A new rubber dam frame design—Easier to use with a more secure fit

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The application of the rubber dam (dental dam) is indicated in endodontics and for restorative dental treatments involving the acid-etch technique. The frequency of the technique's use varies significantly according to individual circumstances, and is generally too low given its advantages. One possible reason for many dentists' reluctance to use it could be frustrating results in the past with technically difficult applications. Such conditions arise, for example, when the taut rubber dam sheet exerts too much pull on the rubber dam clamps, causing them (and the entire rubber dam) to come loose. Particularly susceptible here are clamps attached to molars. This undesired tension results from stretching the rubber dam material—a necessary step—for attaching the sheet to the traditional rubber dam frame. As an alternative, a new easy-to-use rubber dam frame (Safe-T-Frame) has been developed that offers a secure fit without stretching the rubber dam sheet. Instead, its "snap-shut" design takes advantage of the clamping effect on the sheet caused when its two mated frame members are firmly pressed together. In this way the sheet is securely attached, but without being stretched. Held in this manner, the dam sheet is under less tension, and hence, exerts less tugging on clamps—especially on those attached to molars. Even in cases where there are no distinct anatomic undercuts, this lack of tension in the sheet eases isolation procedures and permits the use of standard rubber dam clamps. As a further benefit, the frame's raised edging provides a barrier around the sheet, which prevents small amounts of fluids from escaping. This contributes to greater patient comfort. *(Quintessence Int 2003;34:203–210)*

Key words: dental dam, endodontics, restorative dentistry, rubber dam frame, rubber dam holder

Even more than 100 years after the invention of the rubber dam by Barnum, this isolation method is still up-to-date.[1,2] The number of original research articles and case studies on the rubber dam technique listed in Medline indicates increasing interest in this technique. The reason for this may be that dental treatments that require absolute dryness of the working area are becoming more important:

- At the beginning of the last century, Black[3] in the US and later Preiswerk[4] in Germany called for the systematic application of the rubber dam for endodontic measures. The main priority then was endodontic isolation against fluids and microorganism contaminants in the oral cavity. The validity of this concern remains unchanged today.[5–8]
- Added to this is the need to protect the patient against accidental aspiration or ingestion of small endodontic instruments. According to court rulings in many countries, such occurrences often are considered avoidable, and therefore can be attributed to negligence on the part of the dentist.[9,10] For protecting both the patient and the dentist, the most recent guidelines of the German Dental Association (DGZMK) recommend the routine use of the rubber dam for endodontic treatments.[11]
- An additional restorative application field requiring absolute dryness has come to be with the increased use of the acid-etch technique. A review of published clinical results of such treatment with and without a rubber dam has not, however, provided conclusive proof that this isolation technique is superior to others in ensuring the long-term clinical success of these types of restorations and that therefore, the use of the rubber dam is indispensable for them. Nonetheless, the authors of these reviews agree that the rubber dam technique offers clear advantages for such procedures.[12,13]
- In view of new diseases with potential for infection during dental treatment, the rubber dam gains added

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significance as a simple and clear-cut prophylactic measure against infection.[13–15]

Despite these factors, the use of the rubber dam still has not established itself to any great extent in many countries. Commonly considered responsible for this aversion to the rubber dam is inadequate training and the resultant great amount of time needed for its use[16,17]–though even inexperienced students have been shown to need only around five minutes for it.[18]

Other, up to now, less recognized factors contributing to current reservations about using a rubber dam are frustrating experiences early on with technically difficult applications. A typical problem, with which regular users of the rubber dam technique are familiar, is the frequently inadequate retention of the rubber dam on molars. This arises because of the great amount of tension created when the rubber sheet is stretched onto the frame. This tension, in turn, can exert such a tug on the rubber dam clamps that, under adverse conditions, the whole rubber dam can spring loose.

The new rubber dam frame discussed here solves this problem by allowing for the secure attachment of the dam to the frame without requiring it to be stretched. In this way, no tension is created by the assembly of the rubber dam and its holder, considerably reducing elastic tension tugging on the clamps.

METHOD AND MATERIALS

History of the rubber dam frame

Several developments of the rubber dam frame design have been published since the account of the metal frame attributed to Young.[1] For example, McConville[19] and later Shanel[20] presented enhancements to the basically unchanged U-formed frame by Young. In comparison to this, the development of the metal folding frame by Kahn was a significant innovation, which was later followed by a plastic folding frame with two hinges developed by Sauveur.[21–23] The objective of the folding mechanism introduced in both cases was to enable easier access to the oral cavity under the rubber dam for taking periapical radiographs.

Another field of further development is related to the material used in manufacturing the rubber dam frame. Whereas the traditional metal frame developed by Young was made of radiographically opaque steel (Fig 1), various frames made of plastic have been introduced in the recent past. These first resembled in their shape the traditional U-formed metal frame (Starlite Visiframe; Hygienic Master 6 [Coltene/Whaledent]) (Fig 2). In addition, there was the polygonal nylon frame by Nygaard-Østby known as the "shark mouth" (Svenska Dental Instruments) (Fig 3). Other frames based on the Sauveur folding frame design mentioned above were using various types of plastic depending on the manufacturer (Cadre de Digue; Roeko) (Figs 4 and 5).

The problems mentioned earlier regarding the use of the rubber dam for restorative and endodontic applications on lateral teeth are not mitigated by any of the frame modifications mentioned above. This is because the mechanics of attaching the sheet to the frame with tension remain in effect unchanged.

Development of a new rubber dam frame

Underlying the new development[24–26] presented here was the goal of combining the advantage of using radiographically translucent plastic for endodontic treatments, with easier and more secure use on lateral teeth.

- In regard to practical use, the author noticed during numerous undergraduate and continuing dental education courses that less experienced users had particular difficulty pulling both sides of the rubber dam material over the stubs on the outer ends of the conventional rubber dam frame, while at the same time keeping the frame firmly in hand (Fig 6).
- In order to ensure more secure retention, it appeared necessary to reduce the tautness of the dam, and consequently the tugging pressure exerted on the rubber dam clamps, especially for the isolation of premolars and molars.

Because stretching the sheet over the frame contours is difficult and furthermore is responsible for the undesired tension effect, a new means of attaching the dam to the frame appeared to be necessary. After preattached frame/dam combinations (eg, Quickdam [formerly by Ivoclar Vivadent]) were not successfully adopted, it was decided that the new frame should be designed to work with commonly available dental dams in the standard format (6 × 6 in; 15.4 × 15.4 cm). Furthermore, it should be compatible with normally available sheet thicknesses (light, medium, heavy) made of various materials by various manufacturers, and should be autoclavable.

These considerations gave rise to a workable solution that replaces the conventional one-piece frame with a two-piece frame design. The Safe-T-Frame (Sigma Dental Systems) is composed of two hinged frame members whose snap-shut locking mechanism securely clamps the rubber dam sheet in place (Fig 7). This concept also makes it possible to retain the traditional U-formed frame geometry and dimensions.

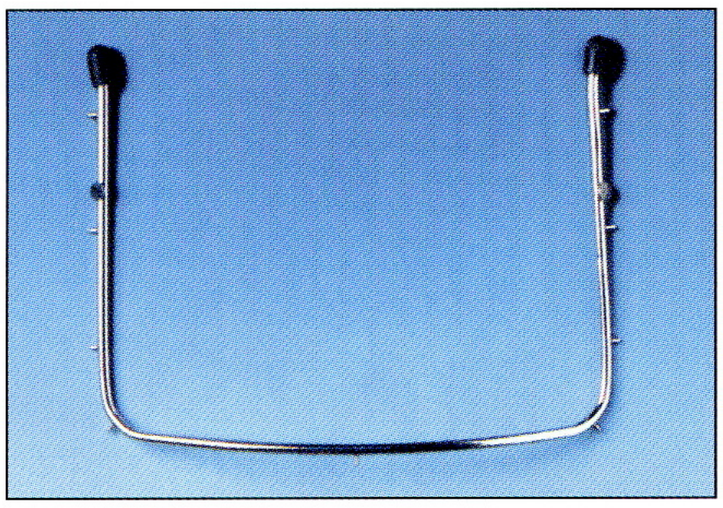

Fig 1 Traditional U-formed rubber dam frame by Young made of metal.

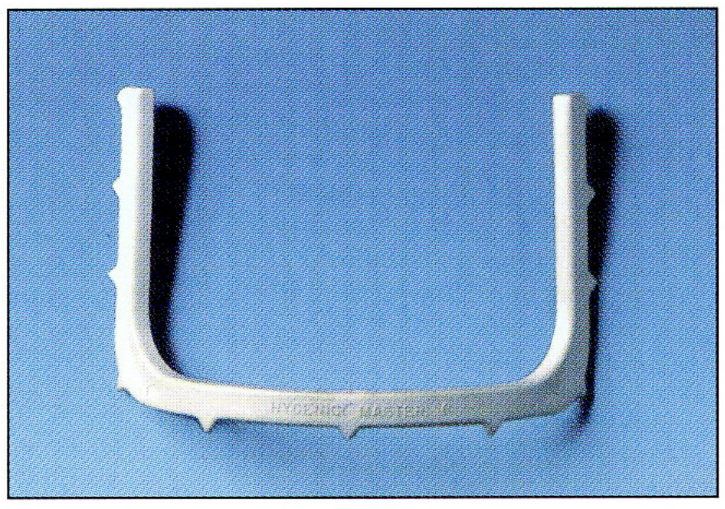

Fig 2 Hygienic Master 6 U-formed rubber dam frame made of plastic.

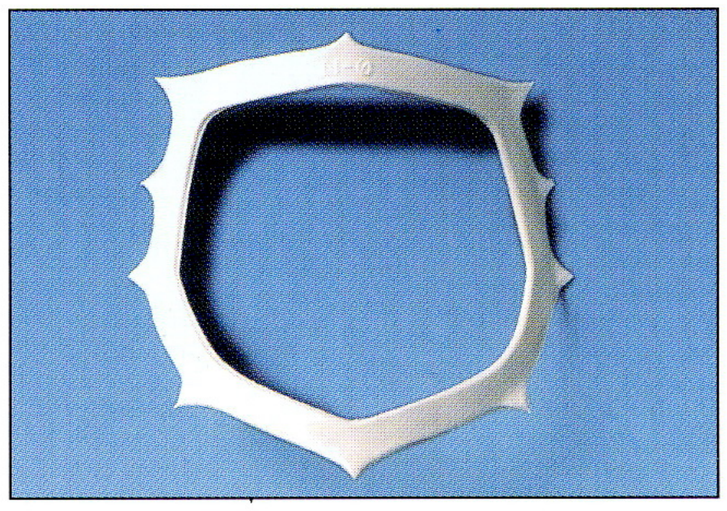

Fig 3 Polygonal plastic frame nicknamed the "shark mouth."

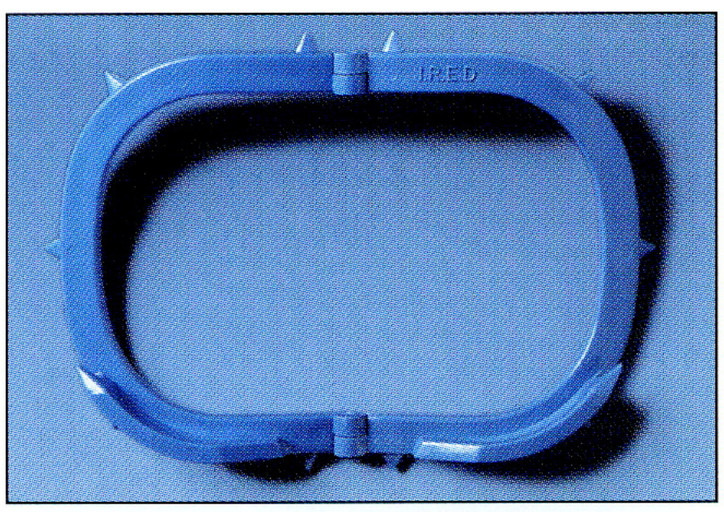

Fig 4 Oval plastic folding frame by Sauveur (Cadre de Dique).

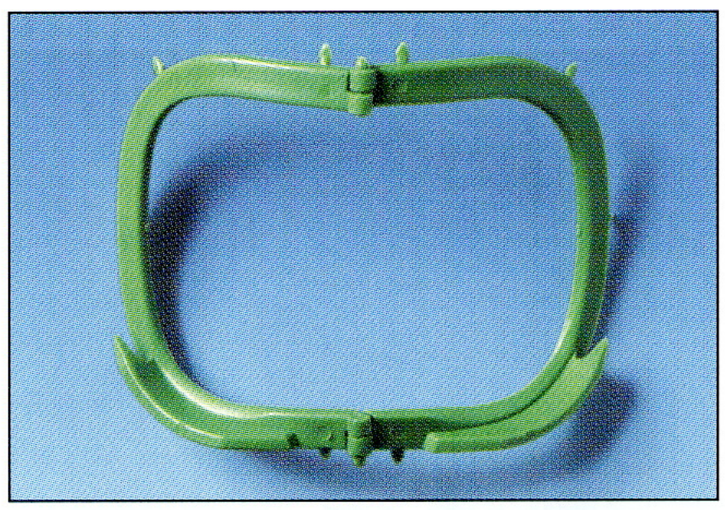

Fig 5 Oval plastic folding frame by Sauveur (Roeko).

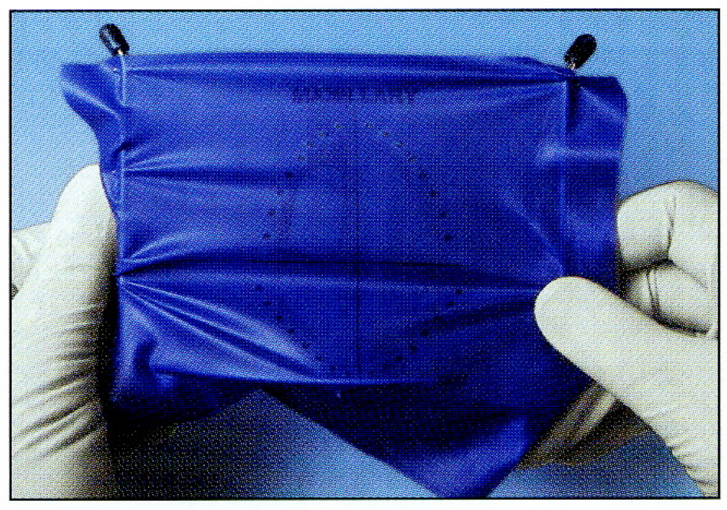

Fig 6 Slipping the stamped and perforated rubber dam sheet over a frame having conventional geometric dimensions: stretching first over the stubs on the frame's end-points secures the attachment of the sheet to the frame. This step often is considered difficult.

Use of the frame for anterior teeth

The use of this new frame draws on the concept of shifting as many work steps as possible into the preparatory phase prior to the placement of the rubber dam into the patient's mouth. This requires that clinical placement not occur before the dam is securely attached to the frame.

As long as conventional templates are used to mark off tooth positions on the sheet where perforations are to be later made (using stamps or stencils), this step is most effectively completed initially before attaching the dam to the frame.

For assembly, the frame is first set flat on an even surface and opened up using both hands (Fig 8). The previously stamped rubber dam sheet is then laid on the lower member of the opened frame such that the upper edge of the sheet extends to just below the two hinges (Fig 9). Because the frame is scaled so that standard-sized sheets will adequately fill out beyond the outer edge of the frame, correct and reproducible positioning is easily attained. Next, the frame is closed by first pressing the top member of the frame down onto the mated lower member (Fig 10). The sheet is now clamped securely in the frame, and the frame/sheet assembly is ready to be placed in the patient's mouth (Fig 11). In situations where the isolation area is to remain limited to just one tooth (eg, for endodontic work on lateral teeth), a rubber dam clamp with wings can be fitted into the prepunched sheet in advance (Figs 12 and 13).

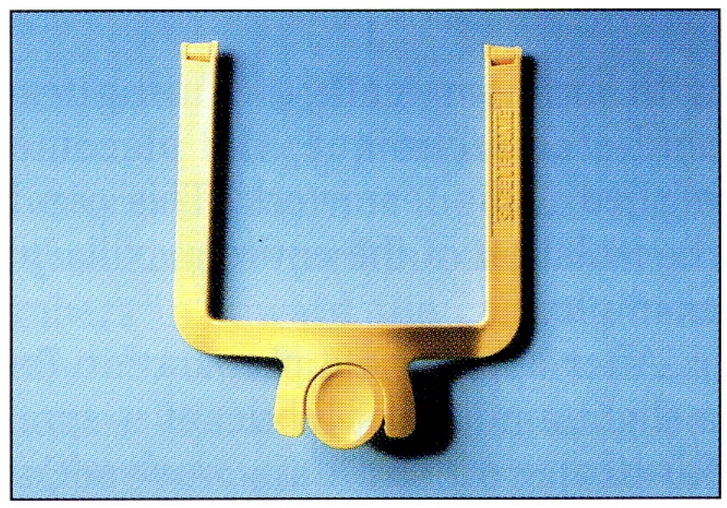

Fig 7 The Safe-T-Frame U-formed plastic hinged folding frame.

The actual placement of the rubber dam assembly can be handled by a single person as long as only one tooth is to be isolated in the manner described.[6,17,27] If larger areas are to be isolated, as is generally the case

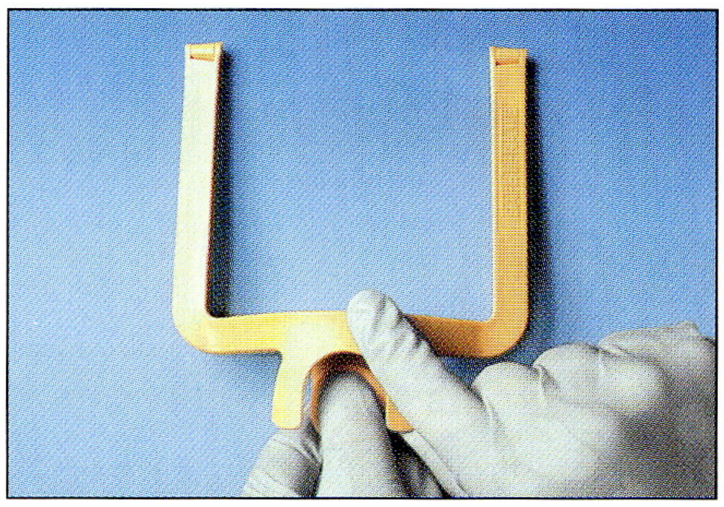

Fig 8 Using both hands to open the Safe-T-Frame, which should be set out on a flat surface.

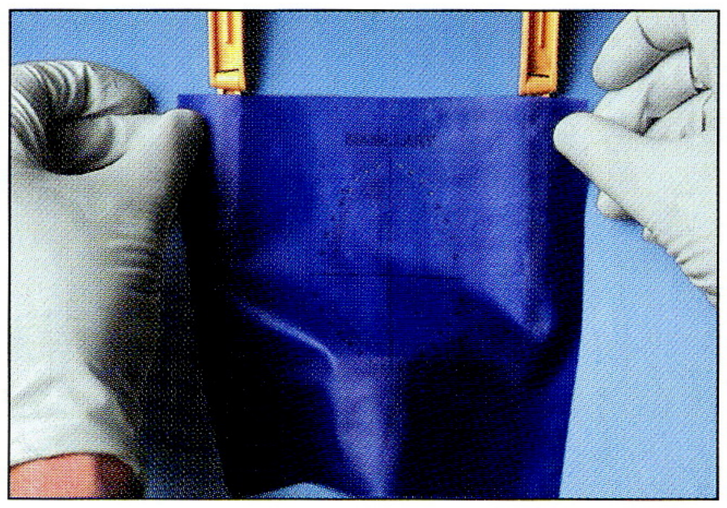

Fig 9 Placement of the premarked rubber dam sheet (Ivory Premium Dam, Heraeus-Kulzer) onto the opened Safe-T-Frame.

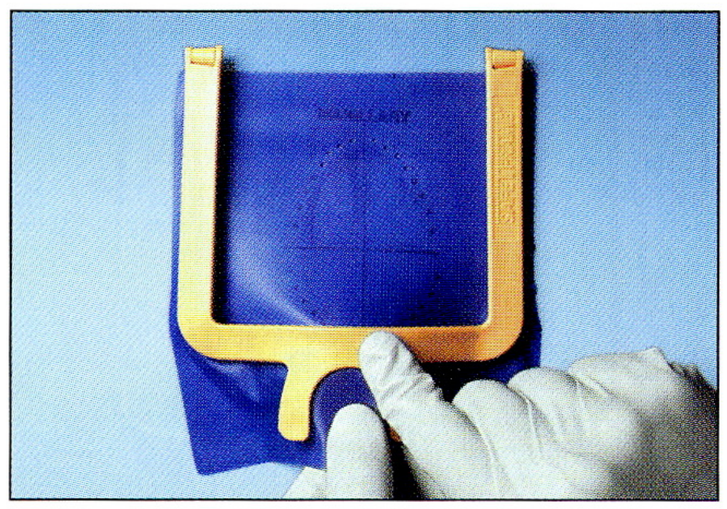

Fig 10 Preliminary or final closing of the rubber dam frame by using light or heavy pressure above the bottom grip.

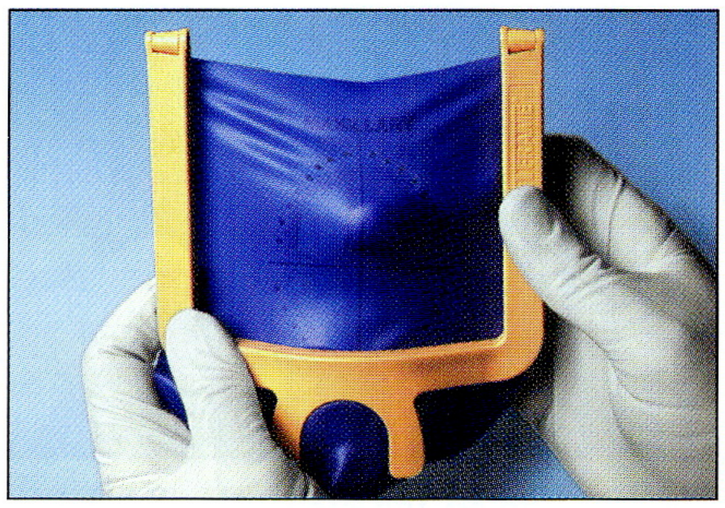

Fig 11 After firmly pressing the frame halves together, the sheet is now fixed securely between them, without tension, even in the area next to the bottom grip.

Fig 12 Placement of the rubber dam frame with a loosely held clamp for isolating a lower right molar for endodontic treatment.

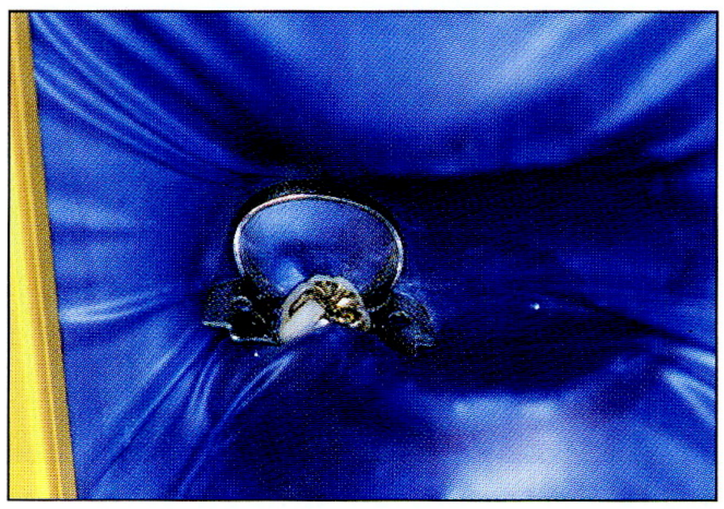

Fig 13 After slipping the rubber dam over the clamp wings, the isolated tooth is ready for treatment (placement accomplished despite minimal anatomic undercuts and inadvertently leaving a layer of rubber dam material between the clamp and the tooth surface).

with anterior teeth or during treatments using the acid-etch technique, the placement is best accomplished using teamwork. This can be illustrated using the isolation of the entire maxillary anterior area as an example:

After appropriate preparation (as described above), a slight amount of lubricant is spread around the perforations on the dam now secured to the frame. Vaseline (Unilever) is not suitable for this because it leaves an undesirable film on the isolated tooth surfaces, and because it can harm the rubber dam sheet itself. Instead, a flavorless water-soluble lubricant should be used which is explicitly approved for intraoral use (designated a "medical product" as required today [Dentaglide, DDS Front Office]). The prepared rubber dam assembly is then positioned in the patient's mouth beginning from the side furthest from the dentist (Fig 14). It is first slipped over the distal tooth to be isolated (Fig 15).

Directly after this, the rubber dam sheet is securely attached to the distal isolated tooth using the appropriate rubber dam clamp. Attachment to premolars makes clamp choice and fit easier because these teeth provide sufficient retention for universal premolar clamps (No. 2 or 2A [Ivory, Heraeus-Kulzer]). After attaching the first clamp, the rubber dam can no longer slip loose. This makes the next steps in guiding the sheet over the other teeth to be isolated considerably easier (Fig 16).

The following process of feeding the rubber dam septa through the individual interproximal contact points is greatly facilitated by the prior application of the lubricant to the bottom side of the rubber dam material. If guiding the rubber through is at first difficult in certain points, these can be ignored for the time being; later correction is easier once the rubber dam is completely in place.

In the meantime, the dental assistant proceeds with a second rubber dam clamp. It is opened with rubber dam clamp forceps and then applied in the same manner to the distal tooth to be isolated on the side closest to the dentist (Fig 17). The rubber dam is now completely in place and fully able to meet the demands of isolation for endodontic applications (Fig 18).

For restorative applications it is a good idea at this time, as pointed out above, to make the necessary

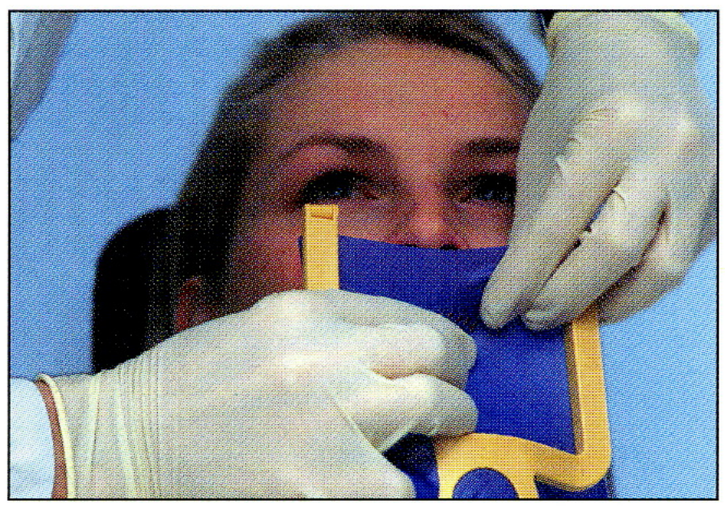

Fig 14 After proper preparation (attachment of the stenciled dam material to the frame, punching out the necessary perforations), the rubber dam is quickly applied with teamwork.

Fig 15 Beginning the application of the rubber dam on the side furthest from the dentist (on the assistant's side) with the distal tooth to be isolated (in this case the maxillary left first premolar).

Fig 16 "Knifing" the dam's septa through the approximal spaces of the maxillary anterior teeth to be isolated after application of a suitable lubricant to the "shiny" bottom side of the sheet.

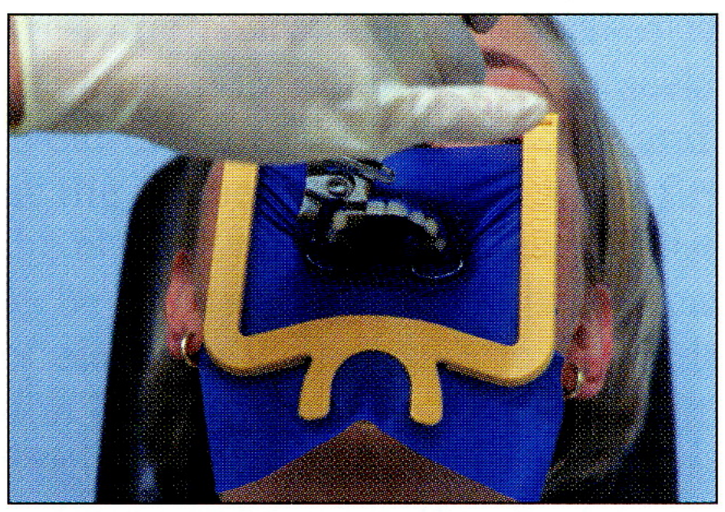

Fig 17 Attachment of a second rubber dam clamp on the distal tooth to be isolated on the side closest to the dentist.

Fig 18 Rubber dam completely in place between the maxillary left and right first premolars using two standard 2A rubber dam clamps.

Fig 19 Correction of the cervical position of the rubber dam sheet on individual anterior teeth to be treated using dental floss.

cervical adjustments to the sheet's fit. Where approximal contact points earlier resisted entry of the rubber dam septa, dental floss can now be used to gently "coax through" the rubber (Fig 19). In some cases, (eg, due to soldered joints) it may instead be necessary to exclude certain interproximal spaces. For these, the necessary septa should be cut out of the sheet with a small pair of scissors prior to the dam's placement in the patient's mouth. After the corresponding correction of the cervical position, the rubber dam is now complete and ready for use in restorative treatments using adhesive techniques (Fig 20).

The perspective view of the rubber dam set up in this manner reveals that in its locked position, the frame's edge is raised above the sheet (Fig 21). This design element is intentional in order to prevent small amounts of fluids from escaping onto the patient (Fig 22).

Use of the frame for lateral teeth

For the isolation of molars, the new frame design allows for precisely altering the position of the rubber dam sheet prior to the final snap-tight closure of the upper and lower members. This is accomplished simply by holding the already loosely shut frame in one hand near the bottom grip while using the index finger and thumb of the other hand to pull the dam between the two frame members in toward the center of the frame (Fig 23). Finally, the two halves of the frame are firmly snapped together in the overlapping area between the horizontal bottom part of the frame and the two vertical frame arms. At this point no "accident" can occur: According to the manufacturer, the frame's fiberglass-reinforced plastic construction renders it indestructible during normal use (Fig 24).

Prepared in this way, the rubber dam is now applied to the patient in principally the same manner described earlier.

For the isolation of individual (pre-)molars prior to their endodontic treatment, it may make sense to use only a single clamp for isolation. The clamp can be positioned within a given perforation in the dam before its placement in the patient's mouth (see Fig 12), making it possible to apply the frame, the dam itself, and a clamp in one work-step without assistance (see Fig 13).[6,28–31]

Fig 20 Rubber dam positioned ready for subsequent restorative treatment on maxillary anterior teeth.

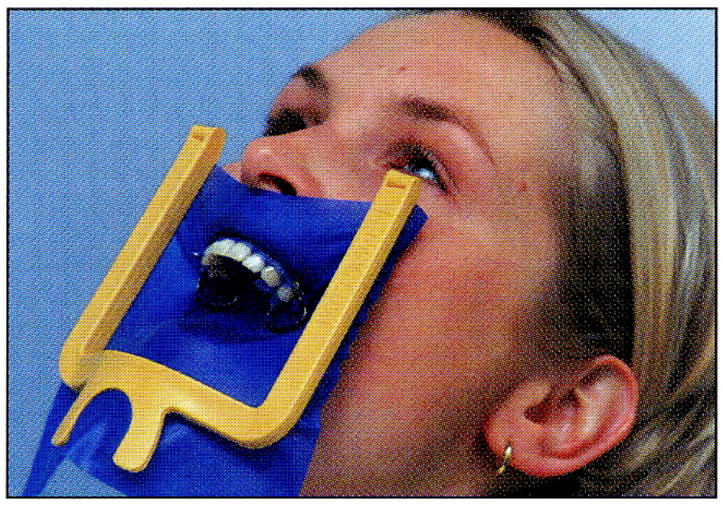

Fig 21 The perspective view of the completely placed rubber dam shows that the frame, using the conventional arrangement of punched holes, is correctly positioned under the nose. Moreover, it can be seen that the frame forms a clearly raised ridge above the surface of the rubber dam sheet.

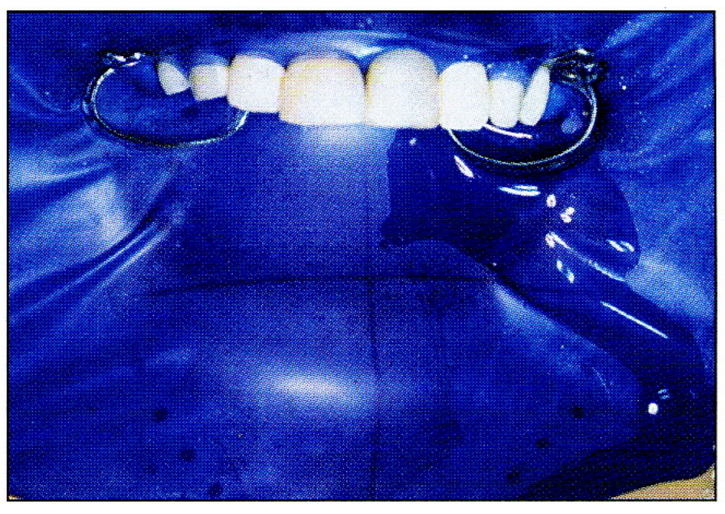

Fig 22 The frame's raised border edging, as well as the water-tight clamping mechanism, ensures that smaller amounts of water do not accidentally escape, ensuring sufficient protection even without the creation of a "pocket" in the rubber material as done with conventional frames.

Fig 23 Adjusting the position of the rubber dam sheet between the two frame halves by pulling the sheet toward the center of the frame prior to firmly pressing the upper and lower frame halves together.

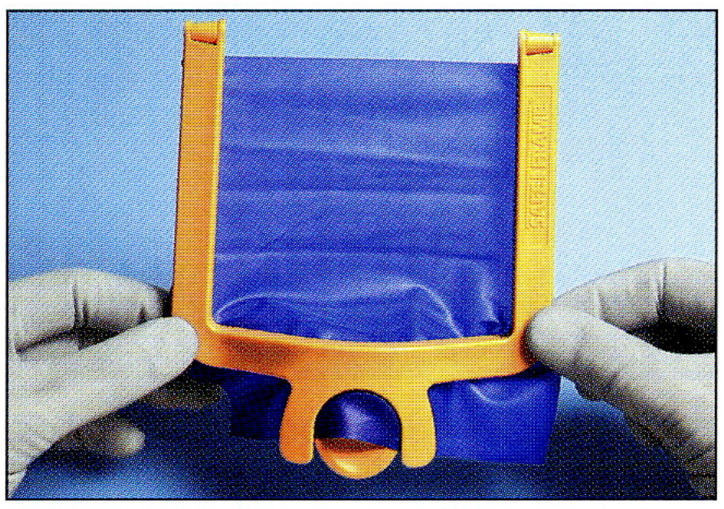

Fig 24 In the end, the frame must be locked in the closed position with pressure now applied to the outer edges at the bottom of the frame arms near the grip; small markings underneath the grip aid in this.

DISCUSSION

Rubber dam indication

The indication of the rubber dam technique for the applications described above remains indisputable. Even though scientific studies have not been able to prove that these applications are not feasible without using a rubber dam, this does not change the fact that its use offers considerable advantages to both the patient and the dental team.[12,13] Furthermore, recent studies have addressed the issue of patient comfort in treatments with and without using a rubber dam. Interestingly, the authors demonstrated that from the patient's point of view, the use of the rubber dam significantly increases comfort during treatment.[32] In addition, using a rubber dam can actually save time.[33] For these reasons, it is desirable to overcome the various barriers against the use of the rubber dam for the corresponding indication areas. Where technical obstacles are concerned, technical solutions must be found.

For the difficulties discussed regarding inadequate retention for lateral teeth, a number of solutions and ideas have already been proposed. These have focused on increasing the dam's retention at the sheet's tension point (eg, the tangential connection with the combined surface of the rubber dam clamp and isolated tooth). Efforts in this regard have resulted in the development of virtually countless numbers of variously shaped rubber dam clamps. From the dentist's point of view, though, this course has been problematic for a number of reasons:

- It is difficult to obtain a clear overview among the variety of clamps, a situation fostered by the unsystematic numbering systems developed over time by the different manufacturers–particularly since several clamp makers (Ivory/Sigma Dental Systems-Emasdi, Hygienic/Coltene/Whaledent, HuFriedy, Ash, Roeko) use different designations for essentially the same clamps.[34]
- In addition to this practical limitation, the concept itself is an issue because it basically involves a system of clamps of increasing tension and/or square-edgedness. Because it has been shown that damage to the dental hard tissue by rubber dam clamps is

possible due to suboptimal positioning, especially in the root area,[35] such increases in the clamp's tension force, or the increase in the number or size of the clamp's beaks, must be regarded with caution.

Other alternatives, such as the replacement of spring-tension clamps by tensionless resin-bonded wings attached to the tooth to be isolated through the acid-etch technique,[36] are at least temporarily invasive and require more effort.

Evaluation of the new frame

Against this background, it appears reasonable to address the source of this series of problems instead of the effects–in other words, to seek where possible to avoid creating the unnecessary and undesired tension in the rubber dam sheet in the first place. Reducing the elasticity of the dam material itself does not appear to be practicable here. This is because a certain level of elasticity is necessary to facilitate intraoral adaptation to individual conditions, and in order to avoid the tugging effect on the clamps without some amount of damping or "give" in the sheet material.

Another conceivable approach would be to change the geometric shape of the dam, which up to now has been available in rolls or precut quadrants. This could allow a reduction in the elastic forces, particularly in the middle part of the isolated area. Countering this idea, though, is that with any of these changes, a secure fit with conventional frame types could not be guaranteed. Furthermore, such sheets are currently not available, and according to the latest proposal of the American Dental Association's Working Group 90 (in which the author is a participant), there are no plans to develop them.

With these issues in mind, it appears that the most promising approach is through changes in frame geometry, which minimize the tension in the rubber sheet after attachment to the frame. A conceivable approach for achieving this would be to draw or "bow" the central section of the frame inwards. This idea also fails, however, because with such a bent frame design, no secure attachment of the dam to those pins placed in the frame's bowed middle section can be guaranteed. Additionally, this format undesirably reduces the accessible working area.

An alternative in this connection is to adopt a new system for attaching the dam to the frame. This idea first attracted attention when a variety of preattached frame/sheet combinations were being developed.[37,38] None of these systems, however, were able to establish themselves successfully.

The proposal presented here, on the other hand, is based on a frame having new geometric dimensions which works in combination with standard-sized dam sheets. The only new demand its use makes is that the application must follow the procedure described in this article–an approach calling for first attaching the properly prepared dam to the frame prior to placement in the patient's mouth. Other techniques (eg, setting a rubber dam clamp intraorally on the isolated tooth, followed by intraorally slipping the perforated dam over the entire clamp and the isolated tooth, and ultimately attaching the frame to the dam now secured in the patient's mouth) are in any event linked with greater time and work effort for the dental team, and more discomfort for the patient.[28] In contrast, the method presented here is a basic one which simplifies application of the rubber dam, and hence, serves to promote the use of this effective tool.

Practice has shown that increased efficiency is achieved by having a number of frames outfitted with darns marked and perforated for various indications and ready for immediate use. This decreases the prep time for applying the rubber dam down to zero, and in doing so helps overcome reservations in the dental office against this presumably time-consuming measure. It has also been proven effective to apply this rubber dam system at the earliest possible point in treatment, and to even carry out endodontic trepanation measures beneath it. The necessary evacuation of fluids can also be done with the dam fully in place. The design of the new frame with its raised edging confines small amounts of escaping fluids; the frame's clamping mechanism remains sufficiently watertight throughout treatment.

Perspective on future developments

This innovation is particularly important in view of its application in restorative treatments using the acid-etch technique. It offers a framework for making the use of the rubber dam even simpler, and hence overcoming inhibitions about its use right at the start.

In regard to endodontic treatments, one problem for which an optimal solution has not yet been found concerns the interaction between the rubber dam and radiograph machine. Various proposals have been published on this, but none have been completely convincing. Temporarily removing the complete rubber dam for taking radiographs does not appear to be an efficient solution. The alternative of leaving only the dam in place but completely or partially removing the rubber dam frame[29,39] has proven to be even less of an answer. Furthermore, it can result in discomfort and embarrassment for the patient, particularly when the endodontic treatment area is located separately from the radiograph equipment.

The plastic folding frame by Sauveur[22,23] (see Figs 4 and 5) offers a promising alternative in this regard even though, here too, difficulties remain. An article[40] reported that "with this frame ... when snapping it shut a strong tug on the rubber dam clamp was nonetheless exerted by the rubber sheet."

Because the frame introduced here does not stretch the rubber dam itself, the frame/dam assembly in its applied state provides greater sideways mobility than results with other techniques. In endodontics, this makes it possible to position the radiograph film intraorally with the corresponding film holder in basically the same manner as when using the folding frame.[31] This also enables its use in combination with the currently used radiograph film holder (EndoRay II, Dentsply/Rinn), as well as with future products.[40]

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