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Review Article

Educational Study of the Best Eco-Friendly Applicatory Dental Restorative Methods in Using Well-Designed Chemical Composition of Amalgam

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Abstract

Objective: Tooth decay is a common problem affecting both children and adults. Cavities form in the teeth by the action of acid producing bacteria present in dental plaque. A number of techniques and a variety of materials can be used to restore teeth and one of the most commonly used and comparatively cheap filling material is dental amalgam (a mixture of mercury and metal alloy particles). So, we came to assess the effects of the physical and the chemical impacts as the adhesive bonding on the in-service performance and longevity of restorations of dental amalgam including the effects of certain polishing instruments on the surface hardness of this material.

Methods: Amalgam restorations have been accomplished and accurately are carved using a systematic technique. To avoid marginal infiltration, the amalgam was burnished immediately after the cavity is filled. Besides, clinical factors affecting residual basic metals as mercury and marginal adaptations of amalgam restorations were investigated. The effect of moisture in zinc-containing amalgams was also studied.

Results: There is no evidence to either claim or refute a difference in survival between bonded and non-bonded amalgam restorations; in addition, amalgam bonding has eliminated the unnecessary removal of sound tooth structure during cavity preparations. Burnishing has disturbed surface crystallization, bringing an excess of mercury to the surface, with the possibility of weakening and susceptibility to tarnish and corrosion on the particular surface. The use of mercury-rich amalgam has significantly improved the fracture toughness; however, it is removed quickly before it "seeps" back into the condensed mass. Gold foil resists the penetration of the condenser nib and protects the fragile, brittle enamel walls, but amalgam in its plastic state is incapable of this, and the possibility of shattering the enamel walls can lead to flaws developing at enamel margins. The amount of saline and zinc in the amalgam specimens has produced no perceptible differences in the amount of expansion.

Conclusion: Well-adjusted chemical composition and thermal preparation (lower than 65° C) of dental amalgam are the paramount for restorative material especially for posterior teeth.

Keywords: Filling Material; Tooth Structure; Residual Mercury; A.D.A. Specifications; Metamorphosis; Hydrogen Gas

Introduction

A wise man once said. "In the wide arena of the world, failure and success are not accidents, as we so frequently suppose, but the strictest justice. If you do your fair day's work, you are certain to get your fair day's wage-in praise or pudding, whichever happens to suit your taste". Certainly the success and failure gained in the dental restorative arts are no longer accidents. For the past 100 years amalgam has become so well understood that success and failure can be predicted with fair accuracy.

Too often satisfaction with amalgam work is short-lived. In the early hours or days after its placement there seems to be justifiable pride in a task well done. Then, peculiar things begin to happen, and gradually, but surely, the technical details of the restoration are altered-margins collapse, caries recur, discoloration develops, or it cracks and loses its footing.

Every dentist has recognized that there are peculiar, unexplainable facts which are associated with this prediction of failure or success in restorations. It has been stated that restorations are not normally capable of producing perfect "seals" in the tooth regardless of the time of service [1], and yet caries recurrence around restorations cannot be foretold. Experience with failure and success seems to relate principally to the evaluation of caries susceptibility of the patient and to the well-established cardinal principles that can produce a sound restoration. Hovering over these idealistic principles are the ever-present problems presented by indifferent attitudes toward present day understanding of dental caries. If oral hygiene, the diet and modern caries control measures are disregarded, even the perfectly restored tooth can be destroyed [2,3].

There are numerous factors which influence the life of amalgam, but only those factors which are most commonly neglected will be emphasized. It must be recognized that many of the discrepancies found in amalgam are not necessarily failures, but, for the sake of brevity, it is necessary to combine flaws and failures into one category.

Cavity preparation

It has been established that cavity preparation is more commonly linked with failures in amalgam than any other single consideration. Of those defects which may be associated with preparation the most frequent is inadequate extension [4]: thus caries recurrence seems inevitable, particularly in mouths with a high dental caries index. On the occlusal surface it is generally accepted that the preparations shall be extended fully to resistant boundaries but include all susceptible regions (Figure 1a). Deviations from this principle are so infrequently permissible that they shall not be considered an issue. The most common of all cavity preparation failures, however, is found where there is inadequate extension on the proximal surface [5]. If mechanical cleaning by brush or mastication is ineffectual in these areas, the restoration is quite likely doomed to fail, as illustrated in figure 1b. With the advent of the diamond proximal opening wheels and increased rotary speeds, it is possible that there will be less proximal conservatism practiced, and margins will be fully extended to the classical self-cleansing area. However, these same instruments are capable of radical extensions which result in mutilations that must be replaced with restorations of questionable life expectancy, or leave a tooth which may be seriously weakened. Special caution must be directed to the lower bicuspids and the distal regions of the maxillary and mandibular first molars where frail walls can be formed easily.

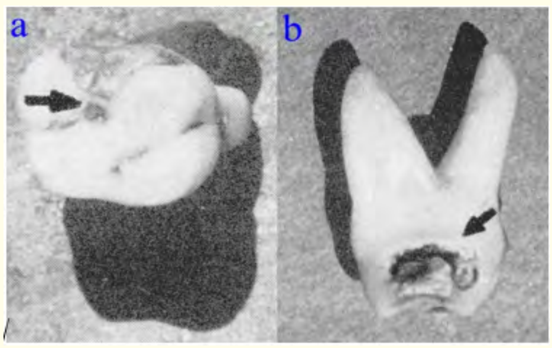

Figure 1: (a) Failure of an amalgam due to inadequate occlusal extension of cavity preparation and (b) Typical failure due to inadequate extension of proximal walls, most frequent of all amalgam failures.

A commonly observed flaw at the occlusal margins is the "ditching" that slowly develops as the filling is subjected to masticatory stress. It is wishful thinking to rely on amalgam to hide ragged or beveled cavosurface margins. These frail margins of amalgam crumble because of certain intrinsic weaknesses and because the strictest care has not been given to the finishing of the cavity margins. Figure 2a illustrates the creation and prevention of such ditching.

The marginal ridge discrepancies in figure 2b are sufficiently common to suggest that they stem from carelessness rather than oversight, since they are the result of unnecessary flaring at the buccal or lingual walls or both as the proximal surface is being prepared. These flaws are not encountered immediately after the insertion of the restoration but are born in the preparation and mature as the weakened portions of the amalgam collapse under occlusal stress. To assure strong junctions between amalgam and tooth, regardless of its location, it sounds judgment to create full butt joints, particularly in those regions where occlusal stresses are to be encountered, but unnecessary extension in order to attain these full butt joints can invite weakening of the buccal or lingual walls and result in splitting of teeth.

Occasionally a compound amalgam restoration suffers a fracture through its bulk in the region of the occlusal constriction between cusps (Figure 2c). This failure is attributed to an inadequate proximal retention form which causes the proximal portion to rely completely on the occlusal portion for its stability, and when trauma separates the proximal from the occlusal surface, this retention insufficiency becomes apparent [6].

It appears then that success with amalgam rests in part in the realization that the inherent weakness in the strength of the filling material must be compensated for in the preparation of its foundation in the tooth structure, and since amalgam itself is not normally considered capable of inhibiting caries recurrence (in adjacent regions) the preparation should include all potentially susceptible spots (Figure 2d). The dentist must be aware constantly that his efforts may be liquidated if a rigorous oral health regimen is not established. Briefly, the following principles should be adhered to figure 2e:

1. All grooves and fissures on the occlusal surface must be included, particularly if the dental caries index is high.
2. Proximal walls should be carried to a self-cleansing portion, buccally and lingually, without flares.
3. A sharp, right-angle butt joint should be established at the cavosurface margin.
4. Adequate depth and breadth to the preparation, without unnecessary extension, must be provided.

5. Definite, strong retention regions in the proximal walls must be established.
6. When restoring cusps an adequate hulk of amalgam that will replace lost tooth structure must be ensured (Figure 2f).

In using increased speeds every operator has become conscious of heat production during cavity preparation. Since postoperative pain can be allied to failure, it is the dentist's obligation to make certain there is adequate cooling of tooth structure at all times during the rapid cutting procedure. The use of adequate coolants not only controls a temperature rise but also acts to increase the rate of tooth removal on condition that excessive cutting pressure is not applied. A highly efficient method of cleaning the operative field and controlling heat production has been introduced by Kilistoff [7] in the washed field technique.

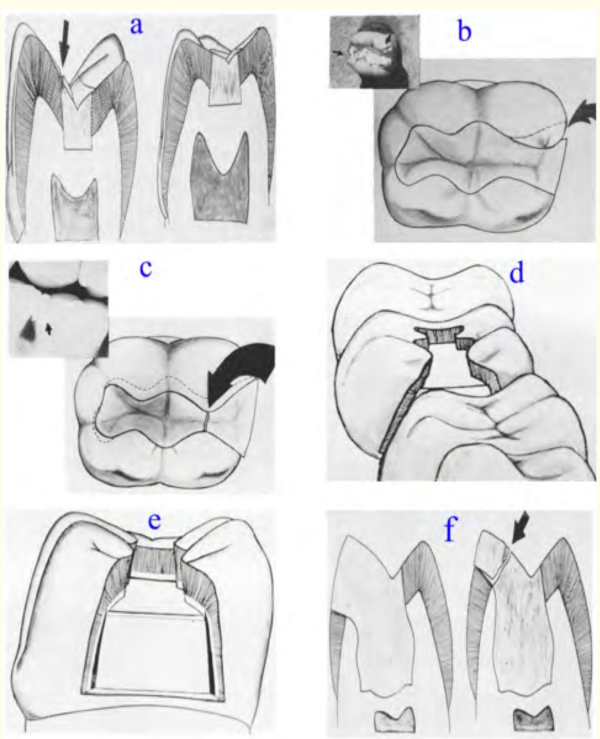

Figure 2: (a) Left: Illustration of ditching of amalgam due to weakening of margin by beveling of preparation and deep carving of restoration. Right: Strong butt joint of amalgam and tooth resists marginal weakness. Note: Direction of cavity walls and shallowness of amalgam carving which are consistent with an atomic design of tooth, (b) Ditching flaws due to flaring of cavity preparation at marginal ridge area, (c) Isthmus fracture with complete detachment of proximal from occlusal portion of restoration. Inset shows caries beyond arrow. Extension of outline to dotted lines is not considered a substitute for strong proximal retention, (d) Extension of proximal walls of the cavity preparation. Note that the occlusogingival design conforms to contour of adjoining tooth, (e) Class II preparation in a lower first molar. Note that proximal outline permits adequate extension of self-cleansing area in cervical third of tooth, and (f) Illustration of the need for adequate cuspal amalgam to resist fracture in tooth structure.

Matrix

The design and relation of contacts, the anatomical design of the marginal ridge, the marginal continuity of restoration and tooth, and the re-establishment of contours all play vital roles in assuring that the tissues of the periodontium will return to and maintain a state of health. Stafford [8] had challenged the operative dentist to recognize and respect the relationship of his work to periodontal health. Each restorative dentist whether be openly professes it or not, is practicing preventive periodontics with every successfully designed restoration. The stepping stone to success in establishing proper contour and contact is the assurance that these physical shapes in a restoration can be attained with the matrix applied. It is never safe to assume that the condensation of the soft plastic mass will push the matrix about, or stretch it, in order to distort it into the form desired.

Once the matrix design has met requirements satisfactorily, attention is directed to its stability. Instability of a matrix will not only result in a distorted restoration but will invite gross marginal excesses (Figure 3a), and under condensed, and soft amalgam. The cervical excess provides a perpetual mechanical irritation to the periodontium; gradually and certainly these periodontal tissues will be destroyed in the vicinity of the trauma (Figure 3b). Contouring, wedging, stabilizing and establishing a proper contact are fundamental to the successful amalgam [9]. Every operator has recognized the ease of condensing amalgam to a Class I cavity. Pressure against unyielding walls makes for an ideal situation and permits thorough condensation and the development of a completely homogeneous restoration. The loss of natural walls in a cavity requires a substitute which must provide similar qualities. If a complete, effective condensation is attempted against a poorly stabilized matrix, "landslides" are inevitable. The result is a weakened restoration with gross cervical excesses. Too often a compromise with matrix instability is attempted with gentle tamping in condensation, and a soft amalgam, filled with voids, is the price of this maneuver (Figure 3c).

Amalgam manipulation

It has been stated [10] that more amalgam restorations fail from poor workmanship than from the use of poor alloys. Today this statement is truer than ever before. Research which developed specifications and techniques of manipulation has provided acceptable materials and procedures. How this knowledge is used rests with each dentist and with only the slightest effort he or his assistant can conform to proven detail for preparing and condensing the amalgam. Successful restorations are more apt to result when variables are kept under strict control. It is the basic principle of all manipulative procedures to provide the mold with a well prepared and well condensed amalgam, and its residual mercury content might be considered an appropriate measure of an operator's ability to produce such amalgam.

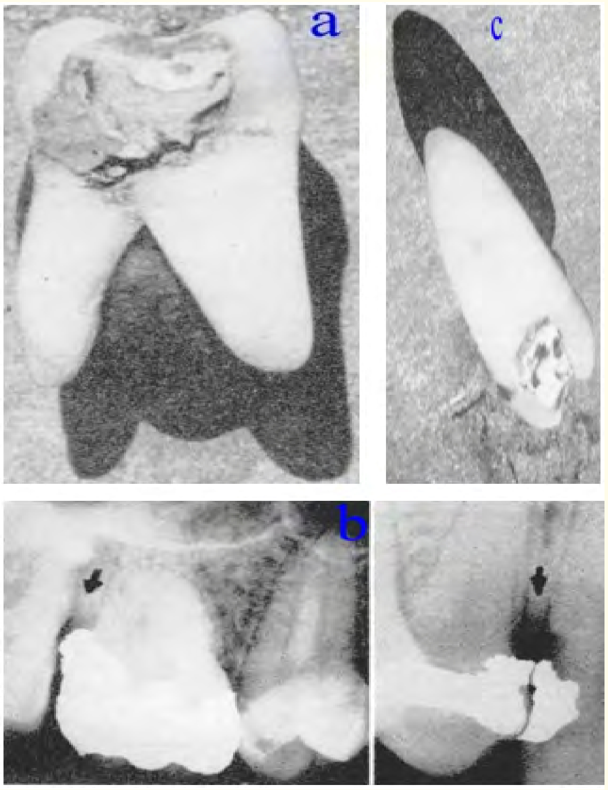

Figure 3: (a) Gross cervical overhang. There is adequate evidence here that no matrix was used. Calculus can be seen below the excess, (b) Roentgenographic evidence of restorative inadequacies and their effect on the periodontium. Note lack of contour, contact and confinement of restorations, and (c) Voids in proximal portion of an amalgam due to inadequate condensation. Caries recurrence at cervical margin suggests that under condensation caused cavity to be incompletely filled.

A serious loss of strength results when mercury in excess of 55 per cent remains in the restoration [11]. The clinical result of an increase in residual mercury is reduced crushing strength, increased flow, and increased susceptibility to tarnish and corrosion. Gupta [12] states that excess mercury used in the original mix unfortunately results in a higher percentage of mercury in the final restoration, and that no method of condensation can alter this effect. The correct ratio is obtained quickly and accurately from balances or scales if the ratio recommended by the manufacturer of the alloy in the instructions is used.

It is well known that mulling is a continuation of trituration, a process which gives added assurance that all alloy particles have been duly coated with mercury. Some prefer to do this manually; others prefer the amalgamator with or without pestle. Most operators today realize that palming is a poor practice, and may use a clean piece of rubber dam to minimize any chance of moisture contamination of the plastic amalgam. Frequently, following trituration, the pestle is removed from the capsule and trituration is repeated for 1 to 2 seconds. This procedure is helpful in mulling and cleaning the capsule of amalgam remnants. Amalgam which hardens in the capsule will contaminate future mixes [13], and is frequently the cause of the hard islands of amalgam that pull out of the plastic mass while the filling is being carved. For this reason capsules should be checked carefully for cleanliness after each use.

Condensation

The principal reasons for condensation are to reduce the residual mercury content and to ensure that amalgam reaches all parts of the preparation. An excess of mercury imparts many undesirable features in the amalgam if it is allowed to remain in the mass: it reduces its compressive strength and flow resistance; it retards the set, and it encourages tarnish and corrosion. It has already been stressed that freshly prepared amalgam has more desirable working properties, since the mercury has not had time to be trapped or combined with the newly crystallized mass. The effectiveness of its removal during condensing procedures is largely dependent on the use of an amalgam which is no more than four minutes old. It has been a well-recognized fact that prolonging plasticity by continuing to mull the amalgam beyond its normal initial setting time, or replasticizing it by adding mercury, will seriously reduce its strength. If a larger cavity demands that the working time of the amalgam exceeds 3 to 4 minutes, the use of multiple mixes will allow the operator to handle new plastic amalgam throughout the condensing procedure and ensure the building of a homogeneous restoration.

There are limits, however, to the amount of mercury which must be removed from the amalgam to assure that its properties will be optimal. Although it imparts certain undesirable properties to amalgam, mercury is also necessary to bind the mass together into a homogeneous form. Elimination of mercury by excessive squeezing of newly triturated mass may induce a laminated effect and seriously reduce the strength of the restoration. The end result, it appears, is similar to the working of a partially crystallized or "set" amalgam.

A greater percentage of mercury removal during restoration construction is accomplished by squeezing the freshly mixed amalgam. The critical reduction, however, to a point below 55 per cent is attained by conscientious packing. It does not appear necessary for the first portion of the amalgam being condensed to be mercury-rich in order to attain sufficient plasticity for marginal adaptation [14]. If a forceful and thorough technique is followed, adaptation will prove no problem to the operator.

The method of packing is an individual choice, since both manual and mechanical methods have certain distinct advantages and shortcomings. Regardless of method, much of the procedure in the condensation of gold foil is applicable also to the packing of amalgam. The thoroughness of condensation that can result from stepping and wedging will ensure an excellent adaptation and increased strength to the restoration. Lovadino and his colleagues [15] cautioned operators by saying that: Stepping with small pluggers or burnishing the material within the cavity is strongly condemned. Small pluggers merely push the amalgam from one place to another and condensation is not realized. The small pluggers push holes in the mass, which had previously been laid down, and their use tends to result in a weak restoration. In burnishing, the soft material is pushed ahead of the burnisher, this weak amalgam depositing itself on the margins and in the sharp angles where the strongest alloy is desired.

Effective condensation can be achieved by using condensers which are shaped roughly to the outline of the tooth portion being restored. The packing motion, when performed manually, is most effective if the condenser is "rocked" under a steady, heavy thrust. The mercury-rich amalgam that works to the surface is removed quickly before it "seeps" back into the condensed mass. Light tamping, on the other hand, will move very little mercury to the surface.

Each operator who has employed mechanical condensation realizes that it can do much in assuring that an adequate packing force is being delivered against the mass. Jorgensen and Hero [16] demonstrated that mechanical methods of condensation generally cause the amalgam to harden sooner and have a slightly higher ultimate compressive strength than those amalgams which have been condensed by hand. It is interesting to note, however, that the strength of properly hand-condensed amalgam exceeds the requirement of the A.D.A. specifications. The principal value of mechanical condensing, it appears, lies in the assurance that, there is some protection against a premature fracture of the restoration during the first few hours after insertion.

A word of caution against the careless use of the mechanical condenser is indicated here. Gold foil may resist the penetration of the condenser nib and will protect the fragile, brittle enamel walls, but amalgam in its plastic state is incapable of this, and the possibility of shattering the enamel walls can lead to flaws developing at enamel margins.

Contamination

Words have been spoken, written, read and forgotten on the problem of keeping oral fluids out of the prepared tooth structure and restoration; moreover, since the middle of the last century this problem has been gradually solved. Attention has been called to the deleterious effect that moisture, in any form, can have on the filling material-gold foil, amalgam or silicate cement-but the experience of 100 years in the practice of dentistry by five generations of dentists has failed to stimulate the profession into a complete recognition of the problem.

It was stated early in this presentation that the satisfaction of a well-placed restoration is often measured in the early hours after its placement. Because failures cannot be seen, usually, within these early hours, the operator is prone to accept his efforts with a smug "well done." However, with time, and in the warm climate of the mouth, a contaminated amalgam will slowly undergo a metamorphosis. Gradually, a new chemical action takes place in the mass, in which hydrogen gas is formed [17]. Then expansion, followed by marginal flaws, tarnish, pitting, and corrosion, changes the whole appearance of a restoration that was once considered a "successful" restoration (Figure 4a).

The effect of moisture in zinc-containing amalgams is demonstrated in figure 4b. Amalgams contaminated with varying amounts of physiological saline solution were condensed into 4 by 8 mm. cylinders. Each of the four brands of alloys demonstrated excessive expansion within one month. The amount of saline and zinc in the amalgam specimens appeared to produce no perceptible differences in the amount of expansion.

The attention that has been given to moisture contamination of this nature has centered around, its effect in producing delayed expansion. This is unfortunate because it fails to show the entire picture of its dangers, and has in recent years, given the profession a false sense of security. The amalgam of nonzinc alloys will not produce the delayed expansion that is inevitable in the zinc-containing amalgams, but this is its sole advantage. No one yet has been able to demonstrate that palm moisture or saliva [18] is considered a desirable ingredient of dental amalgam. To the contrary, moisture in any form will weaken amalgam (Figure 4c), reduce its desirable qualities, and place it in the category of temporary cement.

We found that nonzinc alloys will not provide protection against the development of more numerous and probably more serious flaws or failures that can occur in amalgam restorations. If moisture is allowed to contaminate the plastic amalgam of the zinc or nonzinc variety, it is quite proper to assume that the entire restorative technique is faulty also.

In a gun factory a great steel bar was suspended vertically by a delicate chain. Nearby, a bottle cork was suspended by a silk thread. Could the cork set the steel bar in motion?

The cork was swung gently against the steel bar: the bar remained motionless. Then the cork was swung repeatedly. In ten minutes the bar gave evidence of feeling “uncomfortable”; a “nervous chill” ran over it. Ten minutes later the chill was followed by vibration. At the end of half an hour the great bar was swinging like a pendulum.

Our predecessors and our modern teachers have probably felt like the cork as they have tried to show the value and need for using a rubber dam and preventing the contamination of the restorative field. Slowly, very slowly, the pendulum is beginning to swing, and there is heartening evidence everywhere that both dentists and the public have been educated to the value of the rubber dam in stimulating better dental treatment. In the past four decades there has been nearly a 40 per cent increase in yardage sales of this item by one manufacturer alone [19], and this is a sound indication that the efforts of Kovarik [20], and others have gradually borne fruit.

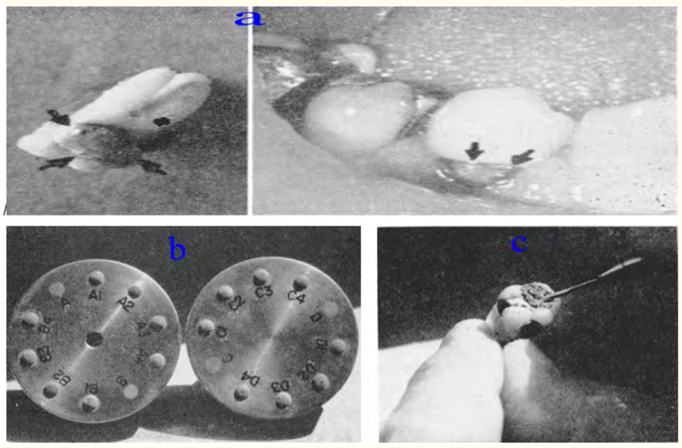

Figure 4: (a) Amalgam blisters which were created by an accumulation of hydrogen gas under surface of restoration. Blister on left of inset was opened and found to be hollow, (b) Delayed expansion in amalgam. Four brands of alloy containing 0.45 to 1.0 per cent zinc were contaminated with varying amounts of physiological saline solution. A, B, C, and D were controls. All contaminated specimens produced gross expansion within one month, and (c) Soft, powdery amalgam which results from inadequate mercury removal during condensation or follows moisture contamination.

Finish of restoration

Many flaws which gradually become apparent in amalgam may be attributed to methods employed in finishing restorations after their placement. All dentists realize that some of these flaws eventually become failures. Caries recurrence may result under the shelter of marginal excess which could have been dressed to the margins in a cautious finishing procedure. Many flakes and spur-like overhangs fracture from the restoration sooner or later and leave susceptible crevices in vulnerable areas of the tooth surface. The results of these marginal amalgam fractures, and those which culminate from cavosurface beveling, often are erroneously mistaken as being the results of abnormal amalgam expansion (Figure 5a).

Larger fractures will lead to failures in amalgam where the zealous operator overcarves a restoration in an attempt to replace normal, anatomic features in the restoration. Unless adequate resistance form compensates for this weakening, the trauma of mastication will destroy beautifully carved but impractical restoration.

The problem of tarnish and corrosion of a restoration is usually one that is controllable, on condition that care is taken in the preparation, placement and finish of the amalgam. If a cautious, thorough trituration is accomplished and this is followed by an effective condensation, the resulting amalgam is assured of being a homogeneous mass. Uncoated alloy particles, cracks or voids, and a mercury rich, soft amalgam will lead to a restoration that resists polish and readily tarnishes or corrodes. Amalgams which may have been contaminated in placement will present a well-polished surface in the early days after placement. However, this surface eventually changes and an irreparable pitting by corrosion results. Its polish can never be regained.

It has been noted that the well prepared and placed amalgam can resist tarnish efficiently if it is polished as soon as it is hard enough and then kept polished (Figure 5b). Eomes and others [21] have warned against injudicious polishing. When such procedures produce temperatures above 65°C (140°F), mercury is released from the amalgam to produce weakened or defective regions. If these results at margins they may ultimately invite caries recurrence.

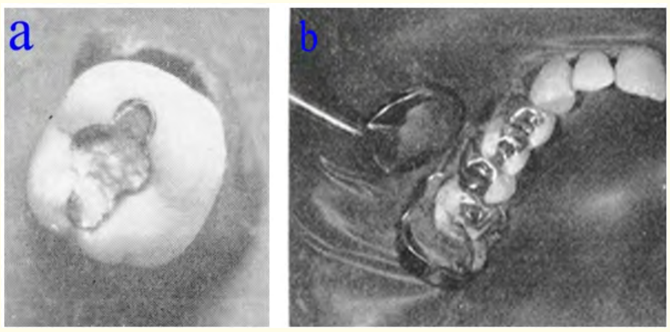

Figure 5: (a) Ditching due to fractures of untrimmed excess over margins, or of weakened edges over beveled cavosurface margins and (b) Resistance to tarnish and corrosion is greater with well-condensed, uncontaminated and well-polished amalgam restorations.

Summary

Amalgam restorations are capable of developing countless minor defects, and when these become failures may lead to the eventual loss of teeth. Other failures seem to be born shortly after the placement of the restoration, having been created by gross shortcomings in the preparation of the cavity or by misjudgment in its indication for use. It is unfair to direct criticism of these failures to amalgam without awareness of its intrinsic shortcomings or inadequacies. Instead, it is obligatory to aim evaluation of amalgam to the dentist's skill in attaining the maximum results from its numerous potentials. Its success or failure rests in the hands of professional experts.

Conflict of Interests

No conflict of interest exists.

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