The use of pit and fissure sealants

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Abstract

This paper reviews key issues of sealant use and methodology and poses recommendations to inform the discussion toward a consensus statement by participants. A comprehensive review of sealant literature, including policy recommendations from previous conferences that reviewed best practices for sealant use, was completed. Building on the review paper by Simonsen and on previous policy statements by dental and public health groups, this paper discusses key questions about sealant use in light of contemporary caries data and cost-benefit analyses. In addition, newest material advancements are reviewed to establish the next step in sealant improvement for young patients.(*Pediatr Dent*. 2002;24:415-422)

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The dental battle against decay in pits and fissures has a long and creative past that includes such preventive innovations as early physical blocking of fissures with zinc phosphate cement,[1] mechanical fissure eradication,[2] prophylactic odontodomy[3] and chemical treatment with silver nitrate.[4] Creativity in this effort against fissure caries continues, with new materials and technologies tested each year. At the time that acid etch bonding to enamel was first described by Buonocore in 1955,[5] bonding was a new technology, and a logical step in its use was the prevention of pit and fissure decay. Thus, resin sealant methods were born.[6]

New methods of caries prevention focus on pit and fissure caries because tooth surfaces with pits and fissures have always been the earliest and most prevalent of carious areas. The disproportion of caries on fissured surfaces continues to this day, with these surfaces accounting for over 80% of all caries in young permanent teeth.[7]

During the time of the first clinical sealant trials, caries rates were high. The strong probability of fissure caries on nearly all molars drove the profession to see sealants as a highly advantageous procedure. It was generally accepted that nearly all molar occlusal surfaces would eventually become carious.[3,8-10] As reviewed by Eklund and Ismail,[11] during the 1950s, 1960s and 1970s, 70% of all molar occlusal surfaces would become carious within 10 years of emergence into the oral cavity. A high percentage of these occlusal lesions occurred in the first 3 years after eruption.[10,12] These early caries data supported Council of Dental Research policy that sealants should be universally applied, principally to molar teeth within 3 or 4 years of eruption.[13] More recent analyses indicate that caries susceptibility of molar occlusal surfaces is lower and more continuous, resulting in lower overall occlusal caries prevalence and an extended time of risk reaching into adulthood.[11,14-16]

Caries rates have changed dramatically since the 1970s, with fewer of our present patients falling into high caries risk groups. While the caries attack has decreased in numbers, intensity and speed on smooth surfaces, it also has decreased on occlusal surfaces. The concurrent reduction in fissure caries risk can be seen in analyses of NHANES III data from the early 1990s.[7] It is clear that there has been a dramatic change in occlusal surface caries over the US population of young patients, with pits and fissures accounting for 88% of caries in children while making up only 13% of total tooth surfaces. Therefore, the economic and health benefit for sealant treatment has undergone a redefinition based on the newer caries risk figures.[16] A more contemporary perspective is that sealants should be directed to those teeth judged at risk for caries, not directed to all teeth with pits or fissures.

Questions concerning sealant use deserve reexamination in a forum such as this:

1. Do contemporary changes in caries rates affect sealant use?
2. Should sealants be placed only on caries-free pits and fissures or can we seal over enamel caries?
3. Should sealants be placed on all non-carious pits and fissures?
4. Should sealant application be limited to the first years after eruption/emergence?
5. Can sealants be placed effectively on buccal and lingual pits and fissures?

6. Are sealants effective on primary teeth?
7. Can sealants be placed effectively immediately after a fluoride treatment?
8. What advances in dental materials have improved sealant effectiveness?

The purpose of this paper is to review previous large-group agreements on sealant use in light of the most contemporary literature. In the process, a goal is to uncover persistent beliefs and myths about sealants that need changing based on the newest research. The work of the consensus conference will be to consider the newest information, to weigh the evidence and to form recommendations that guide our clinical decisions until further knowledge is gained.

Previous dental organization guidelines on sealant use

Excellent reviews of sealant studies and thoughtful discussions of sealant philosophy exist.[17-21] These previous works were key to the evolution of the profession's present philosophy on sealants. They are required reading for anyone charged with making recommendations for sealant use in the year 2002. Nonetheless, these past conferences are products of their times, and they reflect the knowledge and the biases of the years in which they were held. Therefore, the previous work is a treasure of information for us today, but the conclusions drawn in each of these conferences are not fully relevant to the present situation. On the other hand, it is interesting to note how many of the ideas considered new and contemporary today were described at previous meetings. Most surprising is that some of the previous discussions included statements against myths that persist to this day, and most disappointing is that the collective wisdom of the profession has yet to take up many of the changes in thought and action strongly suggested in these past discussions.

The last review chaired by Siegel[20] stated that "sealants are an important dental caries prevention technology, ideally used in combination with patient education, effective personal oral hygiene, fluorides and regular dental visits." In addition, this conference discussed determinants of sealant delivery in both community programs and in individual care programs. Among other recommendations were these key positions:

1. Caries risk assessment of the individual and the tooth are important as determinants of sealant need.
2. Caries risk on surfaces with pits and fissures may continue into adulthood; therefore, post-eruptive age alone should no longer be used as a major criterion for sealant decisions.
3. Sealants should be used to prevent caries in at-risk teeth (preventive sealants).
4. Sealants should be used to treat teeth with questionable caries or definite caries confined to the enamel pits and fissures (therapeutic sealants).
5. Sealed teeth need to be evaluated periodically for sealant integrity and retention.

Sealant use in the context of contemporary caries epidemiology

It is universally understood that caries rates have fallen dramatically for populations in industrialized nations. Reasons for such a decrease have been previously described. Latest data analyses of caries[22-24] illuminate subtleties in the changes in caries rates not previously appreciated. Subgroups of overall populations continue to experience the bulk of dental caries. Educational levels and socioeconomic status relate inversely with caries experience. Primary tooth caries rates and distributions differ from rates and distributions in permanent teeth.

For the purposes of this discussion, it is prudent to focus on changes in caries rates and distributions seen on tooth surfaces that suffer from pit and fissure caries. The surfaces most at risk for caries in young patients are occlusal surfaces of permanent first and second molars. The next most susceptible are buccal surfaces of lower molars and lingual surfaces of upper molars. Caries rates on all permanent tooth surfaces have dropped for each age level for 4 subsequent national caries surveys covering the years between 1971 and 1994.[25] While overall caries have decreased, surface specific caries rates illustrate important issues. As the overall smooth surface caries rate has decreased significantly, the percentage of total caries attributable to pits and fissures has increased. The latest evaluations suggest that pits and fissures account for about 80% of all caries in young US patients.[7]

A casual observer might conclude that there has been no decrease in occlusal surface caries, or that occlusal surface caries rates have increased. In fact, occlusal caries has also decreased dramatically. Initiation of new carious lesions in pits and fissures of molars 4 years after eruption has decreased more than 70% over 20 years and progression of lesions in the majority of the population has slowed. For example, prevalence of decayed or filled occlusal surfaces on first permanent molars in 10-year-old children dropped from about 55% to about 15% between national surveys in 1971-1974 and 1988-1994. In the same time period, prevalence of decayed or filled occlusal surfaces on permanent second molars in 16-year-old children has dropped from about 68% to about 25%.

Benefit analysis of sealants involves comparing caries rates on sealed teeth and caries rates on those surfaces that were not sealed. The decline in occlusal caries, therefore, affects benefit analyses. As the actual caries rate on non-sealed surfaces decreases, the number of sealants placed to "save" or protect one surface from caries must increase and the computed percent effectiveness of the sealants decreases. For example, if 70 out of 100 non-sealed surfaces became carious in a study, while only 10 out of 100 sealed teeth became carious, the effectiveness would be 60 saved surfaces divided by 70 expected carious surfaces (60/70=86%); while if only 20 of those same unsealed teeth became carious in the study while 10 of the sealed teeth became carious, the effectiveness would be 10 saved surfaces divided by the 20 expected carious surfaces (10/20 = 50%). The same caries rate on the sealed surfaces as shown in the 2 sides of this example is, therefore, viewed as much more effective when the comparison, or control, group develops caries at a higher rate.

From the previous example, it is clear that to gain the greatest benefit for the sealant treatment, it is imperative to determine caries risk of teeth and then to seal those that have the highest risk of caries. This understanding of risk-based sealant treatment is not new, but its adoption has been slow.

This concept of risk-based sealant application is supported by published data. A 5-year study of caries rates after sealant application on molars diagnosed into 2 groups, sound and incipient occlusal lesions, showed a dramatic difference in effectiveness of sealant placement.[26] In this study in a fluoridated community, molars scored initially as sound became carious at a rate of 13% if not sealed and a rate of 8% if sealed, representing a modest protective effect (13% vs 8%). Molars scored initially as incipient or questionable became carious at a rate of 52% if not sealed and a rate of 11% if sealed. This represents a striking protective effect (52% vs 11%).

Along with changes in our contemporary understanding of the caries process on surfaces affected by pits and fissures has come the necessity to re-think sealant use. The majority of fissures and pits no longer are destined to become carious in the first 3 years after tooth eruption, and a significant number of fissures and pits will not become carious at all. The rate of caries initiation is slower and over a much longer span of time. Therefore, it is faulty to emphasize sealant placement only within a few years of eruption. Sealant use must be based on personal, tooth and surface risk, and this risk may change at any time in the life of the patient. Many fissures are at risk immediately at eruption. Others are not, and therefore, should not be sealed. Alternatively, the unsealed and unrestored fissures may reach an at-risk stage later due to changes in a patient's habits, oral microflora or physical condition. Therefore, these fissures must continually be evaluated into adulthood, and sealants may be appropriate later in life.

Sealing enamel caries

Many reports have described arrested caries and the elimination of viable microorganisms under sealants or restorations with sealed margins.[27-29] Dentists are reluctant to accept these concepts even though investigations have clearly indicated the facts for 30 years. With the bulk of evidence increasing and a more open discussion about minimal intervention therapies for caries, ideas are changing. Professional leadership has advocated that any fissure lesion judged to be limited to enamel is a candidate for sealant therapy.[20] This stance is supported by the large body of literature showing that lesions effectively sealed do not progress.

This position in favor of sealing early carious lesions should not be surprising. In retrospect, early caries has been watched or sealed over for decades. When we view the low sensitivity and specificity of current fissure diagnostic methods, it is clear that we have always misdiagnosed a significant number of fissures, calling between 20% to 80% of true enamel caries sound and diagnosing as carious about 5% to 20% of actually sound fissures.[30,31] Depending upon the caries risk level of the population one is treating, a judgment must be made as to the relative value of general overdiagnosis or general underdiagnosis. For most contemporary clinicians in fluoride-rich areas, it would be better to underdiagnose early caries, since many incipient lesions either become inactive, remineralize or progress very slowly to cavitation and dentin involvement. Rather than surgical intervention on all questionable or incipient fissure lesions, a more rational approach is to observe carefully until a time at which diagnosis is more clear, or to seal the questionable fissure to limit any future progression of the lesion.

Enameloplasty, caries-detecting dyes and proper treatment codes

A logical extension of the treatment philosophy in favor of sealing early enamel lesions is an argument against enameloplasty of all fissures before sealant placement. Careful cleaning of the enamel surface and the fissure followed by effective etching of the fissure walls will result in a successful sealant and will halt progression of any existing incipient caries. Therefore, universal use of fissure eradication or enameloplasty with rotary instruments or air-abrasion is an unnecessary addition to good sealant methodology. In addition, the enameloplasty procedure itself may injure normal enamel resulting in higher caries susceptibility of that fissure in the future.

While a large body of laboratory studies show potential benefits to enameloplasty, only a small number of short-term clinical studies with small samples support this technique as equal to, but not better than, sealant placement without enameloplasty.[32,33] Most important to the decision on the use of enameloplasty methods is the fact that there are no long-term clinical studies to show that enameloplasty is safe. One could speculate that removal of enamel in areas of thin or no enamel (ie, the depth of fissures), leaves the tooth more susceptible to caries attack in the event of sealant loss. This has not been tested.

A recent in vitro study compared preparation of fissures vs no preparation and compared minimal sealant placement vs overfilling with sealant on teeth that were then thermally and mechanically stressed. The marginal leakage that occurred was greater in non-prepared fissures, suggesting that fissure preparation could improve sealants. Yet, greater than the benefit of fissure preparation was the improvement shown by minimal application of sealant as opposed to overfilling the occlusal surface leading to heavy occlusion on the tested sealant. One could suggest from these data that careful placement of the proper sealant volume is more beneficial than enameloplasty.[34]

Despite the lack of long-term clinical evidence of benefit through enameloplasty prior to sealant placement, a majority of pediatric dentists use the technique; with 17% of respondents to a recent survey stating that they always used enameloplasty and 70% stating that they sometimes used enameloplasty.[35]

Another extension of the logic of sealing early caries argues against the use of caries-detecting dyes in fissure caries diagnosis. The last remnants of caries in a fissure should be inconsequential to the success of the sealant. Surface cleaning is all that is appropriate, unless one judges a fissure to contain caries that has progressed to the dentin. Thus, caries-detecting dyes hold no therapeutic value.

In addition, those who use fissure eradication procedures and/or caries-detecting solutions to justify placement of, and charging for, a posterior composite rather than sealant and thus increasing fees for treatment of that surface often are overtreating the disease. They are working counter to policy of the ADA Council on Dental Benefit Programs. The Council policy since 2000 states that a sealant (CDT-code #D1351) is a "mechanically and/or chemically prepared enamel surface sealed to prevent decay," while a 1-surface posterior resin (CDT-code #2385) is "used to restore a carious lesion into the dentin...not a preventive procedure."

Risk analyses and sealant use

It is appropriate to ask how to analyze the risk of caries in the process of decision-making for sealants. The topic is too large for this paper, but a summary is in order. As a deeper understanding of cariology develops, more insight is gained into the factors that predict caries. Therefore, the future will bring improvement to caries risk analyses. Presently, clinical studies indicate that an experienced dentist can make such a decision without expensive technology.[36] The best predictors are: prior caries experience of the patient, fluoride history of the patient, fissure anatomy and plaque load.[37,38]

The main goal of a recommendation for risk-based decision making for sealants is to have dentists actually make a decision, rather than to assume sealant application for every tooth. The formal process of the risk analyses may not be as important as the fact that some risk analysis is done followed by a decision to treat based on the risk analysis.

The need for vigilant recall and repair

A previous review of sealant clinical trials show a failure rate (judged by sealants needing repair, replacement or restoration) to be between 5% and 10% each year.[39] This number is supported in many large sealant studies and in numbers from private pediatric practices using the best of sealant procedures. Without appropriate clinical follow-up of these sealants, the failures would compound over a few years, leaving most of the surfaces equally susceptible to caries as surfaces that were never sealed. Long-term success of sealant therapy, therefore, is dependent upon vigilant recall and repair when necessary. With such follow up, sealant success is very high. Studies that incorporated routine recall and maintenance are able to report success at levels of 80% to 90% after a decade or more.[40,41]

The necessity of recall and maintenance for sealants is based on an understanding that partial loss of sealant leads to a surface equally at risk for caries than one never sealed.[42,43] One-time sealant placement does not impart any long-term caries protection unless the sealant remains in place and intact. Loss of coverage of any susceptible pit or fissure leads to an immediate risk of caries attack for the uncovered area. Newer data supporting this concept[44] report on treatment for first and second molars over time with data derived from billing records in a large population of subjects covered by insurance and actively seeking care. Sealed molars showed a caries-reducing treatment effect at 3 years (6% on first molars and 9% on second molars), but this treatment effect did not increase significantly between 3 and 5 years after sealant placement. In other words, restorations did occur on sealed teeth at about the same rate as on non-sealed teeth after 3 years. Over the 5 years of data collection, on average, 15 sealed first molars and 10 sealed second molars resulted in the prevention of one occlusal restoration.

Sealants on primary teeth and on permanent teeth other than molars

The focus of most sealant studies is the occlusal surface of permanent teeth. Permanent molars have been selected as teeth most at risk for occlusal caries and thus, the teeth that most benefit from sealants. This perspective comes from population data. It reflects the realities of "normal" tooth anatomy and thus average susceptibility to caries. It does not account for individual differences among patients and among teeth. Such differences are the basis for risk analysis and decision making in sealant care that is now recognized as necessary for the best cost-benefit ratio in sealant therapy.

Therefore, many primary teeth may be judged to be at risk, due to fissure anatomy and/or patient caries risk factors. This also is true for permanent teeth other than molars (eg, incisors with deep lingual pits or premolars with incipient caries in deep occlusal grooves). Any teeth judged to be at risk can certainly benefit from sealant application.

Early suggestions that primary tooth enamel does not etch well and therefore, was difficult to bond, have been erased by the long successful experience of dentists using acid etching on primary enamel. Much of our contemporary restorative treatment relies on this method of bonding and retention, and it has been found successful in primary as in permanent teeth. Clinical studies reporting on sealant success when applied to primary molars are rare. Those that have been published report retention and success equivalent to permanent molar sealants.[45-48] When reviewing this literature, we must remember the vital importance of patient behavior and compliance (and thus critical isolation and careful technique) as a significant factor in sealant retention studies.[49]

Some clinicians and some clinical investigators are not skilled with young patients, leading to a bias about the success of sealants on children. We must advocate for the acceptance of sealant placement on any tooth, primary or permanent, that is judged to be at risk for pit or fissure caries. The challenge, then, for any clinician is to provide the service in the most appropriate and correct way, working with the patient to assure patient compliance and careful methodology to the application of sealants.

Inclusion of primary molars, and any other teeth judged to be at risk for caries or having incipient lesions, as appropriate for sealant therapy should be a prominent recommendation.

Sealant placement immediately after fluoride treatment

For years there existed an opinion that a recent fluoride exposure, such as in-office fluoride treatment, would interfere with the etching pattern and, therefore, the retention of sealants. This opinion is not correct. It has been dispelled in several reports using sealant bonding and orthodontic bracket bonding to test the hypothesis.[50,51] Therefore, sealant application can be planned to follow fluoride treatment during the same office appointment if desired.

Can sealants be placed effectively on buccal and lingual surface pits and fissures?

Few clinical sealant trials have measured effectiveness on buccal surfaces of mandibular molars and lingual surfaces of maxillary molars. Those few that report on these surfaces generally report greater failures on buccal and lingual sealants than on occlusal sealants.[52-55] More recent work suggests that sealants can be placed successfully on buccal and lingual surfaces.[49] Of particular interest is the observation that adding an intermediate layer of bonding agent primer and adhesive is more advantageous on these surfaces than it is on occlusal surfaces.[49] This may be due to the added flexibility and stress-breaking effect afforded by the unfilled adhesive layer and the benefit this flexibility has on the sealant bond to a buccal or lingual surface undergoing continuous flex in the process of mastication.

Sealant improvement through dental material advancements and technique changes

Several advancements in dental materials chemistry and application have potential benefit for sealant success. Many are new enough that little clinical data are available. Others have proven benefits.

An example of the former is the benefit of fluoride-containing sealants. While we intuit an advantage of placing sealant resin that contains fluoride, no clinical studies can suggest a benefit of this fluoride content. Original inclusion of fluoride into bis-GMA or resin sealants resulted in very low levels of fluoride availability and release[56] compared to other dental materials such as glass ionomers. The latest fluoride additions to resins may be more available since they are less bound into the resin chemistry, yet proof of the clinical benefit has yet to be shown. Since the addition of fluoride to sealant resin chemistry has no detrimental effect on sealant retention,[57] it is certainly appropriate to use fluoride-containing sealants, but one cannot expect an anti-caries advantage due to the fluoride in the product.

A dental materials change with much more data support is the inclusion of a bonding primer and adhesive layer between etched enamel and the sealant itself. This technique change, first used in a successful attempt to minimize negative effects of salivary contamination of etched surfaces, has been shown effective in improving bond strength and minimizing microleakage in lab studies[58-62] and a clinical study of sealants[63] when used on contaminated enamel. Further work on bonding to non-contaminated surfaces[49] has reported that use of single-bottle bonding systems as a layer between enamel and sealant in a clinical study decreased risk of failure of occlusal sealants 47% and reduced the risk of failure of buccal/lingual sealants by 65%.

It can be speculated that the benefit of this primer and adhesive layer under the sealant is based on a combination of: moisture-chasing effects of the hydrophilic primers, increased flow imparted by the less viscous primer and adhesive and increased flexibility of the combined and polymerized primer/adhesive/resin complex once complete. Together, these factors lead to a better initial bond and a more resilient long-term bond.

Even more recent advances in bonding chemistry may portend additional benefits to sealants for young patients. Self-etching primer and adhesive combinations may lead to a dramatic simplification of the steps involved in sealant application with equivalent sealant retention. Such simplification minimizes time of treatment, decreases the need for patient compliance and minimizes potential errors in technique. Two-year data[64] shows equivalent sealant retention on occlusal and buccal/lingual surfaces of permanent molars using the self-etching primer/adhesive Prompt L-Pop (3M ESPE, St. Paul, Minn) as compared to normal etch and seal methods on contralateral teeth. Minimizing steps of the procedure and eliminating the rinsing and drying steps from the normal method allow a 50% savings of time and a much greater comfort level for the patients. Self-etching adhesives require additional study, but the potential is great that improved chemistry will add to the success numbers for sealants in the near future.

Improving sealant materials is exciting because the improvements may dramatically change the calculations on cost-benefit. With more sealant staying in place, the effectiveness data improves. In addition, clinician judgment about where and when to use sealant may be altered, so that, ultimately, those surfaces most susceptible to decay could have the benefit of early sealant.

Recommendations

The dental literature supports:

1. Bonded resin sealants, placed by appropriately trained dental personnel, are safe, effective and underused in preventing pit and fissure caries on at-risk surfaces. Effectiveness is increased with good technique and appropriate follow up and resealing as necessary.
2. Sealant benefit is increased by placement on surfaces judged to be at high risk or surfaces that already exhibit incipient carious lesions. Placing sealant over minimal enamel caries has been shown to be effective at inhibiting lesion progression. Appropriate follow-up care, as with all dental treatment, is recommended.
3. Presently, the best evaluation of risk is done by an experienced clinician using indicators of tooth morphology, clinical diagnostics, past caries history, past fluoride history and present oral hygiene.
4. Caries risk, and therefore potential sealant benefit, may exist in any tooth with a pit or fissure, at any age, including primary teeth of children and permanent teeth of children and adults.
5. Sealant placement methods should include careful cleaning of the pits and fissures without removal of any appreciable enamel. Some circumstances may indicate use of a minimal enameloplasty technique.
6. A low-viscosity, hydrophilic material bonding layer as part of or under the actual sealant has been shown to enhance the long-term retention and effectiveness.
7. Glass ionomer materials have been shown to be ineffective as pit and fissure sealants, but could be used as transitional sealants.
8. The profession must be alert to new preventive methods effective against pit and fissure caries. These may include changes in dental materials or technology.

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Abstract of the Scientific Literature

Nutritive and Nonnutritive Habits and Their Effects on Dental Arches in Primary Dentition

Assessment of sucking habits and their effects on dental arch formation have been carried out by various authors over the years; however, the majority of these have relied on retrospective data, interviews or cross-sectional designs. It was the purpose of this study to assess the effects of the duration of breastfeeding and pacifier or digit-sucking habits on the dental arches among a birth cohort of children assessed at 5 years of age.

Sucking behavior data were collected from 372 children followed longitudinally from birth by the use of periodic questionnaires completed by the parents. Study models were obtained from the children at 4 to 5 years of age and assessed for posterior crossbite, anterior open bite, overjet, arch width, arch length and arch depth. Subjects were separated by habit and duration of breastfeeding. Subsequent comparisons of arch parameters were made among the groups. No relationships were found between breastfeeding during the first year of life and dental arch malformations. When comparisons were made between subjects with prolonged pacifier and digit habits (greater than 24 months), those with pacifier habits had a significantly greater mandibular arch widths and incidence of posterior crossbites. Conversely, those with prolonged digit habits had greater overjet. Both groups experienced anterior open bites.

Breastfeeding for up to 1 year had no detrimental effect on arch formation. Both habits were associated with anterior open bites. Pacifier habits produced more posterior crossbites and digit habits were more strongly associated with increased overjet, greater maxillary arch depth and smaller maxillary arch widths. Persistence of detrimental effects was seen well beyond cessation of the habit.

Comments: This article confirms previous literature on the effects of habits on arch formation. It is unique in that the data was collected prospectively at regular intervals and culminated in the clinical evaluation of a large number of children. Of interest is the observation that occlusal changes persisted even in children that had stopped their habit early (24 to 36 months) which would make one reconsider when to recommend habit cessation. **KV**

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