The Evolution of Matrix Systems for Composite Restorations

A Peer-Reviewed Publication
Written by Jeffrey A. Sibner, D.M.D.

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The introduction of posterior composite resin materials in the 1980’s created a set of restorative problems unique to these new restorations. Placement of posterior composites is technically more challenging than working with amalgam and can result in open contacts, open margins, and incorrectly contoured restorations. Many of these problems were not due to operator error, but to the materials themselves and the way matrix containment systems worked with them. Over the last 25 years, new matrix systems have been developed specifically for posterior composites that address the problems found with the original amalgam matrix systems. This course reviews the history of matrix systems designed for posterior composite restorations and illustrates how they have changed in order to make the optimal placement of these restorations predictable.

Educational Objectives
At the conclusion of this educational activity participants will be able to:
1. Cite the reasons traditional amalgam matrix systems are inadequate for creating Class II composite restorations.
2. Identify several methods for creating proximal contact with Class II composite restorations.
3. Discuss the concepts behind sectional matrix systems.
4. Describe the components of sectional matrix systems.

Author Profile
Jeffrey A. Sibner, D.M.D is an Adjunct Assistant Professor at the University of Pennsylvania School of Dental Medicine. Dr. Sibner maintains a private practice in general dentistry in Bucks County, Pennsylvania and is affiliated with St. Mary Medical Center.

Author Disclosure
Jeffrey A. Sibner, D.M.D has/have no commercial ties with the sponsors or the providers of the unrestricted educational grant for this course.
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Abstract
The introduction of posterior composite resin materials in the 1980’s created a set of restorative problems unique to these new restorations. Placement of posterior composites is technically more challenging than working with amalgam and can result in open contacts, open margins, and incorrectly contoured restorations. Many of these problems were not due to operator error, but to the materials themselves and the way matrix containment systems worked with them. Over the last 25 years, new matrix systems have been developed specifically for posterior composites that address the problems found with the original amalgam matrix systems. This course reviews the history of matrix systems designed for posterior composite restorations and illustrates how they have changed in order to make the optimal placement of these restorations predictable.

Since the late 1980’s, when posterior composite restorative materials first made their debut, dentists have struggled with problems associated with switching from amalgam restorations to more demanding composites. Several problems presented themselves. The quality of the bond was often inadequate. Marginal seals were patent. Patients experienced sensitivity due to bonding materials and shrinkage. The contours of restorations could not be adequately controlled. Contacts were often open, weak or improperly contoured. Of these problems, adequate contour and contact have been the most elusive. The evolution of composite matrix systems is the roadmap to how dentistry has attempted to address these lingering challenges.

Early on, posterior composites were viscous, but not very condensable. Composite materials were placed in proximal boxes and condensers just pushed the materials around without compacting them. This led to voids in the material, often at the margins, especially at line angles or acute angles between matrix bands and lateral cavosurface walls. Early materials also tended to slump instead of hold their shape and, most importantly, they could not be used to deform matrix bands in any way. Push composite into a circumferential matrix band, and as soon as the lateral force is released, the band bounces back to its original position.

Inadequate contour and contact has important implications for the health of the adjacent tissues. Food impaction can lead to discomfort, recurrent caries and periodontal disease. The direct cost to the restorative dentist who places an inadequate restoration is the time required to replace the restoration and the materials used in the new restoration. The indirect costs include patient dissatisfaction and erosion of trust. The cost to the patient if the restoration is not replaced could be much higher; additional tooth loss due to recurrent decay or increased pocket depth and bone loss due to food impaction. Food impaction can also cause tooth movement and expansion of the inadequate contact in some molar areas.

Two advances were developed to counter these problems. On the composite side, materials were improved to make posterior composites stiffer. These materials gave dentists considerable advantages over older materials. They were more highly filled and so there was less wear. They tended to hold their shape better, so accurate occlusal anatomy could be developed. They tended to seal proximal boxes better, with a lower incidence of internal voids and fewer open margins. And because they were more highly filled, they exhibited less shrinkage. Their condensability and ability to hold their shape made them better at keeping matrix bands from returning to their original positions, and so dentists were able to develop better anatomy when the proximal boxes involved these surfaces.

Circumferential Matrix Bands
With all of the innovations in dentistry, it may seem odd that something like the Tofflemire matrix system is still in prominent use today. Even the companies that produce the most advanced systems available today produce options that work with a Tofflemire retainer.

They key advantage to working with the Tofflemire system is ease in restoring larger three or more surface preparations. Matrix bands can be placed in the retainer ahead of time, so it is easy to place it on a prepared tooth and continue with the restoration process. This is not to say there have been no innovations to Dr. Tofflemire’s 1946 system. It is now possible to purchase bands in a range of heights, thicknesses and materials. The traditional 0.002” thick stainless steel matrix band used with amalgams has been updated to 0.0015” or 0.001” thick bands. Pre-contoured bands, dead-soft bands and coated bands are also available.

One manufacturer produces matrix bands that are 0.0015” thick but have a segment that is just 0.0004” thick at the contact area. The idea here is that the band thickness is so minimal, a contact is assured, as long as the matrix band is in intimate contact with the adjacent tooth.

There are two inherent problems with circumferential matrix bands. The first can be called the push-pull effect. Pull the mesial contact tight with a burnisher, and the distal contact opens up. Burnish the distal and the mesial opens back up again. To some extent, this problem can be reduced by loosening the Tofflemire retainer, but then you can get flash at the buccal and lingual margins and sometimes a ledge or flash at the gingival margin as well.
Even with the dead-soft bands, which hold the contour better after burnishing, Tofflemire bands create flat, straight proximal contours. This produces contacts that are often narrow occluso-gingivally and more occlusal than the adjacent height of contour. Resulting restorations tend to trap food and are structurally weak. Often, contact, when it is achieved, is lost when the marginal ridge area is smoothed and shaped because the height of contour of the restoration is right at the occluso-proximal line angle.

One way to make the Tofflemire system more predictable is to combine the traditional system with a simple ring from one of the early segmental ring systems. The rings can sometimes be applied to both proximal surfaces simultaneously, but usually the ring is placed on one proximal surface while that box is restored and then switched to the other surface to complete the restoration. It has been shown that pressure from forcing a wedge between teeth is insufficient to separate teeth enough to establish consistent contacts with a Tofflemire matrix. The segmental ring, however, can separate teeth by as much as 0.08 mm (see Figure 1), enough to create tight contacts in most cases. This technique can provide the best of both old and new, as long as there is adequate space for both the bulky Tofflemire retainer and the separating band.

**AutoMatrix® Circumferential Matrix Bands**

The AutoMatrix® is an alternative to the Tofflemire matrix system. Here, a small locking clip allows a stainless steel matrix band to be pulled tightly around a tooth, sealing the proximal boxes. The advantages and drawbacks of the AutoMatrix® are similar to the Tofflemire system described above. However, the AutoMatrix® has its own unique advantages and disadvantages too.

The best thing about the AutoMatrix® is that the locking clip is placed mid-buccally or mid-lingually, and will not interfere with a segmental separating band like the Tofflemire retainer does. In fact, kits are available that package a separating ring with AutoMatrix® bands. There are a few unique disadvantages, however. First, there is little choice in band sizes. There is a medium height band that is 0.0015” thick, and three heights that are 0.002” thick. There are no pre-contoured options and no coatings to keep resin adhesive from sticking to the band.

Two tools are required with the AutoMatrix®. One tool is used to pull the free end of the band through the Auto-lock Loop, and the other is used to section the matrix band in order to remove it. This makes the system less convenient than the Tofflemire system which can be easily placed and removed.

**Sectional Matrix Systems**

Since the introduction of the first sectional matrix system in 1986, they have been an alternative to circumferential bands. The sectional bands eliminated the “push-pull” problem with circumferential bands described above. Combined with the extra force supplied by separating rings, these systems produced more reliable contacts in most situations, even when there is significant space between teeth. However, there were several disadvantages to the original sectional matrix systems. They didn’t sit as tightly against the tooth as circumferential bands, leading to a greater chance of gingival overhang. The bands were shorter than many modern bands and harder to hold and manipulate. They could be difficult to position and stabilize. When a wedge was introduced, they often shifted, opening margins, damaging tissue or tilting away from an ideal contact area and proximal form. The separating rings were not ideally shaped and the prongs often pushed the matrix band into the prep space, or were not sufficiently retentive to stay in place.

**Early Sectional Systems**

The earliest sectional bands were contoured to create better proximal form, and U-shaped to allow the band to curve around the tooth. Usually, the bands were dead soft, so they could be easily contoured to the adjacent contact area (Figure 2). Many systems supplied bands that were so short the edges were too close to the proximal areas, and the separating rings crumpled the bands when they were placed. Once the restorations were completed, it was very difficult to remove the bands. Hemostats or special forceps were required to grab onto the short ends of the band and it was often very difficult to remove without pivoting the band around the contact point, causing gingival laceration.
problem during the transition from one box to the other. The possibility of moisture or blood contamination could be a circumferential band. If wedges have to be moved or replaced, time to restore as a comparable restoration completed with a had to be completed one box at a time, taking twice as much time to place a ring with the loop to the distal, so the restorations that involved three or more surfaces, it was often not possible to be completed sequentially. For instance, with restorations one ring in the mouth simultaneously, so restorations had to

The biggest problem, however, was with the prongs. The straight, narrow prongs did not engage the teeth very well and were prone to popping off in the middle of the restorative procedure. The ring also had to fit around the wedge used to seal the gingival cavosurface margin. Sometimes the ring only fit on the opposite side of the wedge from the tooth to be restored, which meant that the sectional matrix band was not held closely to the tooth at the proximal margins, creating a higher risk of marginal overhang. When the preparation was wide, the wedge often forced the ring prongs and band into the prep space, resulting in under-contoured restorations. It could take several attempts to place the ring around the wedge so that it functioned properly, adapted to the tooth and was stable.

In most situations, it was not possible to place more than one ring in the mouth simultaneously, so restorations had to be completed sequentially. For instance, with restorations that involved three or more surfaces, it was often not possible to place a ring with the loop to the distal, so the restorations had to be completed one box at a time, taking twice as much time to restore as a comparable restoration completed with a circumferential band. If wedges have to be moved or replaced, the possibility of moisture or blood contamination could be a problem during the transition from one box to the other.

**Sectional Matrix Systems at the Turn of the Century**

From their introduction in the late 1980’s through the next 25 years, changes to matrix systems were made to address the shortcomings noted above. Nickel titanium was substituted for stainless steel in the rings. NiTi is more brittle than steel, but keeps its shape and spring better, so the rings lasted longer. The straight prongs were made with supporting tines that were better at engaging undercuts for better retention. In many situations, however, the tines, which were just metal burs at the end of the prongs, actually made it harder to position rings next to the wedges, and placement of the ring was still challenging and time consuming.

In order to position contacts properly, systems included more band forms. Wedges were created that offered removable curtains to protect adjacent teeth during tooth preparation, aprons for deep gingival boxes and more widths and lengths.

Other problems with the sectional matrix systems became apparent. It was often impossible to access the preparation to restore the tooth because the ring blocked access. Placement of two rings was still a big problem. In particular, if you couldn’t face one ring posteriorly, it wasn’t possible to place two rings simultaneously because the bottom ring kept the top ring from engaging the interproximal area properly.

Modern all-in-one bonding systems decrease sensitivity and increase bond strength, but create their own problems. They provide enough adhesive strength for composites to stick to the sectional bands. This made it even more difficult to remove the bands, increasing the chances of laceration because the bands are so thin. It also increased the chances that a band would stick to the restoration, resulting in damage to the composite as the band was removed.

**Modern Matrix Systems**

Beginning in 2008, new systems started to appear on the market that not only included redesigned bands and rings, but also innovative wedges as well. For the amalgam restoration, the wedge performed three essential tasks. It sealed the gingival margin to prevent flash or gross overhangs which occur when condensation forces amalgam past the edge of an improperly secured matrix band. This seal also prevented moisture or blood products from contaminating the preparation. Perhaps more importantly, in the amalgam restorative system, the wedge provided the force to separate teeth enough to account for the width of the Tofflemire matrix band. But this force proved inadequate in composite restorations because composites weren’t bulky enough to push the matrix bands tightly against adjacent teeth and because they exhibited shrinkage. Now rings provide the force of separation, so the wedge’s main functions are to adapt the band to seal the gingival margin, shape the band so that it can create the proper three dimensional curvature for the proximal surface, and protect gingival soft tissue.

One innovation was to make curved right and left handed wedges. These help recreate the buccal-lingual curvature of the tooth. Another manufacturer introduced wedges with a wave-like contour. These wedges also help recreate convex contours, and the wave-like shape of the wedge can also push the matrix band tightly against the tooth in a situation where there is a proximal concavity or a wide gingival embrasure.

**Figure 3 - An early tined separating ring.**

Short, narrow prongs were not sufficiently retentive and did not seal matrix bands proximally.
One manufacturer recommends that dentists place their wedges prior to cavity preparation so that the gingiva is protected from damage during development of the proximal box. This is possible because the wedges don’t sit as tightly against the tooth as wooden wedges did for amalgam procedures.

Some wedge systems come with a removable curtain that prevents damage to adjacent teeth during preparation of the proximal box. The curtain is removed from the wedge just prior to ring placement and restoration. In one system, wedges are mounted on a 2-inch handle (Figure 4). It is utilized by bending the wedge at right angles from the handle, seating the wedge and twisting the handle to remove it. Another system includes a perforation at the end of the wedge that can be grabbed with pin forceps and carried to the proximal space.

Figure 4 – Examples of modern wedges.

Wedges are now easier to place and come in a variety of sizes, stiffness and shapes.

Along with this new class of wedges, ring prongs continued to evolve. The stainless steel tines at the end of the prongs were replaced with soft silicone or glass-fiber reinforced plastic tines (Figure 5). This allowed one of the biggest innovations in the sectional matrix system – the grooved tine. The grooves were shaped to straddle wedges packaged with the different systems. This was a very important advance, because it allows the dentist to position the prongs of the ring directly between the two teeth, maximizing the separation force applied by the ring. More importantly, this gave manufacturers more room to redesign the way the ring seated in the proximal area. The silicone or plastic prongs on the newest rings are contoured to fill the proximal embrasure space. This helps retain the ring better at the same time that they adapt the matrix bands to the transitional line angles of the tooth, recreating ideal contour and reducing proximal flash.

Perhaps the most fundamental change was to prong position. Ring prongs are now usually placed at an obtuse angle from the ring. When a separating ring is placed, the ring is no longer parallel to the occlusal plane. This allows one ring to sit above another ring placed more anteriorly. Now, three-surface restorations or two restorations in the same quadrant can be restored simultaneously.

Many systems now include two rings, a standard ring that provides sufficient force to allow for contact with a single sectional band in a typical situation, and a second ring with prongs that are closer together. This ring provides more retention and greater force of separation and is ideal for situations where two bands need to be placed next to each other or where the normal separating ring won’t stay seated, as is often the case distal to canines.

Figure 5 – Modern separating rings.

Ring prongs now feature silicone or plastic tines that increase retention and reduce proximal overhangs.

New sectional bands were introduced to complement the redesigned rings. Band heights now generally run the gamut from 3.5mm to 7.5mm and can run as little as 0.0013” thick. One innovation common to a number of systems was the nylon fiber coated band (Figure 6). The coating has two advantages. Most importantly, it prevented the composite from adhering to the band. This allows quicker, easier band removal, so there is less chance of rocking the band and damaging the gingival papilla. It also prevents marginal ridge fracture, a common problem when the composite next to the band is irregular or unsupported. The nylon fiber coating can be colorized, so manufacturers could design their systems with color-coded bands that allow the different bands to be easily recognized or separated.

Figure 6 – Coated sectional matrix bands.

Longer, super-curved bands (right) aid in restoring larger preparations. Tabs aid in band removal. The widest bands have gingival aprons. Colors help differentiate the different band sizes.
Figure 7. Super-curved non-stick bands are designed to hug the tooth, and have tabs to aid in placement and removal. Colors differentiate sizes from 3.5mm -7.5mm, and the widest ones have gingival aprons.

Around 2011, a super-curved, longer band was introduced that made it easier to contour proximal form in teeth with wide proximal boxes or missing cusps. The bands have proven so popular they were made standard in the matrix system introductory kits in 2015.

One system added two new features that greatly enhance band placement and removal. The bands have tabs placed on the occlusal aspect, and perforations placed in the tabs and at each end of the band. A special pin plier was added to the matrix system to engage the perforations, making it very easy to place the bands, stabilize them during wedge placement and remove the bands when the restoration is complete. The tabs don’t significantly affect visibility during proximal box restoration, because they can be easily folded against the adjacent marginal ridge.

Discussion
When posterior composites were first introduced in the early 1980’s, matrix systems designed for amalgam restorations did not allow dentists to predictably create posterior composite resins with adequate contours or contacts. This increased delivery costs associated with replacing under-contoured restorations or the cost to the patient who may suffer the dental consequences of the inadequate restoration.

Since the introduction of sectional matrix systems in 1986, it has become easier to create composite resin restorations with better proximal form and contact. Modern systems developed after 2007 have gone a long way toward addressing problems that existed with the original sectional products. Bands now are more contoured to help develop convex proximal form and ideal contact areas. They are coated and colored to help distinguish bands from one another. The coating also makes it easier to remove bands after composite placement, and with less likelihood of damage to the gingival papilla or composites. One system placed tabs and perforations in their bands and wedges, making them easier to place and remove.

The rings in modern systems make it easier to shape proximal contours and are more stable. Rings and wedges have been designed to complement each other. Modern wedges are designed to protect soft tissue and help contour the sectional bands while the rings sport grooves in their prongs that allow them to sit directly above the wedge and are correctly centered in the proximal embrasure. Rings are now stackable, making it possible to place more than one ring in a quadrant at a time.

There are still issues that need to be addressed as matrix systems continue to evolve. Several manufactures are designing clear bands and rings with clear tines to allow for better composite cure in deep restorations or in places where it is hard to position a curing light.

Wedges will also continue to evolve. Current wedges designed for use with sectional matrix systems are soft plastic and do not create a tight seal when placed against the sectional bands. Gingival overhangs are not uncommon in composite
restorations. This problem could get even worse in the future as condensable nanofilled composite continue to evolve. The shape and stiffness of the wedges will need to account for increased condensation forces against sectional bands in the future, something that manufacturers are already beginning to address. Wedges will also need to be made more universal, so they can be placed as easily anteriorly as posteriorly.

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Author Profile
Jeffrey A. Sibner, D.M.D. is an Adjunct Assistant Professor at the University of Pennsylvania School of Dental Medicine. Dr. Sibner maintains a private practice in general dentistry in Bucks County, Pennsylvania and is affiliated with St. Mary Medical Center.

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1. Problems associated with early posterior composites include all of the following except:
   a. Marginal seal
   b. Sensitivity
   c. Shade stability
   d. Open contacts

2. New bands for use with the Tofflemire retainer and posterior composites includes all of the following EXCEPT:
   a. Pre-contoured bands
   b. Thin bands
   c. Dead-soat bands
   d. Perforated bands

3. Wedges aid in all of the following EXCEPT:
   a. Sealing the gingival margin
   b. Creating enough separation for reliable contacts in composite restorations
   c. Contouring the restoration bucco-lingually
   d. Protecting gingival tissue

4. Advantages to using an AutoMatrix® include all of the following EXCEPT:
   a. Extra tools are not required
   b. The band can be pulled tightly against the tooth
   c. The locking clip won’t interfere with a separating ring
   d. The locking clip can be placed both buccally or lingually

5. Which of the following statements about the AutoMatrix® is correct?
   a. The Automatrix® band has a “window” at the contact area
   b. The AutoMatrix® band and locking clip come pre-assembled
   c. Pre-contoured matrix bands are available for the AutoMatrix®
   d. The AutoMatrix® is an example of an early segmental band system

6. Compared to early posterior composites, modern composite materials have all the following properties EXCEPT:
   a. More condensable
   b. Hold their shape better without slumping
   c. Less likely to cause gingival overhangs
   d. Seal proximal margins better

7. Tofflemire matrix bands tend to create restorations with all of the following EXCEPT:
   a. Flat, straight proximal contours
   b. Squared-off marginal ridges
   c. Heights of contour that are more occlusal than adjacent heights of contour
   d. Narrow, high contacts

8. All of the following statements about Tofflemire matrix retainers are true EXCEPT:
   a. Retainers can be used with separating rings
   b. Wedges have no function when the Tofflemire is used in conjunction with a separating ring
   c. The retainer can interfere with separating ring placement
   d. Dead soft matrix bands can be used along with separating rings

9. When comparing the Tofflemire retainer to the AutoMatrix® retainer, which statement is incorrect?
   a. The Tofflemire is less convenient to place because there are two components – the retainer and the band.
   b. The AutoMatrix® has more band options than the Tofflemire system.
   c. More tools are required with the AutoMatrix® system.
   d. Neither system produces predictable contacts in all situations.

10. Which of the following was not true of early separating rings?
    a. The separating rings often came off during placement or restoration
    b. Prongs could push against the bands, creating under-contoured restorations
    c. Sometimes the prongs could not be placed between the wedge and the sectional band
    d. It was not possible to place the ring facing posteriorly

11. Sectional matrix systems were first introduced in:
    a. 1946
    b. 1986
    c. 1996
    d. 2006

12. NiTi separating rings work better than stainless steel rings because:
    a. They don’t lose their spring
    b. They don’t tarnish
    c. They are more brittle
    d. They are lighter

13. Early sectional matrix bands had all of the following problems EXCEPT:
    a. They were difficult to position and stabilize
    b. They were too long and could interfere with ring placement
    c. The risk of gingival overhang was greater than with circumferential bands
    d. Hemostats were often required to remove the bands after the restoration was completed

14. All of the following are true about the earliest separating rings EXCEPT:
    a. Made of stainless steel
    b. Had prongs at right angles to the ring
    c. Very retentive
    d. Sported metal tines on the prongs for better retention

15. The original Tofflemire matrix bands for amalgam were 0.002” thick. By comparison, the thinnest sectional bands are:
    a. .001”
    b. .0015”
    c. 0.0015” with a 0.0004” thick window at the contact
    d. .0013”

16. One of the problems with modern adhesive systems is that they:
    a. Require placement before the band is seated
    b. Require etching, which can damage the metal in dead-soat bands
    c. Cause the band to adhere to the composite
    d. Result in increased proximal marginal leakage

17. Beginning in 2008, the newest sectional matrix systems featured separation rings which:
    a. Had grooves at the end of the prongs
    b. Had wider prongs
    c. Were made of nylon fiber
    d. Created more separation force in the gingival third

18. In both amalgam and composite restorations, wedges serve to:
    a. Support the papilla
    b. Create three-dimensional proximal form
    c. Seal the gingival margin
    d. Stabilize the separating ring

19. Wavy-shaped wedges can do all of the following EXCEPT:
    a. Recreate convex proximal contours
    b. Seal teeth with proximal concavities
    c. Seal proximal margins when there is a wide gingival embrasure
    d. Help define the marginal ridge anatomy

20. One of the biggest innovations to sectional matrix systems introduced around 2008 was:
    a. No new innovations is 2008
    b. Prongs with grooved tines that straddled wedges
    c. Clear tines that allowed light to cure composites in proximal boxes better
    d. Clear sectional matrix bands

21. Glass-fiber reinforced plastic tines provide all of the following advantages EXCEPT:
    a. The ability to center the separating band equally between teeth
    b. The ability to place two separating bands in the same embrasure space
    c. Better retention of the separating band
    d. Less proximal flash

22. Costs associated with inadequate contours or contacts to the dentist include all of the following EXCEPT:
    a. Time
    b. Materials
    c. Indirect costs such as patient satisfaction
    d. Self-esteem

23. Modern separating rings have prongs:
    a. At right angles to the ring
    b. At an obtuse angle to the ring
    c. At an acute angle to the ring
    d. Angled towards each other

24. Pin pliers included with one matrix system do all of the following EXCEPT:
    a. Make it easier to place sectional matrix bands
    b. Make it easier to place wedges
    c. Make it easier to place separating rings
    d. Make it easier to remove bands without damaging interproximal tissue

25. The primary reason marginal ridges can chip or fracture during matrix band removal is:
    a. Incompletely cured composite
    b. Adhesive sticking to the matrix band
    c. Folds in the sectional matrix band
    d. Clear wedges

26. Future advancements in matrix systems might include all of the following EXCEPT:
    a. Clear ring tines
    b. Color coded rings
    c. Stippled matrix bands
    d. Clear wedges

27. More condensable composites will likely:
    a. Create greater force against sectional matrix bands
    b. Require stiffer wedges
    c. Require more curing time
    d. Both a and b only

28. Most matrix systems include a smaller separating band designed to:
    a. Lift and separate
    b. Create more force than the larger ring
    c. Work in the incisor areas
    d. Work with smaller cavities

29. Separating rings can move teeth apart:
    a. 0.5mm
    b. 0.0013”
    c. 0.002”
    d. 0.08mm

30. Super curved bands
    a. Are difficult to remove
    b. Make it easier to restore wide preparations
    c. Fit better against premolars
    d. Are not very popular
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Educational Objectives
1. Cite the reasons traditional amalgam matrix systems are inadequate for creating Class II composite restorations.
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