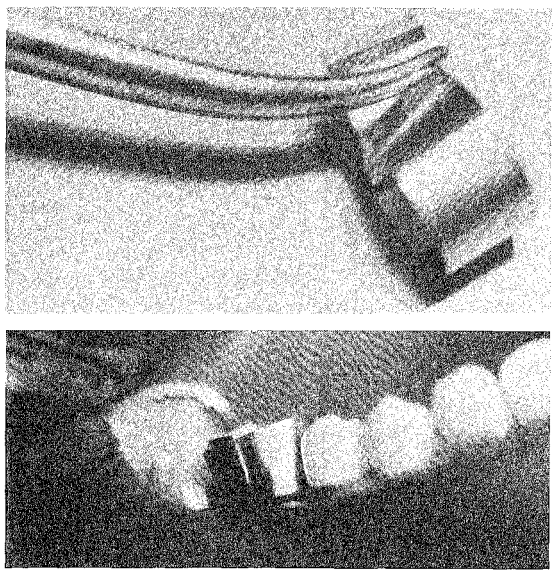

FIG 32. Top - *Tinner's joint;* bottom - *matrix with tinner's joint applied to a tooth*

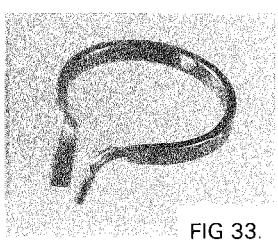

FIG 33. *McKean master separator*

Welded circumferential matrix: This is a matrix preformed and manufactured by Unitek Corp (Monrovia, CA 91016, USA) (Tocchini, 1967).

Rivet matrix: In this matrix (Fig 34), a rivet was used to secure the free ends of the continuous band, which could be cut in an arcuate shape (Seibert, 1929; Pedersen, 1944;

FIG 34. *Rivet matrix (after Tocchini)*

Tocchini, 1959). The rivet was made with riveting pliers No 141 (S S White Co, Holmdel, NJ 07733, USA) or a band-forming punch. The band was contoured with contouring pliers, placed, and wedged, completing the matrix. As an additional modification, the band itself could be substituted with an orthodontic band (Pedersen, 1944).

COLLAR, OR BAND, MATRICES

The collar, or band, matrices consisted of a seamless, continuous band made of gold, platinum, copper, or German silver. If gold or platinum were used in matrices for amalgam restorations, the band was coated with colloidal copal, sandarac, or shellac varnish to avoid contamination with mercury (Harris, 1889). Later modifications made use of a seamless copper band, in various sizes, that was contoured and wedged (Fig 35) (McGehee & others, 1956). An

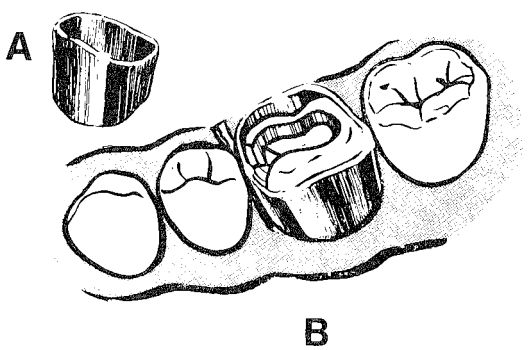

FIG 35. *Copper band matrix:*
A - *Copper band*
B - *Band applied to the tooth and wedged*

interesting variation of the seamless copper band was a matrix consisting of a strip of flexible steel wrapped around the tooth and the band itself. The band was retained by binding upon itself in the contact area with the adjacent tooth (Gabel, 1940).

Harrison matrix: Another modification to the band, or collar, matrix was the Harrison nickel-ferrule matrix (Goodhugh, 1921). This matrix consisted of a nickel or German silver collar that was adapted to the tooth with pliers by pinching the collar at the facial surface (Herbert & Vale, 1962). The resulting loop was turned on itself and the matrix was burnished to contour. The collar was available in various sizes and shapes and the size selected was usually larger than that of the tooth to receive the matrix. To improve the stability and adapt the band closer to the cervical margin, Nichols (1930) added a screw and wedge.

Copper-band matrix: Markley (1951) redesigned the collar, or band, matrix and introduced the copper-band matrix (Blackwell, 1955; Brown, 1955; Simon, 1956; Strickland, 1968). This matrix consisted of a seamless copper band, which was wedged and stabilized with compound. To facilitate contour, the band was annealed, trimmed, and thinned in the area of the contact. It was also contoured with flat-nosed pliers. Some criticized the use of this matrix because of the thickness of the band, the amount of time required to fabricate the matrix, and its ineffectiveness in producing the proper contour and contact (Biales, 1944).

Modifications to the copper-band matrix included the use of bands of nickel, aluminum, or stainless steel and the contouring of the band with a burnishing instrument after the matrix had been placed (Gainsford, 1965; Pickard, 1966).

Pinch-band matrix: Another variation was the pinch-band matrix (Miller, 1959; Rutsky, 1968). This matrix reintroduced the nickel-ferrule matrix of Harrison but consisted, instead, of a band of copper or nickel alloy, 5/16 or 7/16 x 0.002 in (8 or 11 mm x 5 μm). It was pinched and soldered along the seam.

WEIRICH MATRIX

The Weirich matrix consisted of a single band of metal alloy (Weeks, 1894; Harris, 1895). One end of the band was made into a loop through which the free end was threaded. After the band had been placed, the free end was wrapped around the loop again, which

was bent sharply back on itself, securing the matrix (Fig 36).

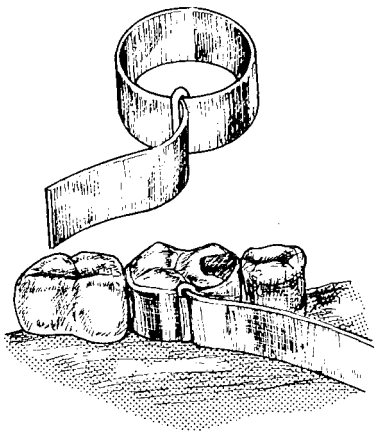

FIG 36. *Weirich matrix consisting of a single band of metal alloy (after Weeks)*

T-band matrix. Levitt introduced the T-band matrix, which succeeded the Weirich matrix (Brown, 1955; Gainsford, 1965). The T-band matrix consisted of a steel band, 0.002 in (51 μm) thick, which was wedged (Fig 37). The

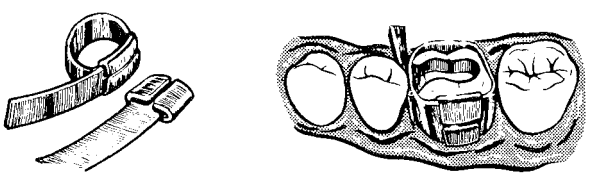

FIG 37. *T-band matrix and its placement on the tooth with wedge*

band could be cut on a curve to produce an arcuate shape (King, 1940; Nyström, 1963). Later modifications included use of bands of stainless steel, 0.0015-0.002 in (38-51 μm) thick, copper strips, or German silver, contouring of the band with No 114 pliers, use of a spot-welded joint to secure the ends, and compound to stabilize the matrix (Brown, 1955; Messing & Ray, 1972). A similar design appeared as Eveready bands (Fig 38) (Union Broach, New York, NY 10010, USA).

FIG 38. *Eveready band (courtesy of Union Broach)*

OTHER CONTINUOUS-LOOP MATRICES

Hazlett matrix: This matrix obtained constriction by means of small locks (Gustafsson & Magnusson, 1977).

Automatrix: The Automatrix (L D Caulk Co, Milford, DE 19963, USA), introduced in 1973, consists of a coiled band, 0.0015-0.002 in (38-51 μm) thick, of various sizes and an auto-lock, which secures the band (Fig 39) (Gustafsson &

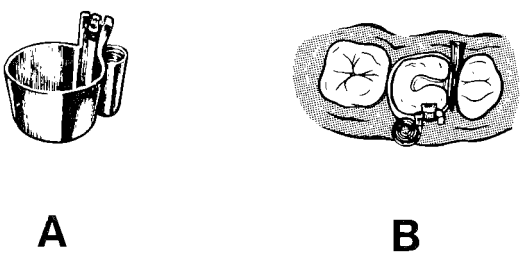

FIG 39. A - *Automatrix;* B - *Automatrix cinched to a tooth and wedged*

Magnusson, 1977). The coiled band is placed with college pliers and tightened around the tooth with the Automate II instrument. After use, the auto-lock is removed with shielded nippers, which releases the coiled band for removal (Shaffer, 1981; Caulk, 1981). The Automatrix is indicated in large posterior restorations and those with one or more cusps needing replacement (Strickland & Wilder, 1985). The advantages of the Automatrix include ease of manipulation, convenience, and improved access and visibility. Because the components of the matrix cause less interference, multiple Automatrices can be placed in the same quadrant (Clinical Research Associates, 1977; Strassler & Porter, 1982). Although cervical adaptation and interproximal contour are considered adequate by some (Soelberg & others, 1979), others have criticized the Automatrix for its expense, the need for accessory items, and the difficulty of contouring the band (Gustafsson & Magnusson, 1977).

For light-cured resin material, the Translite Automatrix (L D Caulk Co) has been introduced. It consists of a precontoured band of clear plastic and is retainerless.

Cleartrix matrix: The Cleartrix matrix (Parkell Products Inc, Farmingdale, NY 11735, USA) is also retainerless with self-locking adhesive ends for use with light-cured resin material. The band is of clear plastic and is arcuate. The Sure-Cure transparent instrument (Parkell Products Inc) for composite placement is used with the band to assist in achieving contact of the restoration with the approximating tooth.

Generally, the various continuous-loop matrices have been popular; however, some feel that when the band is drawn tightly around the tooth, loss of contact and contour in the final restoration can result (Green & others, 1943). In addition, acute angles between the cavity and the matrix can lead to weak margins in the restoration (Miller, 1952).

Advantages and Disadvantages of Custom Matrices

The various custom matrices offer several advantages. Most reproduce the desired anatomical contour and contact of the tooth (Black, 1908; Ingraham & Koser, 1955; Miller, 1959), and are suitable for two-surface and three-surface restorations. Most, because they are not bulky, can be used with other custom matrices to restore more than one tooth in the same quadrant. Also, a matrix that is not bulky can be more comfortable for the patient (Miller, 1959). From their early beginnings, however, the amount of time consumed at the chair in fabrication and manipulation has been cited as a major disadvantage (Gilmore & Lund, 1973). As a consequence, the matrices with mechanical retainers were developed to overcome some of the difficulties of the manipulation of the custom matrices.

MATRICES WITH MECHANICAL RETAINERS

The matrices with mechanical retainers consist of a screw clamp that may or may not incorporate a short length or a continuous loop of band. These matrices, like the anatomic matrices, can be used for both two-surface and three-surface restorations. The early matrices consisted of bands of steel, phosphor-bronze, or German silver, ranging in thickness from "thin" to 0.005 in (127 μm). Few bands were contoured and wedged. The bands of the matrices that followed, however, were made of various materials and ranged in thickness from 0.001 to 0.003 in (25-76 μm). The materials included carbon steel, stainless steel, brass, celluloid, and plastic. Many bands were cut on a curve producing an arcuate shape. Most were contoured before being placed on the tooth, shaped further after the matrix was placed, wedged, and stabilized with compound.

Early Matrices

The early matrices with mechanical retainers superseded the Huey matrix. In 1875 G S Staples introduced a loop matrix; however, the loop matrix introduced by Creager in 1885 had wider acceptance (Brophy, 1886). The Creager loop matrix consisted of a thin flexible band of polished steel, in various sizes and shapes, which was adapted to the tooth with a milled thumb screw (Fig 40) (Harris, 1889; Jack, 1887; Weeks, 1894; Marshall, 1901). Green and others (1943) stated that the main disadvantage of this matrix was the loss of contour and contact when the band was tightened to the tooth.

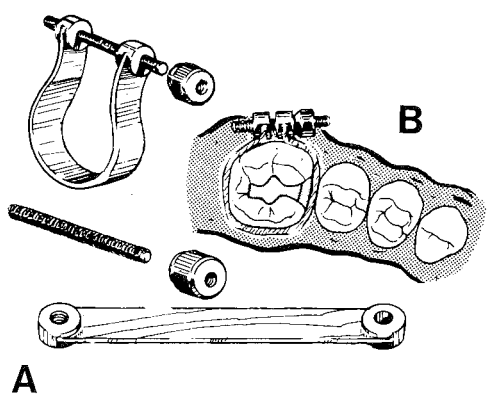

FIG 40. *Creager matrix and retainer (after Jack):*
A - *Band with screw affixed for tightening the band*
B - *Matrix applied to a tooth*

Modifications to this matrix included the use of bands of phosphor-bronze or highly polished German silver and the addition of a wedge (Jack, 1887; Weeks, 1894; Marshall, 1901).

GUILFORD MATRIX

The Guilford (1886) band matrix was introduced as an improvement on the Huey and Creager loop matrices (Jack, 1887; Fillebrown, 1889). It consisted of a band of thin sheet steel, 0.005 in (127 μm) thick, whose lower edge was cut with a dip in the middle to cover deep cervical margins. Small holes were punched near the ends of the band, which extended around three-quarters of the tooth. Various widths and lengths of band were needed. The band was tightened around the tooth with a clamp that engaged the holes in the band and had a screw that was turned with a watch key (Fig 41). If the band were open at the cervical, an orangewood wedge was placed (Marshall, 1901).

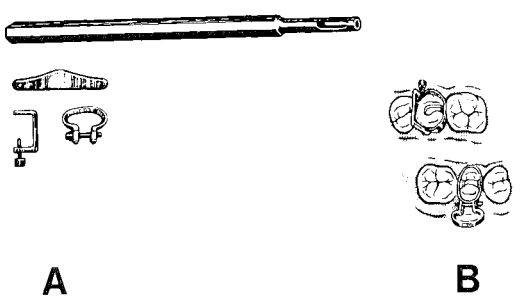

FIG 41. *Guilford matrix and retainer (after Guilford and Fillebrown):*
A - *Band, retainer, and instrument for placement*
B - *Matrix applied to both average and complex restorative situations*

BROPHY MATRIX

Brophy (1886) introduced the band matrix that was one of the first to use thin, spring-tempered steel (Darby, 1897; Fillebrown, 1889; Newkirk, 1908a). It also became one of the most popular matrices (Hartt, 1890). The matrix consisted of a band penetrated by a blunt-pointed screw which, when engaged with a watch key or lever, secured the band to the tooth. The band came in various sizes and shapes. It was also doubled or thicker on one side to accommodate the entrance for the screw (Fig 42). To improve its effectiveness,

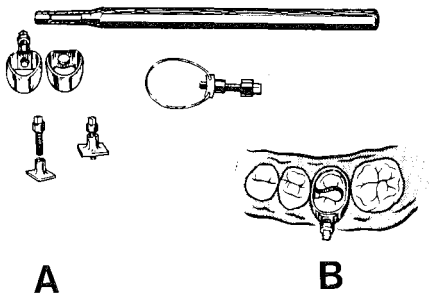

FIG 42. *Brophy matrix and retainer (after Marshall):*
A - *Bands of various sizes, instrument for placing bands, and securing component*
B - *Matrix applied to a tooth*

Brophy modified the band in various ways. When considerable tooth structure was lost during the preparation of the cavity, the band was thickened, making it stiffer for better adaptation, and when there were deep cervical extensions the band was widened with an annex of German silver. Other modifications suggested were the use of a wedge and highly polished German silver for the band (Weeks, 1894; Marshall, 1901).

WOODWARD MATRICES

Woodward (1885) introduced a band matrix that used a model of the prepared tooth to contour a polished band of No 30 phosphor-bronze (Jack, 1887; Darby, 1897). The band was drawn around the tooth with a screw threaded between two posts that were attached near the ends of the band (Fig 43). The band was burnished after the matrix had been placed.

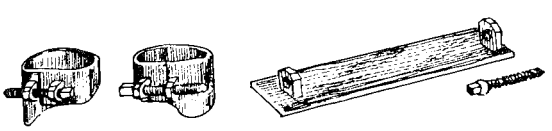

FIG 43. *Woodward band matrix (after Jack)*

Another matrix designed by Woodward, the double-screw matrix, consisted of a steel band in various sizes and possessed two screws, one on each end (Fig 44) (Harris, 1889; Marshall,

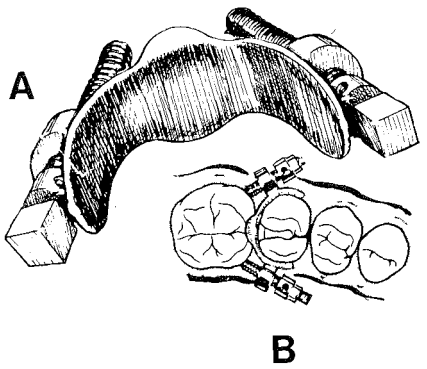

FIG 44. *Woodward double-screw matrix (after Darby):*
A - *Band with screws attached for adjustment*
B - *Activation is achieved by turning the screws of the assembly with a wrench*

1901). When tightened against the adjacent tooth, the screws ensured separation of the teeth and security of the matrix. Many, however, considered the matrix too rigid for adequate adaptability to the tooth (Green & others, 1943).

HINIKER, LODGE, AND HEWITT MATRICES

The Hiniker, Lodge, and Hewitt matrices consisted of a steel band and jackscrew (Fig 45) (Newkirk, 1908a; Reade & Kirkwood, 1965).

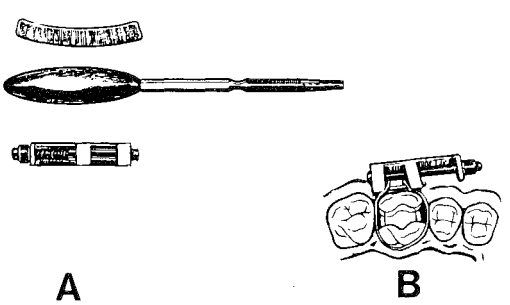

FIG 45. *Hiniker matrix (after Newkirk):*
A - *Band, wrench, and retainer*
B - *Matrix applied to a tooth*

CRENSHAW MATRIX

The Crenshaw matrix was designed in various sizes and shapes for back-to-back or two-surface restorations (Fig 46) (Newkirk, 1908a).

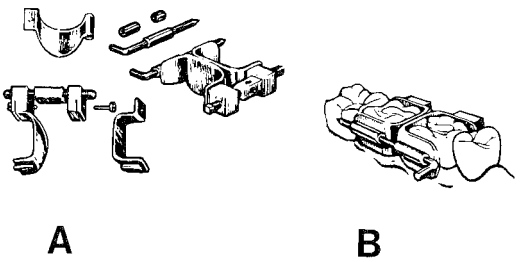

FIG 46. *Crenshaw matrix (after Newkirk):*
A - *Components*
B - *Matrix can be used for single and back-to-back restorative situations*

LADMORE-BRUNTON MATRIX

The Ladmore-Brunton matrix incorporated a jackscrew with a flexible key (Fig 47) (Fillebrown, 1889).

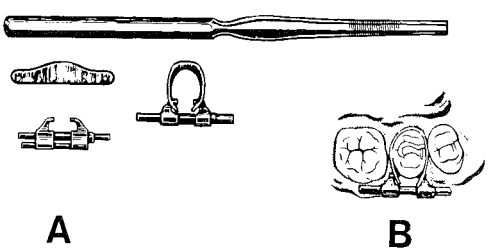

FIG 47. *Ladmore-Brunton matrix (after Fillebrown):*
A - *Band, mechanical retainer, and wrench*
B - *Matrix applied to a tooth*

DICKINSON MATRIX

The Dickinson matrix consisted of a band and the Dickinson wedge matrix retainer (Hardy, 1908). A pair of rotatable, plow-shaped, metal wedges were attached to the retainer and approximated one another by a screw instead of a spring. Thus clamp forceps were not required for the placement of the retainer. The retainer was later marketed by J W Ivory Inc as the Ivory No 4 retainer. The band was available as a single or double band and is still used today

(Fig 48). The double band is also known as the Double matrix (Columbus Dental Manufacturing Co, St Louis, MO 63188, USA) (Newkirk, 1908a).

FIG 48. *Single and double matrix bands (courtesy of Columbus Dental Mfg Co)*

IVORY MATRICES

Original Ivory matrix and retainer: The original Ivory matrix with a retainer was introduced in 1890. It was indicated for the restoration of two-surface cavities. The band extended around three-fourths of the crown of the tooth and was retained by the projections of the jaws of the retainer passing through holes in the band and engaging in the facial and lingual embrasures on the side of the tooth opposite the cavity (Fig 49) (Newkirk, 1908a; Black, 1936). The retainer

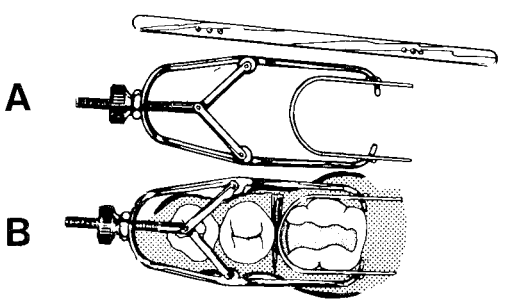

FIG 49. *Ivory matrix (after Simon):*
A - *Retainer and band*
B - *Matrix and retainer applied to a tooth*

engaged the inclined planes of the sound tooth structure on the approximal surface to hold the band, and cinched the band more at the cervical than at the occlusal edge (Gabel, 1954). Later, it was suggested that the matrix could be improved by wedging and burnishing for contour and contact after the matrix had been placed (Gabel, 1940; Green & others, 1943; Simon, 1956). In large cavities, however, the band became straight from cervical to occlusal, producing a loss of contour and reducing the effectiveness of the matrix (Hollenback, 1937b; Gabel, 1940).

Ivory No 1 matrix and retainer: In 1890 the original retainer was modified to produce the Ivory No 1 retainer and matrix consisting of steel bands 0.003-0.004 in (76-101 μm) thick (Fig 50). The matrix, however, was similar to

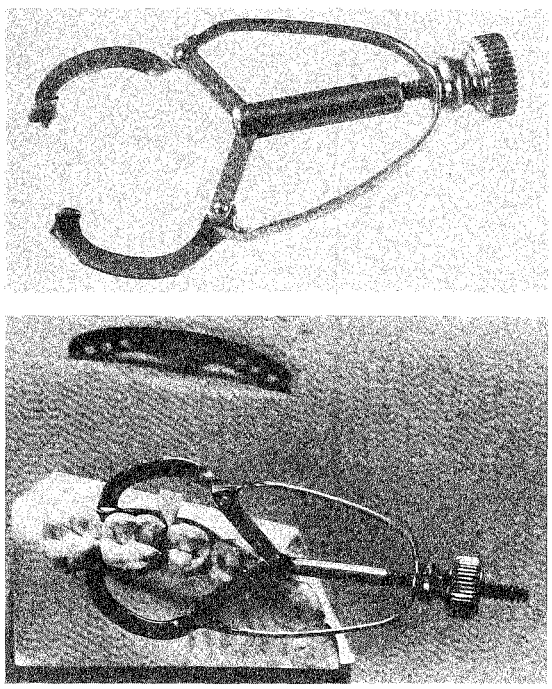

FIG 50. *Ivory No 1 matrix and retainer:*
Top - *No 1 retainer*
Bottom - *Matrix applied to a tooth (courtesy of A Schuchard)*

the original in its use and the placement of the band (Green & others, 1943). It also produced loss of contour and contact after the retainer was activated (Gabel, 1940). To overcome these deficiencies, the matrix was modified by the use of bands, 0.0015-0.002 in (38-76 μm) thick, made of stainless steel, brass, shim steel, or carbon steel in various sizes and shapes (McGehee & others, 1956). The band could be cut on a curve making an arcuate shape (Herbert & Vale, 1962; Gainsford, 1965; Strickland, 1968). The band was contoured with an ovoid burnisher or contouring pliers (Miller No 214, S S White Co, Holmdel, NJ 07733, USA). The

matrix was also wedged and stabilized with compound (Green & others, 1943; Hampson, 1961; Strickland, 1968). Other designs of retainers introduced included the small Ivory No 1 in 1900 and the Improved Ivory No 1 in 1909 (Lieser, 1981).

Ivory No 2 matrix and retainer: The Ivory No 2 matrix and retainer were introduced in 1892 and had a spring-loaded retainer (Fig 51). A

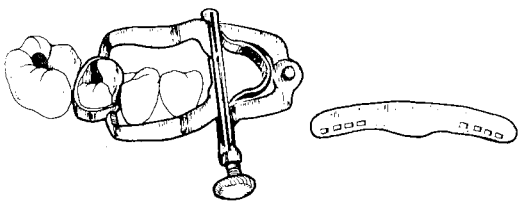

FIG 51. *Ivory No 2 matrix and retainer (courtesy of Columbus Dental Mfg Co)*

yoke engaged the spring to tighten the jaws of the retainer and band to the tooth. A screw could be placed in either end of the yoke thus making the instrument universal. Soon after its introduction, the matrix and retainer became unpopular because this matrix, too, produced loss of contour and contact (Hampson, 1961).

Ivory No 3 matrix and retainer: The Ivory No 3 matrix and retainer were introduced in 1898 as an improvement on the band matrices. The retainer held the band firmly and allowed for close adaptation to the cervical of the tooth without damaging the gingivae (Fig 52).

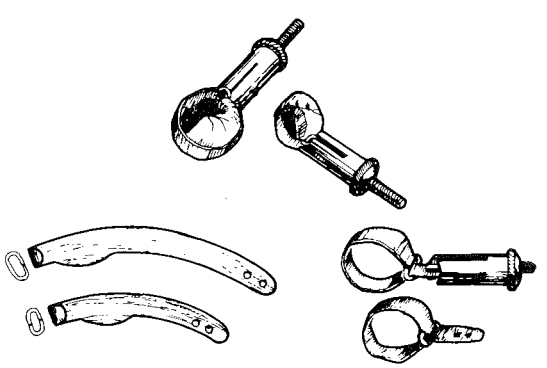

FIG 52. *Ivory No 3 matrix, retainer, and bands (courtesy of Columbus Dental Mfg Co)*

Ivory No 4 matrix and retainer: The Ivory No 4 retainer (Fig 53), formerly the Dickinson

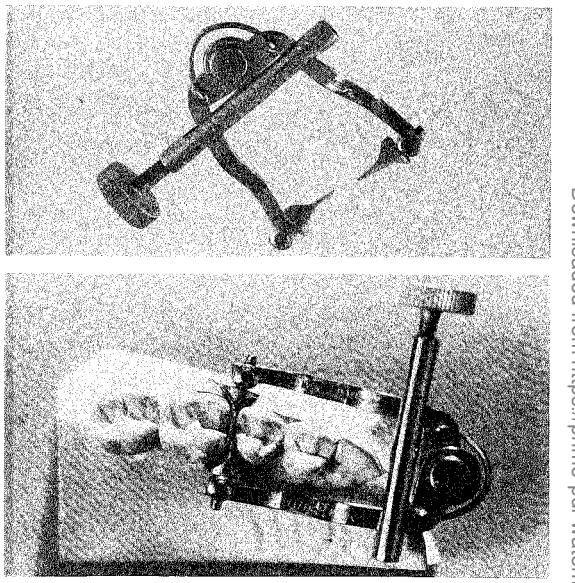

FIG 53. *Ivory No 4 matrix and retainer:*
Top - *No 4 retainer*
Bottom - *Matrix applied to a tooth (courtesy of A Schuchard)*

wedge matrix retainer, was introduced in 1900. The retainer did not differ from the Dickinson retainer except for changes in the shapes and length of the wedges to increase separation. Gradual, continuous separation, and only during the restorative procedure, was prescribed.

Ivory No 5 matrix and retainer: The Ivory No 5 matrix and retainer (Fig 54) were also intro-

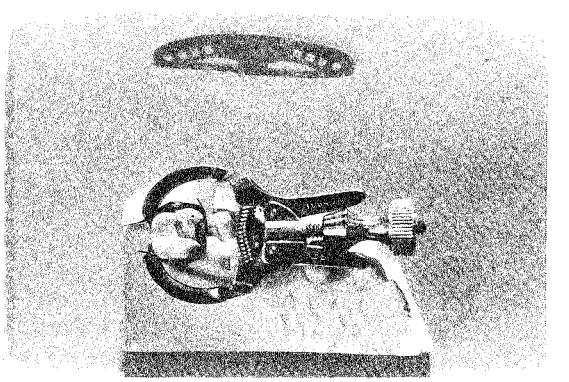

FIG 54. *Ivory No 5 matrix and retainer (courtesy of A Schuchard)*

duced in 1900 and were indicated for the placement of two-surface restorations. The retainer operated much like the Ivory No 1 retainer and differed only in design.

Ivory No 8 matrix and retainer: In 1905 the Ivory No 8 matrix and retainer (Fig 55) were

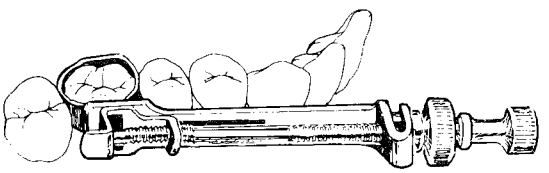

FIG 55. *Ivory No 8 matrix and retainer (courtesy of Columbus Dental Mfg Co)*

introduced (McGehee & others, 1956; Herbert & Vale, 1962). Differing from the earlier designs, this matrix was indicated for restorations of three or more surfaces and bands of steel or celluloid could be used. The band, instead of being engaged by the retainer, was threaded and fastened into the vise of the retainer by the end nut and adapted closely to the cervical of the tooth when drawn into position by the middle nut. When the retainer was tightened, however, loss of contour and contact was produced (Gabel, 1954) so modifications were suggested. For the band, stainless steel 0.001-0.002 in (25-51 μm) thick was used. It was also cut on a curve and contoured with contouring pliers. The matrix was wedged and stabilized with compound (Schultz & others, 1966). In the early 1900s, the Ivory No 8N retainer (Fig 56),

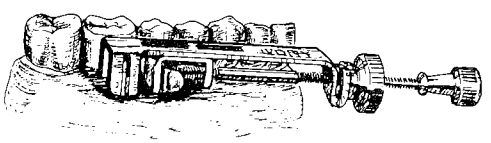

FIG 56. *Ivory No 8N matrix and retainer (courtesy of Columbus Dental Mfg Co)*

which simplified the release of the band, was introduced. Still later, the Ivory No 8 Improved retainer (Fig 57) modified the construction of the vise. In the improved version, the vise had a wide double surface for fastening the band with the screw.

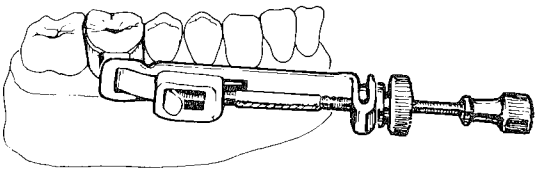

FIG 57. *Ivory No 8 Improved matrix and retainer (courtesy of Columbus Dental Mfg Co)*

Ivory No 9 matrix and retainer: The Ivory No 9 matrix and retainer (Fig 58) were also intro-

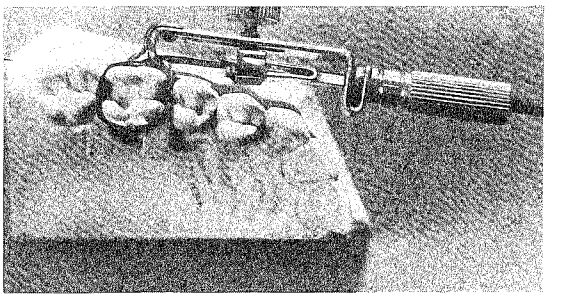

FIG 58. *Ivory No 9 matrix and retainer (courtesy of A Schuchard)*

duced in 1905 as an improvement on the Ivory No 8 retainer. The No 9 retainer simplified the adaptation of the band to the retainer and its release after the restorative procedure. The matrix was indicated for restorations of three or more surfaces (Messing & Ray, 1972). It, too, produced loss of contour and contact when tightened (Gabel, 1954). Modifications to this matrix included a band 0.0015 to 0.003 in (38-76 μm) thick made of stainless steel or carbon steel (Schultz & others, 1966).

Ivory No 14 and No 14S matrices and retainers: Other designs introduced in the early 1900s were the Ivory No 14 (Fig 59) and No 14S retainers.

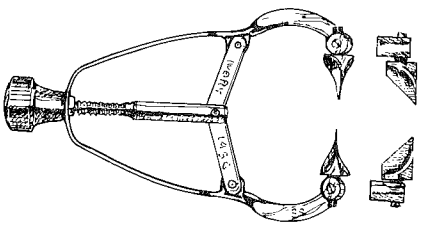

FIG 59. *Ivory No 14 matrix retainer (courtesy of Columbus Dental Mfg Co)*

HARPER MATRIX

Harper (1933) introduced a retainer that substituted springs for the rigid wedges of the Ivory No 4 retainer (Fig 60) (Green & others, 1943; Simon, 1956; Reade & Kirkwood, 1965). In large cavities, however, the springs tended to force the matrix band into the cavity, resulting in poor contour and the loss of contact (Reade & Kirkwood, 1965).

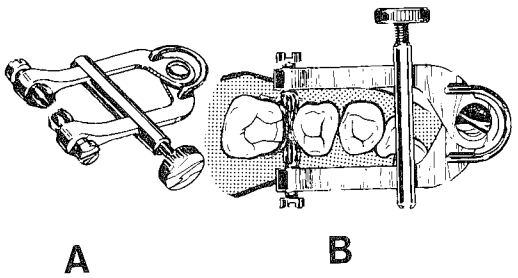

FIG 60. *Harper matrix (after Green, Shellman & Simon):*
A - *Ivory No 4 matrix retainer modified by having adjustable springs at the ends of the jaws*
B - *After placement, the retainer is tightened to the tooth whereby the springs are compressed between the band and the adjacent tooth*

ABERNETHY MATRIX

Abernethy (1937) introduced another modification of the Ivory No 4 retainer (Fig 61) (Reade & Kirkwood, 1965). For the metal wedges, he substituted strips of Monel metal soldered to the retainer and disposed parallel to the facial and lingual surfaces to serve as trays. Compound was placed on the inner surfaces of the metal strips and impressions made of the embrasures of the unprepared tooth. A wedge of wood or metal was inserted through holes present in both strips. The band was made of thin brass shim plated with nickel except for a line running occlusocervically through the contact point. The purpose of this specialized band was realized during condensation of the amalgam, when the expressed mercury would disintegrate the band along the line of exposed brass thus ensuring proper contact.

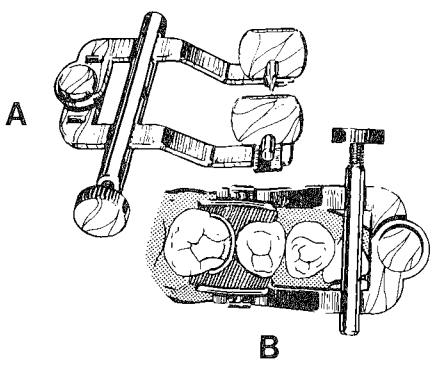

FIG 61. *Abernethy matrix (after Abernethy):*
A - *Modified Ivory No 4 matrix retainer*
B - *Matrix applied to a tooth*

LAWRENCE MATRIX

A variation of the Ivory No 4 retainer was the Lawrence matrix and retainer (Fig 62) (Reade & Kirkwood, 1965). The retainer consisted of a thumbscrew with two jaws that served as impression trays. Compound was placed on the trays and an impression made of the unprepared surface of the tooth. The two jaws were used as wedges and the matrix was completed with a thin strip of contoured celluloid, which reduced the amount of separation needed.

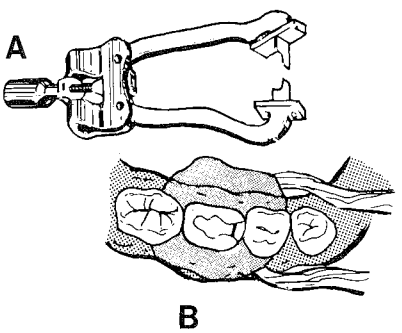

FIG 62. *Lawrence matrix (after Reade & Kirkwood):*
A - *Mechanical retainer modified to accommodate an impression tray*
B - *An impression of the unprepared tooth is made by using the jaws as trays. Upon placement, the retainer with the compound impression is tightened to the tooth and band.*

MIZZY MATRIX

In 1935, the Mizzy matrix and retainer were introduced. The matrix consisted of a band and a retainer with two metal sliding wedges which wedged the band to the contour of the tooth and held the retainer securely in place (Fig 63) (Fanta, 1981).

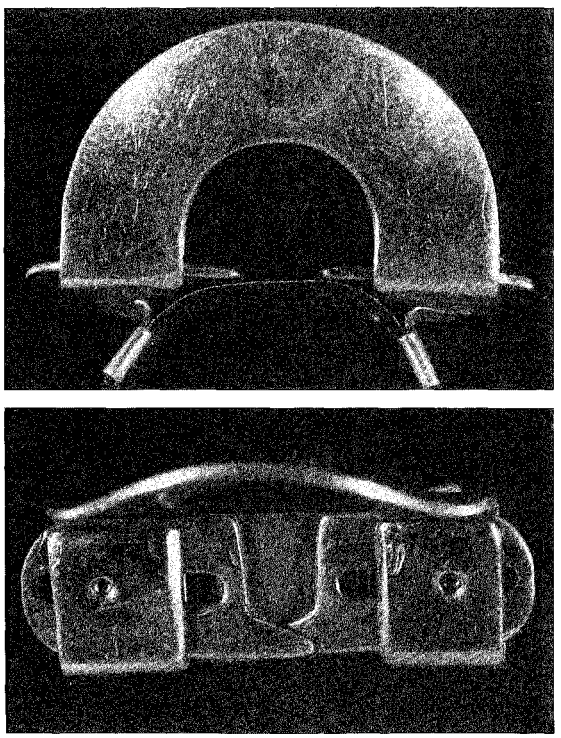

FIG 63. *Mizzy matrix and retainer:*
Top - *Occlusal view*
Bottom - *Lateral view of wedges*

BONNALIE, LENNOX, BIBER, ONDERDONK, AND WAGNER MATRICES

In the 1930s the Bonnalie (Fig 64), Lennox, Biber, Onderdonk, and Wagner (Fig 65) matrices with mechanical retainers were introduced.

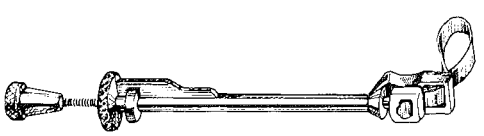

FIG 64. *Bonnalie matrix and retainer (courtesy of Dental Mfg Co)*

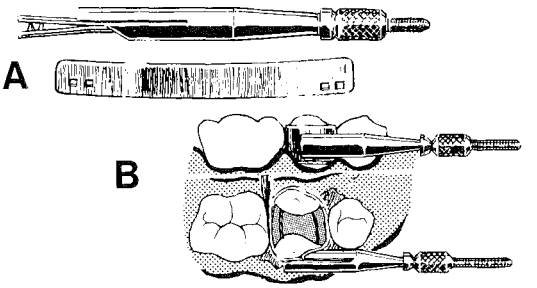

FIG 65. *Wagner matrix and retainer (after Simon):*
A - *Retainer and band*
B - *Band is wedged and tightened to the tooth by tightening the thumbscrew*

They consisted of a circumferential band, which could be cut on a curve (Herbert & Vale, 1962) and retained with a thumbscrew retainer (Simon, 1956; Herbert & Vale, 1962; Pickard, 1966; Chapman, 1969; Eccles & Green, 1973). They were indicated for restorations of three or more surfaces. All produced loss of contact when the retainer was tightened (Green & others, 1943; Simon, 1956; Hampson, 1961).

SIQVELAND MATRIX

In the 1940s the Siqveland matrix and retainer appeared. This matrix also consisted of a circumferential band with a thumbscrew retainer and was indicated for restorations of three or more surfaces (Fig 66) (Green & others,

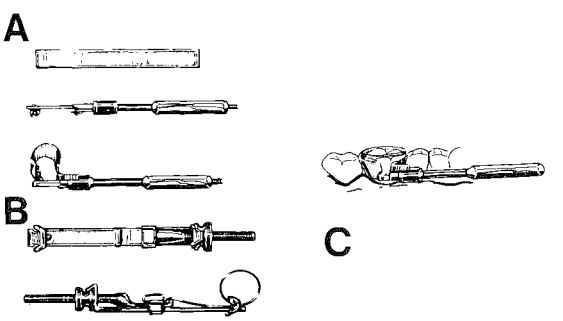

FIG 66. *Siqveland matrix:*
A - *Band and retainer (after Green, Shellman & Simon)*
B - *Steele's Siqveland retainer (after Columbus Dental Mfg Co)*
C - *When placed, the band is tightened to secure the cervical and free the occlusal portion*

1943; Simon, 1956; Eccles & Green, 1973). The retainer, however, contained a swivel lock, which secured the band cervically while allowing it to flare toward the occlusal. Thus the band did not need to be arcuate. To complete the matrix, the contour was burnished into the band. Critics, however, felt that the band did not contour well because it was not cut on a curve (Herbert & Vale, 1962; Eccles & Green, 1973).

The Steele's Siqveland matrix and retainer also consisted of a thin steel band configured similarly by the retainer (McGehee & others, 1956; Tocchini, 1967). The matrix could be wedged with a soft wood wedge and stabilized with compound.

MEC MATRICES

Also in the 1940s the MEC matrix and retainer (A B Dentatus, Stockholm Hägersten, Sweden) were introduced (Gustafsson & Magnusson, 1977; Björncrantz, 1981). The retainer was similar to the Ivory No 8 retainer and had a steel band, 0.0018-0.002 in (46-51 μm) thick, in various sizes and shapes (Fig 67). The band

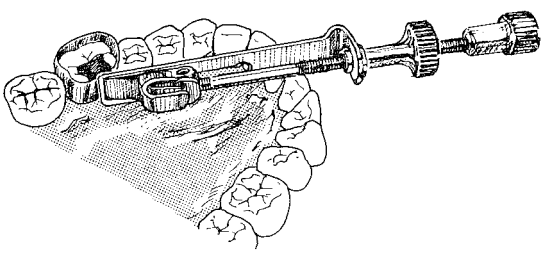

FIG 67. *MEC matrix and retainer (after Nyström)*

was arcuate, contoured, and wedged. The MEC-N retainer (Fig 68), introduced in 1947 by Nyström (1963), was a modification of the original retainer and had an oblique opening and an angulation of 30°, which reduced the risk of

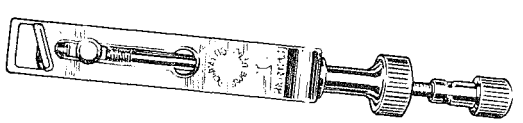

FIG 68. *MEC-N matrix retainer (courtesy of A B Dentatus)*

distortion of the band (Gustafsson & Magnusson, 1977; A B Dentatus Brochure, 1981).

Gustafsson and Magnusson (1977) introduced the MED-N retainer, which was indicated for use on primary molars. It was a modification of the MEC-N retainer and was used with a stainless steel band, 0.0018-0.002 in (46-51 μm) thick, known as the MDD-7 band (Björncrantz, 1981).

TOFFLEMIRE MATRIX

The Tofflemire, or Universal, matrix and retainer (Teledyne Getz, Elk Grove, IL 60007, USA) was designed so that the band could be easily removed from the thumbscrew retainer (Fig 69) (Brown, 1955; Blackwell, 1955). It has

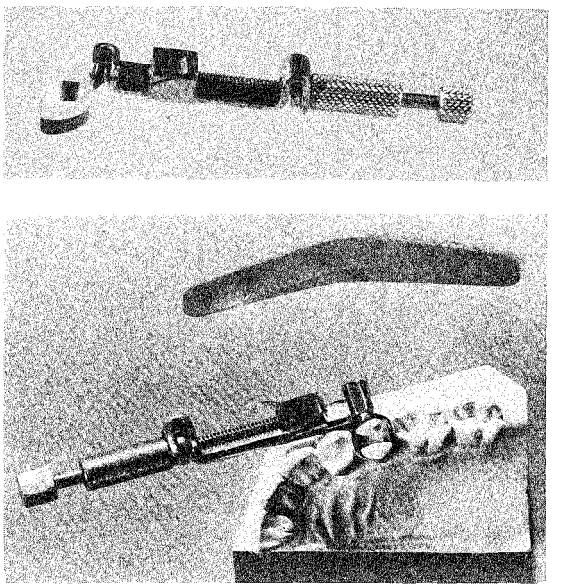

FIG 69. *Tofflemire (Universal) matrix and retainer:*
Top - *Band and retainer*
Bottom - *The band is tightened to the tooth by tightening the thumbscrew (courtesy of A Schuchard)*

become the most popular matrix (Gilmore & Lund, 1973). The band is made of stainless steel or carbon steel, 0.0015-0.003 in (38-76 μm) thick, and is arcuate. It can be precontoured with contouring pliers and burnished after the matrix has been placed. Furthermore it can be wedged and stabilized with compound (Schultz & others, 1966; Gilmore, 1967; Strickland, 1968).

ALL PURPOSE MATRIX

The All Purpose retainer (All Purpose Dental Instrument Co, Flushing, NY 11358, USA), introduced by Reiter (1958), was not designed for an arcuate band but an arcuate configuration was produced in the band through the activation of the retainer (Fig 70). The band of

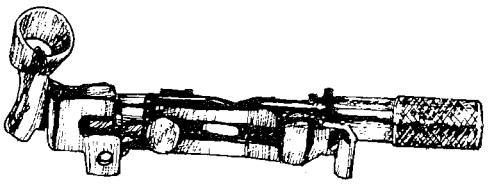

FIG 70. *All Purpose retainer by Reiter (courtesy of All Purpose Dental Instrument Co)*

thin, ductile stainless steel demonstrated little chance of being torn by the retaining nut upon tightening around the tooth. When placed lingually, the retainer can be converted to a contra-angle retainer to clear the anterior teeth. In 1975 a new anatomic forming matrix retainer was introduced, modifying the Reiter retainer by the addition of a universal joint. This joint, plus an oscillating plate, facilitated the placement and the contour of the band.

ARCUATE BANDS

Most matrices with mechanical retainers have met with dissatisfaction and criticism because of the bulky design of the retainer (Biales, 1944; Miller, 1947), the inability to reproduce well-contoured restorations with proper approximal contact (Black, 1908; Green & others, 1943; Markley, 1951; Phillips & others, 1956), and inadequate marginal adaptation of the restorative material due to acute angles formed between the band and the cavosurface margin (Miller, 1952). Practitioners recognized these shortcomings and during the 1930s and 1940s the concept of the curved, or arcuate, band, which, when placed around the prepared tooth, conformed to the shape of a funnel, was popularized. Because the cervical edge of the band was shorter than the occlusal edge, the band flared toward the occlusal and adapted better at the cervical margin of the cavity as well as reproducing better the contact and contour of the tooth.

Twist band: The band that was specifically designed for this purpose was the Twist band, which was made of stainless steel, 5/16 x 0.002 in (8 mm x 51 μm), and twisted at an angle of 45°. The band was available in various sizes and shapes and was burnished to contour after the matrix had been placed. The circumferential twist band was originally suggested for use with the Ivory Nos 8 and 9 retainers and later with the Tofflemire retainer (Berk, 1945; McGehee & others, 1956; Eames, 1966).

Zolnowski twist band: For this band a template was used to construct a band twisted at the appropriate angle to flare occlusally. The band could be made in various sizes and shapes and could be used with the Wagner or Tofflemire retainers (Gilmore, 1967).

Dixieland band: This was originally designed by W B Eames (personal communication). Differing from all past and present bands, this band was configured so that the contact would be located in the occlusal third of the band to assist in producing the proper contour and contact of the tooth. In the proprietary band (Fig 71),

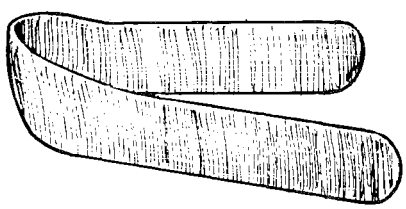

FIG 71. *Dixieland band by Eames*

the configuration is such that the contact would be placed midway between the occlusal and cervical edges of the band. The preformed contour of the band assists in restoring the contour and contact of the tooth (Baum, 1974).

Ho band (Ho Dental Co, Goleta, CA 93117, USA): This band is available in dead soft and regular stainless steel 0.001 in (25 μm) thick. Some believe the dead soft material to be difficult to handle during the placement of the matrix (Clinical Research Associates, 1986).

With the introduction of the light-curing resins, other bands have been introduced:

Contact Molar band (Vivadent (USA), Inc, Tonawanda, NY 14150, USA): This is a precontoured, arcuate band of clear plastic.

Catalar band (The Order Desk, San Dimas, CA 91773, USA): This is an arcuate band of clear plastic shaped similarly to the Universal band used with the Tofflemire matrix and retainer.

MISCELLANEOUS

Other matrices with mechanical retainers include the Automatic No 10 (Union Broach), the Brenner (Pfingst & Co, Inc, South Plainfield, NJ 07080, USA) (Fig 72), the Snap-on (Pfingst & Co, Inc), the Meba (Pfingst & Co, Inc), and the Dental Appliance and the Dental Matrix Appliance (E A Beck Co, Costa Mesa, CA 92627, USA), both introduced in 1955 (Lauer, 1981). In 1972, the Dam Retaining Dental Band Assembly (E A Beck Co) and the Tear Resistant Matrix (E A Beck Co) were introduced (Lauer, 1981).

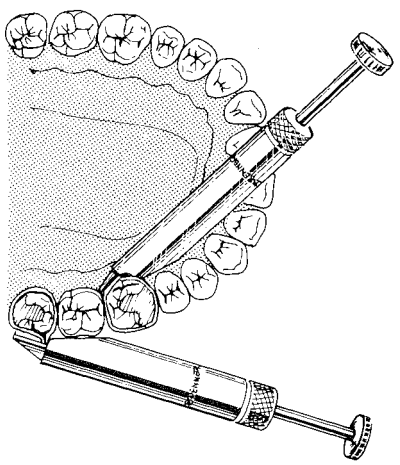

FIG 72. *Brenner matrix and retainer (courtesy of Pfingst & Co)*

MATRICES AND MECHANICAL SEPARATORS

The combination of a matrix band and a mechanical separator was in early use. The matrices consisted of a thin band of copper, brass, German silver, or steel and a mechanical separator (Black, 1908). The early separators used were the Perry, the Darby screw wedge (Fig 73), the Woodward, and the Elliot (Woodward, 1886; Jack, 1887; Nyström, 1963).

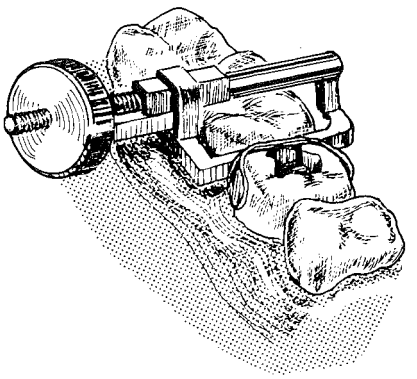

FIG 73. *Darby matrix and screw-wedge separator (after Jack)*

Beginning in the 1930s, the early matrices were redesigned to consist eventually of a band, 0.0015-0.002 in (38-51 μm) thick, of stainless steel, shim steel, or a welded circumferential band to reduce rigidity and provide greater adaptability (Green & others, 1943; McGehee & others, 1956; Simon, 1956). The band was contoured with pliers or a burnisher, wedged, and stabilized with compound. The mechanical separators used included the Walls, the Ferrier (Fig 74), the True, the Nyström, and

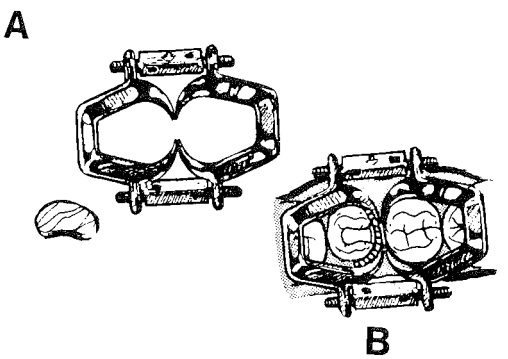

FIG 74. A - *Ferrier separator and shim;* B - *the shim apposes the cavity and is wedged to the tooth by activation of the separator*

the McKean Master Separator (Fig 75) (Green & others, 1943; Blackwell, 1955; McGehee & others, 1956; Hampson, 1961).

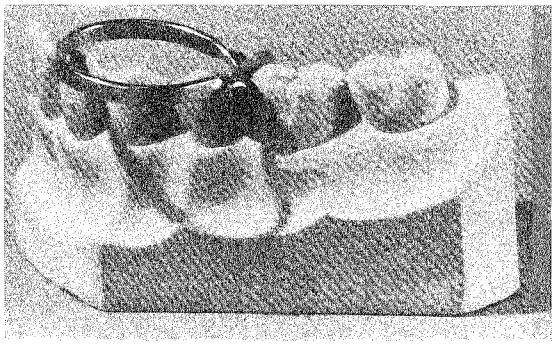

FIG 75. *McKean spring matrix (courtesy of A Schuchard)*

Although the matrices with mechanical separators exist today, they are not as widely used as the custom matrices or the matrices with mechanical retainers. This may be because some consider the mechanical separator cumbersome, complicated, and time consuming (Phillips & others, 1956; Reade & Kirkwood, 1965).

SPRING-CLAMP MATRICES

The spring-clamp matrices, used for two-surface restorations, consist of a strip of metal held in position by some type of spring clamp (Goodhugh, 1921; Eccles & Green, 1973). The early spring-clamp matrix consisted of a band made of No 1 or 2 gauge German silver foil and a clamp made of German silver wire bent into two full coils of spring with the desired shape and size of jaws soldered to its ends (Fig 76). A single-coiled clamp with a cinching sleeve was also used (Fig 77). Later, the spring-clamp

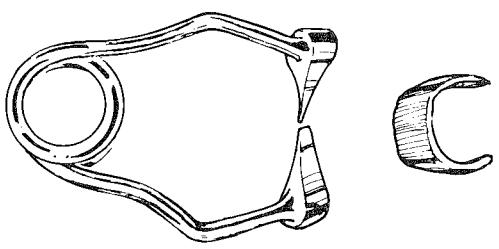

FIG 76. *Spring clamp and band (after Goodhugh)*

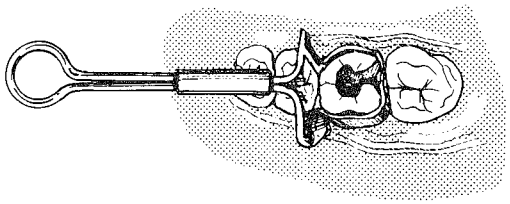

FIG 77. *Spring-clamp matrix applied to a tooth (after Goodhugh)*

matrix consisted of a carbon steel or stainless steel band held in place by a Leonard matrix clamp holder (Fig 78) (Goodhugh, 1921; Herbert & Vale, 1962). The band was contoured with contouring pliers and wedged. Practitioners, however, felt that this type of matrix was unyielding, tended to force the band against the tooth, and tended to distort the band under pressure, making adequate condensation of the restorative material difficult and contributing to its extrusion (Eccles & Green, 1973).

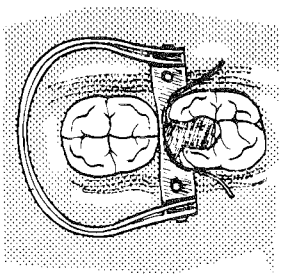

FIG 78. *Leonard spring matrix (courtesy of Dental Mfg Co)*

Miller Matrix

The Miller matrix, indicated for back-to-back restorations, was introduced in 1885 (Brophy, 1886). The matrix consisted of a steel band in the form of duplex spring leaflets in various sizes and shapes (Fig 79). If more separation and greater adaptation at the cervical level were needed, a wedge could be placed between the leaflets (Brophy, 1886; Harris, 1889; Green & others, 1943). The matrix, however, was

considered too rigid for adequate adaptability to the tooth (Green & others, 1943).

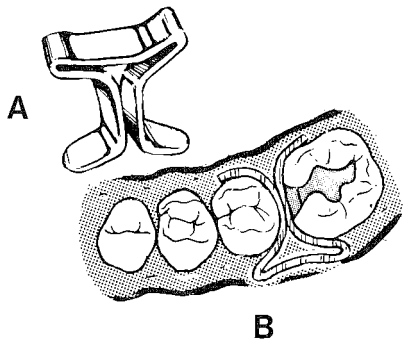

FIG 79. *Miller matrix (after Burchard):*
A - *Duplex spring leaflets*
B - *Matrix applied to a tooth*

Contemporary Spring-clamp Matrices

Other spring-clamp matrices include the Walser and Apis matrices.

WALSER MATRIX

The Walser matrix consisted of a band of stainless steel, 0.002 in (51 μm) thick, available in various sizes and shapes, and was placed with an instrument. It is marketed as the E-Z matrix (Union Broach) (Fig 80) (Union Broach, 1981).

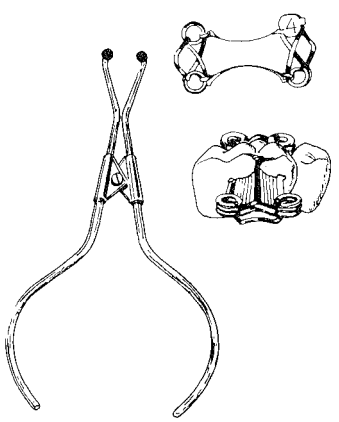

FIG 80. *E-Z matrix, instrument for placement, and placement on a tooth (courtesy of Union Broach)*

APIS MATRIX

The Apis matrix (Pfingst & Co, Inc), indicated for compound restorations, was invented by P Endres in 1952 (Fig 81) (Pfingst, 1981).

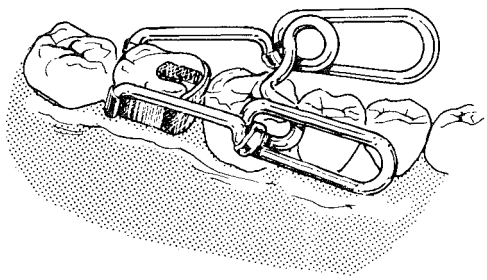

FIG 81. *Apis matrix (courtesy of Pfingst & Co)*

DISCUSSION

The impetus for a universal matrix to be used with direct filling gold, amalgam, and, much later, resin materials, did not result in one design but did promote a consensus of the requirements of a matrix.

Early Matrices

From its introduction, the principle of a matrix has always been to provide for a missing fourth wall in order to confine the restorative material within the cavity and allow for perfect adaptation at the angle of the margin of the cavity and matrix (Bennett, 1885). This fourth wall was supplied by a band, which was made to extend well beyond all the margins, especially toward the cervical edge and occlusal surface.

FOURTH WALL

During the period from 1885 to the early 1900s the band was constructed from materials that included steel, platinum, platinum foil, gold, brass, phosphor-bronze, German silver, copper, silver-plated copper, tinned copper, tin, and Brown's polishing metal. Materials also suggested were pure silver and a gold

band lined with platinum to avoid contamination when condensing amalgam (Bogue, 1908). During this period practitioners were also concerned with polishing the band to create a smooth surface against which the restorative material was condensed and to reflect light into the cavity for increased illumination (Woodward, 1885; Weeks, 1894).

RIGIDITY

It was believed that the band should be thick enough to be firm but flexible enough to allow for proper anatomic contour and contact so that minimal carving of the restoration was needed (Woodward, 1885; Weeks, 1894). The thickness of the band was not necessarily specified except that it should be thin. Later, Davis (1916) was among the earliest to suggest the use of a band with a thickness of 0.001 in (25 μm).

To compensate for the thickness of the band, a separating device was used to ensure proper contour and contact in the restoration (Woodward, 1885; Jack, 1887; Newkirk, 1908a). It was recognized, however, that teeth were difficult to move sufficiently, especially molar teeth. Forcible separation produced a torque tending to rotate the teeth lingually as well as producing lateral displacement (Black, 1899). Thus the proper amount of separation was achieved by direct wedging with wedges, a mechanical separator, or both. Absorption of water by the wooden wedge during the preparation of the cavity was believed to aid in increased separation of the teeth (Jack, 1887).

PROPER CONTOUR AND CONTACT

Jack (1871) was the first to introduce a contoured band, which was indicated mainly for custom matrices. With both custom matrices and matrices with mechanical retainers, the use of contouring pliers to place contour into the band was suggested by Burchard (1897). Another early technique for contouring was to lay rubber dam on a band and place both on the tooth. Putty was then forced into the prepared cavity to contour the band. Upon removal, the rubber dam would lift the putty out of the cavity, leaving the matrix in position (Halloway, 1908). In addition, Black (1908) suggested the band be cut on a curve to improve the contour of the band.

STABILITY

It was also believed that the band should be stable, firm in place, and immovable to withstand the forces of condensation (Jack, 1887). A separating device was the earliest method to stabilize the matrix (Jack, 1871). In use, it should not injure the margins of the cavity and should be contoured to assist in adapting the band to the tooth and not interfere with the restoration of the proper contour and contact of the tooth (Woodward, 1885). Modeling material was also recommended to ensure stability. For the Jack matrix, Darby (1897) suggested the use of quick-setting oxyphosphate of zinc. With his matrices, Black (1899) used gutta-percha or modeling compound.

Later Matrices

Even with the abundance of designs of matrices and devices in the search for a universal matrix, the basic principles and requirements developed for the early matrices formed the basis for all later matrices.

FOURTH WALL

As with the first matrix, the basic principle of an acceptable matrix is to provide for a missing fourth wall, which is accomplished with the use of a band. With later matrices, however, the dimensions of the band have been specified to extend beyond all cavosurface margins by a minimum of 1 mm and to be 1-2 mm beyond the marginal ridge of the adjacent tooth (Pickard, 1966; Strickland, 1968).

Early on, Seibert (1929) criticized the use of steel and copper for the band material. Steel was not flexible enough for contouring purposes and copper absorbed mercury. Introduced in the 1930s (Black, 1936; Cannon, 1936), the stainless steel band has become the predominant material for bands to satisfy the requirement of a fourth wall. The advantages of stainless steel over all other materials are its flexibility, smoothness, and polished surface. Other materials suggested during this latter period include carbon steel (Biales, 1944), nickel, aluminum (Gainsford, 1965; Pickard, 1966), and celluloid (Gabel, 1940). Celluloid was first introduced for use in the anterior

region with silicate cement material; however, Lawrence was the first to use it for posterior restorations (Reade & Kirkwood, 1965). Celluloid, or plastic, in contemporary usage for class 2 restorations, is used with posterior composite material.

RIGIDITY

During this latter period, the thickness of the band has become a major concern. The band was made of a dead soft material or ranged in thickness from 0.001 to 0.003 in (25-76 μm) (Blackwell, 1955; Herbert & Vale, 1962; Pickard, 1966; Gilmore, 1967; Sockwell, Heymann & Brunson, 1985). Most practitioners, however, prefer a band 0.001-0.002 in (25-51 μm) thick because it is rigid but flexible enough to assist in reproducing the contours and contact of the tooth while reducing the amount of separation needed.

Compensating for the thickness of the band is also a concern in this period and a separating device is the method used. Gradual separation, which was used earlier to provide for access to the lesion and assist in producing the anatomical contours of the tooth, has continued to be advocated (Hampson, 1961); its practice, however, has decreased considerably because of the trauma to the periodontium experienced from its abuse (Messing & Ray, 1972). To obtain separation, immediate wedging is used and can be accomplished by either of two methods. The most common procedure is, on the completion of the placement of the matrix, to forcibly place a wedge and thus produce the amount of separation required. Hellie (1985) has demonstrated the maximum amount of separation obtained is 90 μm for posterior teeth, with a rebound effect of 33% while the wedge is in place. Once the wedge is removed the rebound effect is 91% within 60 seconds. He concludes that in the average restorative effort this forcible wedging may not provide sufficient separation to allow for the development of adequate approximal contacts. This same concern was voiced by Black (1899) and later by Gabel (1940). From these concerns, others have recommended placing a wooden wedge prior to the preparation of the cavity (Sockwell & others, 1985). Thus the moisture absorbed during the preparation of the cavity leads to a gradual separation of the teeth, which is thought to cause less aberrant displacement of the teeth and less trauma to the periodontium. To ensure adequate separation, the wedge is retightened during the preparation of the cavity and replaced during the placement of the matrix. Along with this, Meyer (1957), in his matrix, uses the Bi Tine ring to provide additional separation.

PROPER CONTOUR AND CONTACT

Here, too, the contour of the band is an essential requirement for an acceptable matrix. Arcuate bands are a common form and are suggested mainly for continuous-loop matrices and matrices with mechanical retainers. Pliers and burnishers are also recommended for contouring the band (Miller, 1952; Rutsky, 1968). The pliers used include the Reynolds crescent-shaped pliers for custom matrices, the No 112 ball-and-socket pliers for custom matrices and matrices with mechanical retainers, the No 114 pliers, the Miller contouring pliers, and the Delarosa contouring pliers for matrices with mechanical retainers (Miller, 1952, 1959; McGehee & others, 1956; Gilmore, 1967). In addition, Meyer (1978) advocates burnishing the band after the placement of the matrix because of the demonstrated loss of contour that occurs during placement.

Modeling compound is also used to assist in reproducing the proper contact and contour, and is considered an essential requirement of the matrix (Phillips & others, 1956).

STABILITY AND CONTROL OF CERVICAL EXTRUSION

While a separating device is used, as with earlier matrices, for the stability of the matrix and to compensate for the thickness of the band, its other major purpose has become to control cervical extrusion of the restorative material through adequate marginal adaptation (Black, 1936; Herbert & Vale, 1962). For this purpose, Baum (1974) has recommended a short wedge, 4-5 mm long, which is lubricated with cocoa butter or Borofax to prevent interference with restorative procedures and the rubber dam. As an additional benefit, the wedge can be used to protect the rubber dam or gingivae and assist in preventing cervical over-

extension of the class 2 cavity during its preparation (Strickland & Wilder, 1985).

USABILITY

Other principles introduced during this period relate to the usability of the matrix (Herbert & Vale, 1962). The matrix should be comfortable to the patient, convenient, free of trouble, easy to use, reusable, and inexpensive.

SUMMARY

The need for a matrix for restoration of a class 2 cavity has developed an abundance of designs and devices in the search by the dental profession for a universal matrix that would accurately reproduce the original, or natural, contours and contact of a tooth. Rather than developing a universal matrix, however, the profession has established the basic principles and requirements for an acceptable matrix. These requirements are:

1. Provide for a missing fourth wall. The band should confine the material within the cavity. The band must extend beyond all cavosurface margins by a minimum of 1 mm and should be 1-2 mm beyond the adjacent marginal ridge.

2. Rigidity. The band should be thick enough to be firm but flexible enough to allow contouring with a burnisher or contouring pliers.

3. Proper contour and contact. The band should establish the anatomic contour and contact so that minimal carving of the restoration is needed. The contour is placed in the band with a burnisher or a contouring instrument. Compound can also assist in establishing proper contour.

4. Stability. The band should be able to withstand the forces of condensation. This can be enhanced by stabilizing the matrix with wedging and with modeling compound.

5. Control of cervical extrusion of the restorative material. This should be ensured through adequate marginal adaptation and wedging.

6. Usability. The matrix should be comfortable to the patient, convenient, free of trouble, easy to use, reusable, and inexpensive.

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