Amalgamski ili kompozitni ispun?

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Sažetak

Budući da materijali za naknadu tvrdoga zubnog tkiva dolazi u izravan doticaj s oralnim tkivom, moraju biti inertni i biokompatibilni, neštetni za pulpu i meka tkiva te ne smiju sadržavati toksične sastavnice koje bi se otpuštanjem apsorbirale u krvožilni sustav te tako uzrokovale toksične i alergijske reakcije. Brz razvoj novijih generacija kompozitnih materijala sve više istiskuje dentalne amalgame iz uporabe. Prednosti dentalnih amalgama jesu iznimna otpornost spram djelovanja žvačnih sila, jednostavna primjena u ambulantnim uvjetima i pristupačna cijena. Nedostatci su mu neprirodnost boje, dimenzijske promjene i moguća toksičnost. Unatoč izvrsnim estetskim svojstvima, degradacija kompozitnih materijala prvenstveno je povezana s nedostatnom polimerizacijom materijala. Trajnost im je uvjetovana homogenošću strukture, tehnikom priprave kaviteta i postavljanja kompozitne smole u kavitet, završnom obradom i izloženošću žvačnom tlaku. Najbolje su rješenje za rekonstrukcije u području prednjih zuba i alternativa su amalgamu za ispune u području stražnjih zuba.

Ključne riječi: *dentalni amalgami, kompozitni materijali*

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Uvod

Materijali za naknadu tvrdoga zubnog tkiva mogu se podijeliti na dvije osnovne skupine:

- materijali za izravne ispune i
- materijali za neizravne ispune (inlay, onlay, overlay).

Materijali za izravne ispune dijele se na:

- metalne ispune i
- ispune koji odgovaraju boji zuba, a dalje se dijele na:
  - konvencionalne staklene ionomere
  - visoko viskozne staklene ionomere
  - smolom modificirane staklene ionomere
  - kompomere
  - kompozite (uključujući dentinske adhezive) (1).

Amalgam kao materijal za ispune upotrebljava se više od 150 godina. Njegova uporaba zahtijeva opsežniju preparaciju kaviteta nego noviji materijali za ispune koji se adhezijski svezuju za zub. Iako mu boja nije prilagođena zubu, ekonomski je povoljan i lagan za uporabu.

Sveza za jetkanu caklinu i dobro inicijalno rubno svezivanje te štednja tvrdoga zubnog tkiva tijekom preparacije kaviteta svojstva su kompozitnih smola. Kao materijal za ispun pokazuju mnogo bolju estetiku od amalgama i stakleno ionomernih cemenata, slabi su vodiči topline, ali je klinička izradba zahtjevnija od rada s amalgamom. Osim toga, kada se odstranjuje stari kompozitni ispun, zbog nerazlikovanja njegove boje od boje zuba moguće je i da se odstrani zdravo zubno tkivo.

Idealan materijal za naknadu tvrdoga zubnog tkiva trebao bi zadovoljavati sljedeća svojstva:

- biokompatibilnost
- jednostavno rukovanje
- brzo i točno finalno oblikovanje bez destrukcije ostatka zubne supstance
- otpornost na tlak jednaku kao u cakline
- visoku količinu otpuštanja iona
- dugotrajnu svezu s vitalnim zubnim tkivom
- dimenzijsku stabilnost pod utjecajem žvačnoga tlaka
- dugotrajnu stabilnost (bez skupljanja, bez apsorpcije vode)
- radioopaknost veću od cakline
- adekvatnost boje i transparenciju (1,2).

Niti jedan od danas postojećih materijala za izravne ispune ne zadovoljava potpuno sve ove uvjete. Noviji kompozitni materijali dominantni su materijali za ispune u području prednje regije i visoko vrsna zamjena za amalgame u području stražnjih zubi.

Dentalni amalgami

Dentalni je amalgam slitina žive s jednom ili više kovina i do sada najčešće upotrebljavan materijal za naknadu tvrdoga zubnog tkiva. Naziv mu potječe od grčkih riječi *a* = ne i *málagma* = smekšati.

Prvi zapisi o amalgamu postoje već u kineskoj literaturi dinastije Tang. Naziv "amalgam" prvi je uveo godine 1528. Stocker i ujedno dao prvi pisani zapis o njemu. Godine 1895. Greene Vardiman Black preporučio je slitinu koja je sadržavala 65% Ag s manjim količinama Sn, Au, ili Cu i Zn. On je opazio kako sastav amalgama i način rukovanja utječu na njegovo stvrdnjavanje, kontrakciju i ekspanziju. Počekom 20. st. uvodi se u uporabu tzv. "bakreni amalgam", a 1963. godine Innes i Yondelis opisuju novu tzv. "non-gama$_2$" generaciju dentalnih amalgama (3).

Kada je amalgam godine 1833. uveden u uporabu u SAD-u, zbog slabe je kakvoće i nedostatne spoznaje o potrebnom sastavu, uporabi i toksičnosti žive, izazvao snažan otpor i podijelio tamnošnje stomatološke krugove. Zato je godine 1845. Američko društvo stomatologa zabranilo uporabu zubnih amalgama, i to tzv. "prvi amalgamski rat" koji je trajao otkako se počeo upotrebljavati u SAD-u do Townsaeda, Flagga i Blacka koji su uvelike poboljšali sastav i način rukovanja amalgamom. "Drugi amalgamski rat" počeo je u Europi tekstovima Alfreda Stocka, a "treći amalgamski rat" 1979. godine kada su Guy i suradnici u slini pacijenata s amalgamskim ispunima, nakon žvakanja, našli živine pare (4).

Podjela zubnih amalgama

1. Prema količinskom udjelu bakra dvije su osnovne skupine amalgama:
   - konvencionalni zubni amalgami - sadrže do 3% Cu
   - zubni amalgami s visokim udjelom bakra - gotovo potpuno uklanjanje gama$_2$ faze. Dijele se na:
     - miješane amalgamske slitine (oko 9% Cu)
     - zubne amalgame s visokim udjelom bakra (oko 28% Cu; uopće se ne stvara gama$_2$ faza).
2. Prema obliku čestica zubni amalgami dijele se na:
   - krhotinaste (strugotine)
   - kuglaste (sferične)
   - miješane
   - ovalne (sferoidne).

Svojstva zubnih amalgama

Kao mjeru kakvoće zubnih amalgama ADA (Americam Dental Association) specifikacija No I propisuje tri fizikalna svojstva:

1. Tečenje zubnih amalgama

Maksimalno dopušteno tečenje je 3%, a predmnijeva promjenu amalgama u dužinu pod određenim tlakom u određenom vremenu (izražena u postotcima).

2. Otpornost na tlak

Nakon jedan sat trebala bi iznositi 8 MPa, a može biti smanjena zbog:

- visokog udjela žive
- nedostatne amalgamacije
- polaganog stavljanja ispuna
- nedostatnog nabijanja amalgama
- korozije.

3. Promjena dimenzije

Nakon kontrakcije zubnih amalgama u prvih 20 minuta, koja je posljedica otapanja žive, slijedi ekspanzija, a nakon 6 do 8 sati dimenzija postaje konstantna (5).

Ostala svojstva zubnih amalgama

• *Rubna pukotina*

Rubna pukotina nastaje više kod konvencionalnih nego kod non-gama$_2$ zubnih amalgama. Ima oblik slova V, što je prvi opazio Jorgensen koji smatra da ona nije posljedica otapanja kovine nego lokalizirane ekspanzije žive, kao posljedica korozije gama$_2$ faze. Pukotine se tijekom vremena smanjuju jer se pune korozijskim produktima (3).

• *Toplinska provodljivost*

Zubni amalgam dobar je vodič topline pa se dentin i pulpa moraju zaštititi odgovarajućim sredstvima.

• *Toksičnost zubnih amalgama*

Pod toksičnošću se uglavnom misli na citotoksičnost žive. Čestice srebrnog amalgama sadrže elementarni oblik žive koja se prigodom gutanja slabo resorbira iz crijeva i izlučuje se mokraćom. Cu, Zn i Hg pokazuju visoku citotoksičnost, Ag srednju, a Sn i prah dentalnog amalgama nisu citotoksični.

85-90% žive u organizmu potječe iz hrane, a tek neznatni dio 10-15% od amalgamskih ispuna. Alergijske reakcije na živu izražene oralnim simptomima ili kožnim reakcijama su rijetke (6).

Čimbenici pri oštećenju amalgamskog ispuna

Najvažnijim čimbenicima pri oštećenju amalgamskih ispuna smatraju se elektrokemijska korozija i mehaničke sile te njihov sinergistički učinak.

Korozija je nagrizanje kovina, oštećenje njihova površinskog i podpovršinskog sloja, a uzrok su joj kemijske reakcije i elektrokemijska zbivanja. Gama$_2$ faza (Sn_8Hg) jedan je od glavnih čimbenika korozije. Disocijacijom Sn_8Hg oslobađa se živa koja reagira s nereagiranim česticama gama faze (Ag_3Sn), stvara novu gama$_2$ fazu, a kositar se spaja s kisikom, odnosno klornim ionima i stvara korozijske spojeve. Korozija smanjuje otpornost amalgamskog ispuna na tlak i time skraćuje trajnost ispuna (4,7).

Trošenje amalgamskog ispuna posljedica je zajedničkog učinka korozije i mehaničkih sila, jer zbog korozije oslabljeni ispun lakše puca.

Kompozitni materijali

Kompozitne smole (KS) predstavljene su u ranim 70-tim godinama. Primarno su proizvedene kao restorativni materijal za prednje zube. Do uporabe vidljiva svjetla za stvrdnjavanje KS-a u tu se svrhu rabilo UV svjetlo. Postignuća u strukturi punila i matriksa poboljšala su mehanička svojstva (veća rezistencija na abraziju, koeficijent termičke ekspanzije i dimenzijske promjene tijekom stvrdnjavanja su manje) (8).

Najčešće rabljeni oligomeri u kompozitnim materijalima (KM) jesu Bis-GMA (bisfenol A-glycidil methacrylate) i UDMA (urethane dimethacrylate). Slični su po tome što sadrže reaktivne dvostruke sveze na svakom kraju i time mogu podleći radikalnoj polimerizaciji. Visoko su viskozni tako da moraju biti razrijeđeni kako bi se postigla klinički uporabiva konzistencija. Nisko molekulske sastavnice s difunkcijskim dvostrukim svezama obično TEGDMA (triethylene glycol dimethacrylate), dodaju se kao razrjeđivači (9).

Dispergirana anorganska faza može se sastojati od nekoliko anorganskih sastavnica, kao što su:

- pirogeni silicij dioksid (s veličinom čestica između 0,002 - 0,04 μm)

- mikrofino barijevo- ili stroncijevo-silikatno staklo
- fine čestice kvarca
- cirkonij-dioksidno staklo
- ytrij- ili yterbij-trifluorid.

Količina anorganskog punila čini KM radioopaknim. Anorganska faza obrađena je organosilanom prije miješanja s nereagiranim skupinama niskomolekulskoga polimera (oligomer). Organosilani sadrže funkcijske metoxy grupe koje hidroliziraju i reagiraju s anorganskim punilom kao i nezasićene organske grupe koje reagiraju s oligomerom tijekom polimerizacije. Ti se organosilani zovu "*coupling agents*", jer formiraju svezu između organske i anorganske faze KM. Proces silanizacije odgovoran je za hidrofobnost anorganskog punila.

Najlakši način razvrstavanja KM je prema veličini čestica, obliku i distribuciji punila. Prema tome kriteriju danas se KM mogu podijeliti na one s:

- klasičnim makropunilom,
- mikropunilom i
- hibridne KM.

Makropunila su iregularne čestice stakla ili kvarca približno jednakoga promjera. Čine 60-70% volumnog udjela ili 77-80% težinskog udjela punila.

Mikropunilo je najvećim dijelom pirogeni silicij dioksid (100-300 m^2/g) i čestice promjera 0,04-0,2 μm. Imaju 25% volumnog ili 38% težinskog udjela anorganskog punila, što ih čini nepogodnim za kliničku uporabu. Zato su punila od mikrofine silice u polimeriziranom oligomeru preparirana u čestice veličine 10-20 μm i dodana oligomeru tako da anorganski udio naraste na 32-50% volumnog ili 50-60% težinskog dijela.

Hibridni kompozitni materijali sadrže različite veličine čestice anorganskoga punila u količini i do 70% volumena. Dijele se na tip I i tip II. **Tip I** sadrži pirogeni silicij dioksid kao punilo u količini do 15% težinskog udjela i mikrofino staklo (barij-stroncij silikat ili cirkonij dioksid staklo) do 80% težinskog udjela ili fine čestice kvarca (do 60% težinskog udjela). **Tip II** sadrži pirogeni silicij dioksid (do 40% težinskog udjela) i ytrij- ili yterbij trifluorid (do 40% težinskog udjela), ali bez mikrofinih čestica stakla (10,11).

Svojstva kompozitnih materijala

• *Polimerizacijsko skupljanje*

Polimerizacija KM može biti inicirana kemijski ("autocured") peroksidnim inicijatorom i/ili aminskim akceleratorom ili može biti fotoinicirana vidljivim plavim svjetlom valne dužine 468 nm zahvaljujući svjetlosno osjetljivom apsorberu kao što je kamforkinom ili akceleratora kao što je alifatski amin. Polimerizirana smola je visoko unakrsno povezana zbog postojanja difunkcijske ugljikove dvostruke sveze. Stupanj polimerizacije varira ovisno o debljini slojeva, inhibiciji zrakom, udaljenosti materijala od izvora svjetla, vremenu ekspozicije i jakosti izvora svjetla. Stupanj dvostrukih sveza koje reagiraju iznosti 35-80%.

Polimerizacijsko skupljanje u izravnoj je svezi s količinom oligomera i razrjeđivača. Skupljanje proizvodi polimerizacijski stres od oko 130 kg/cm^2 između KM i stijenke zuba te je uzrokom odvajanja materijala od stijenki kaviteta i nastanka mikropukotine. Taj stres može nadjačati snagu otpornosti cakline na tlak i rezultirati napuknućima i frakturama caklinske površine uz rubove ispuna. Što je veći udio polimera veće je i skupljanje, a negativne posljedice toga mogu se donekle izbjeći osvjetljavanjem iz dva izvora svjetlosti, primjenom "softstart" polimerizacijskih žarulja, pulsnim laserom, plavim visokosjajnim svijetlećim diodama te slojevitim nanošenjem i polimerizacijom KS (12, 13,14,15,16).

• *Termička svojstva*

Termička vodljivost veća je kod onih KM koji imaju veći udio anorganskog punila jer je veća vodljivost anorganske faze u usporedbi s polimernim matriksom.

• *Apsorpcija vode*

Apsorpcija vode veća je kod onih materijala koji imaju veći udio polimera u usporedbi s anorganskim dijelom. Makropunila apsorbiraju vodu 0,3--0,6 mg/cm^2, a mikropunila 1,2-2,2 mg/cm^2 i time više ekspandiraju pri izloženosti vodi (10).

• *Topljivost*

Topivost u vodi varira od 0,01-0,06 mg/cm^2. Neadekvatno polimerizirana smola pokazuje veću topivost i apsorpciju vode, što se klinički može manifestirati vrlo ranom diskoloracijom ispuna (10).

- ***Mehanička svojstva***

Mehanička svojstva bolja su kod KM s većim udjelom anorganskog punila. Tvrdoća kristala punila ne bi smjela prelaziti tvrdoću kristala hidroksilapatita koja iznosi 3,39 GPa u ljudskoj caklini. KS namijenjene uporabi za stražnje zube trebale bi imati modul elastičnosti jednak ili veći od modula elastičnosti zuba. Kod KM s malim modulom elastičnosti zbog mehaničke deformacije nastaje rubno pucanje materijala. Čvrstoća i tvrdoća materijala utječu na njegovu otpornost na trošenje i ovise o vrsti i količini anorganskih čestica.

- ***Radioopacitet***

Tipična punila: kvarc, litij aluminij staklo, silica, nisu radioopakni. Kao standardna referenca za radioopaktnost uzeta je količina aluminija (1).

- ***Biokompatibilnost***

KM potencijalni su iritansi i kod dubljih se kaviteta preporučuje uporaba kalcij-hidroksida i stakleno-ionomernog cementa ili dentinskih adheziva.

- ***Boja***

Osim važnog utjecaja na estetska svojstva, o boji ovisi i dubina prodora svjetla tijekom polimerizacije (KM svijetlijih nijansi bolje propuštaju svjetlo od tamnijih nijansi).

- ***Citotoksičnost***

In vitro eksperimenti pokazuju da su nestvrdnute sastavnice KS citotoksičnije od stvrdnutih. Ipak, stvrdnjavanjem vidljivim svjetlom i slojevitom tehnikom aplikacije KM postignuta je manja iritabilnnost pulpnoga tkiva. Citotoksičnost monomera opada tijekom polimerizacije i nakon potpune polimerizacije postaje netoksičan. Iritacija pulpe povezana s kompozitnim ispunom može se pripisati toksičnosti materijala ili prodoru bakterija kroz pukotine nastale zbog polimerizacijskoga skupljanja. Ovaj prvi uzrok danas se gotovo potpuno isključuje. Ipak, tijekom vremena odgovor pulpe opada (17,18).

- ***Postoperativna preosjetljivost***

Postoperativna preosjetljivost može biti prouzročena jakim skupljanjem KS tijekom polimerizacije pri čemu nastaje stres i, kao posljedica toga, adhezijske frakture između površine zuba i smole ili kohezijske frakture u samome materijalu, caklini ili dentinu.

- ***Sveza sa strukturama zuba***

Sveza KM za jetkanu caklinu kreće se između 100-200 MPa. Adhezija je rezultat mehaničke retencije polimernoga matriksa ili svezujućeg spojnog sredstva u nabranu površinu jetkane cakline. Za razliku od cakline, da bi se postigla odgovarajuća sveza s dentinom nužno je rabiti dentinske adhezive (19).

Zaključak

Čini se da zbog stalnog poboljšanja fizičko-mehaničkih svojstava kompozitnih smola sam materijal nije presudan za kliničku trajnost ispuna, već glavnu ulogu preuzima tarapeut svojim znanjem i načinom manipulacije materijalom. Za dobar kompozitni ispun vrlo je važna dostatna konverzija uz minimalni polimerizacijski stres, što je povezano s izborom izvora svjetlosti, kompozitnog materijala, pripravom kaviteta i slojevitom aplikacijom.

Uzimajući u obzir navedene čimbenike, kompozitni ispuni u području stražnjih zuba postaju jednako vrijedni kao i amalgamski.

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Dental Amalgam or Composite Resin Filling?

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Summary

Restorative materials which come in to close contact with oral tissue should be inert and biocompatible, they should not damage the pulp or soft tissue and should not consist of toxic components which can be absorbed in to the circulatory system and consequently cause toxic and allergic reactions. The fast development of new dental composites has decreased the use of dental amalgam. However, the advantage of dental amalgam is its very good resistance to masticatory forces, simple use in clinical conditions and available price. The disadvantage of amalgam is its unnatural colour, dimensional changes and possible cytotoxicity. Despite excellent aesthetic properties composite degradation depends on the degree of conversion. The longevity of composites is conditioned by homogeneous structure, by the cavity preparation, application of the resin in the cavity, finishing and polishing as well as exhibiting masticatory forces. They are the appropriate solution for reconstruction in the frontal region and also an alternative to amalgam for fillings in the posterior region.

Key words: *dental amalgam, composite resins*

Introduction

Materials for hard tissue replacing can be divided in two main groups:

- materials for direct fillings
- materials for indirect fillings (inlay, onlay, overlay).

Materials for direct fillings are divided into:

- metal fillings
- tooth coloured fillings which are divided into:
  - conventional glassionomers
  - high viscosity glassionomers
  - resin reinforced glassinonmers
  - compomers
  - composites (including dentine adhesives) (1).

As a filling material thas been amalgam is in use for more than 150 years. Its use requires a larger cavity preparation than the new dental materials, which assume adhesive bonding to the tooth. Although it has inadequate colour, it is very economical and simple to use.

Composite resin characteristics are bonding to the etched enamel and good initial marginal adaptation, as well as saving of hard tooth tissue during cavity preparation. As a filling material they show better aesthetics than amalgam or glassionomer cement and are bad thermal conductors. However, clinical treatment is complicated compared to amalgam. Furthermore, the surrounding healthy hard tooth tissue could be damaged by the removal of the old composite filling.

Optimal material for hard tooth tissue replacement should ensure the following properties:

- biocompatibility
- simple handling
- quick and exact final forming without destruction of the remaining hard tooth tissue
- occlusal resistance like that of enamel
- ions realising
- durable bond with vital tooth tissue
- dimensional stability by exposition to mastication forces
- durable stability (without shrinkage and water absorption)
- radioopacity higher than enamel
- appropriate colour and transparency (1,2).

There are no dental materials which posses all of these properties. New composite materials are the material of choice in the frontal region and as an alternative for amalgam fillings in the posterior region.

Dental amalgam

Dental amalgam is an alloy composed of a mixture of approximately equal parts of elemental liquid of mercury and an alloy powder and until today is has been the most used material for replacing lost hard tooth tissue. Its name comes from the Greek words "a = *no*" and "málagma = *soften*".

The first report on amalgam came from the Chinese dynasty Tang, and in 1528 Stocker first introduced the name "amalgam" and first wrote about it. In 1895 Greene Vardiman Black recommended a mixture which consisted of 65% Ag with less amount of Sn, Au, or Cu and Zn. He noticed that the amalgam composition and manipulation technique influenced its hardness, contraction and expansion. At the beginning of the 20th century so-called "copper amalgam" was introduced, and in 1963 Innes and Yondelis described a new so-called "non-gama$_2$" generation of dental amalgams (3).

In 1833 amalgam was introduced in USA, which caused strong disagreement because of the insufficient knowledge of the composition, use and toxicity of mercury. Therefore, in 1845 the American Dentists Society prohibited the use of dental amalgam which was known as the "first amalgam war" which lasted from the introduction amalgam in the USA until Townsaed, Flagg and Black improved the composition and handling properties of amalgam. The "second amalgam war" began in Europe with texts by Alfred Stock, while the "third amalgam war" began in 1979 when Guy et al found mercury steam in the saliva of patients with mercury fillings after mastication (4).

Dental amalgam division

1. According to the amount of copper there are two main groups of amalgam:

- conventional dental amalgams consist of about 3% Cu
- dental amalgams with a high amount of copper - almost completely remove of gama$_2$ phase. They are divided into:
  - amalgam alloy mixtures (about 9% Cu)
  - dental amalgams with a high amount of copper (about 28% Cu; almost without gama$_2$ phases).

2. According to particle shape dental amalgams are divided into:

- scraped
- spherical
- mixture
- oval.

Properties of dental amalgam

As the degree of quality of dental amalgams the ADA (American Dental Association) specification No I described three physical properties:

1. Dental amalgam flow

Maximal allowed dental amalgam flow is 3%, i.e. amalgam change in length under particular pressure in a particular time (expressed in percentages).

2. Pressure resistance

It should be 8 MPa after 1 hour, and could be decreased because of:

- high mercury percentage
- inadequate amalgamation
- filling application to slow
- insufficient amalgam condensation
- corrosion.

3. Dimensional changes

The contraction of dental amalgams in the first 20 minutes, which comes as a consequence of mercury solubility, is followed by expansion, and after 6-8 hours the dimension became constant (5).

Other properties of dental amalgam

- ***Marginal leakage***

Marginal leakage occurs more often by conventional than by non-gama$_2$ dental amalgams. It has the letter V shape which was first described by Jorgensen who suggested it was a consequence of local mercury expansion, which is a result of gama$_2$ phase corrosion, and not metal dissolving. Leakage decreases in time as they become filled by corrosion products (3).

- ***Heat conductivity***

Dental amalgam is a very good heat conductor which means that dentine and pulp should be adequately protected.

- ***Dental amalgam toxicity***

The toxicity of mercury is often considered. Amalgam particles contain elementary mercury, which is wery weakly absorbed after swallowing and is excreted through urine. Cu, Zn and Hg show high cytotoxicity, Ag middle and Sn and dental amalgam powder are not cytotoxic. 85-90% of mercury in the organism originates from food, and only 10-15% from amalgam fillings. Allergic reactions to mercury, expressed as oral symptoms or skin reactions are very rare (6).

Factors influencing damage by amalgam fillings

The most important factors which influence damage by amalgam fillings are electrochemical corrosion and mechanical forces and their synergetic effect.

Corrosine etching of metal, damage to the surface and subsurface layer and is caused by chemical electrochemical reactions. Gama$_2$ phase (Sn_8Hg) is one of the most important factors of corrosion. Sn_8Hg dissociation brings mercury free and thus enables reaction with unreacted gama phase (Ag_3Sn) particles forming a new gama$_2$ phase. Sn connects with oxygen or Cl-ions and forms corrosive products. Corrosion decreases amalgam filling resistance and therefore diminishes the longevity of the filling (4,7).

Amalgam filling wear is a consequence of corrosion and mechanical forces and due to the corrosion the poor filling breaks easily.

Composite materials

Composite resins were introduced in the early 1970 s. They were primarily produced for use in the frontal region. Until visible light was introduced for composite resins polymerization, UV-light was used. Fast development in matrix and filling structure enables better mechanical properties (higher abrasion resistance, lower thermal expansion and dimensional changes during the setting process) (8).

The most often used oligomers in composite materials are Bis-GMA (bisfenol A-glycidil methacrylate) and UDMA (urethane dimethacrylate). Both consist of reactive double bonds on each side and can be exposed to radical polymerization. They posses high viscosity and therefore have to be diluted to achieve clinically satisfactory consistence. Low molecule components with difuntional double bonds, usually TEGDMA (triethylene glycol dimethacrylate), are given as diluting agents (9).

Dispersive inorganic phase consists of several components such as:

- pyrogen silicium dioxide (with particle size 0.002-0.04 μm)
- microphil barium - or strontium silicate glass
- fine quartz particles
- zirconii-dioxyde glass
- yttrium- or ytterbium-trifluoride.

The amount of inorganic filler makes the composite materials radioopaque. Inorganic phase is modified by organosilane before mixing with unreacted low molecule polymer (oligomer) groups. Organosilanes consist of functional metoxy groups which hydrolyse and react with inorganic filler as well as unsaturated organic groups which react with oligomer during polymerization. These organosilans are called "*coupling agents*", because they form a bond between the organic and inorganic phase of the composite material. Silanization process is responsible for inorganic filler hydrofobity.

The simplest way to divide composite materials is according to the size, shape and distribution of filler particles. According to this criteria composite materials can be divided into:

- composite macrofilled materials
- composite microfilled materials
- hybrid composite materials.

Composite macrofilled materials contain irregular particles of glass or quartz of similar diameter. They make 60-70% of volume or 77-80% of filler weight.

Composite microfilled materials consist mostly of pyrogen silitium dioxide (100-300 m^2/g) with particle size from 0.04 to 0.2 μm. They have 25% by volume or 38% by weight of inorganic filler what make them unsuitable for clinical use. Therefore, fillers of microfine silica are prepared in polymerized olygomer of particle size 10-20 μm and added to oligomer and the inorganic part rises to 32-50% by volume or 50-60% by weight.

Hybrid composite materials consist of inorganic filler particles of different size, amountinf to 70% by volume. They are divided into **Type I** and Type II. Type I consists of pirogen silicium dioxide as a filler amounting up to 15% by weight and microfine glass (barium-strontium silicat or zirconii dioxide glass) up to 80% by weight or fine particle quarz (up to 60% by weight). **Type II** consists of pyrogen silitium dioxide (up to 40% by weight) and yttrium- or ytterbium- trifluoride (up to 40% by weight) but without microfine particle glass (10,11).

Properties of composite materials

• *Polymerization shrinkage*

Composite materials polymerization may be initiated chemically ("autocured") by peroxide initiator and/or amine accelerator or may be photoinitiated by visible blue light of the wavelength of 468 nm in the presence of photocurable absorber such as camforquinone or accelerators such as aliphatic amine. Polymerized resin is highly crosslinked because of the presence of difuncional carbon double bonds. The degree of conversion varies depending on the layer of thickness, oxygen inhibition, distance between the material and light source, exposition time and light source intensity. The degree of reacted double bonds is 35-80%.

Polymerization shrinkage is connected with the amount of olygomer and diluting agents. Shrinkage produces polymerization stress of about 130 kg/cm^2 between the composite material and tooth tissue what causes separation of the material from the cavity walls and consequently microleakage. This stress may be stronger than enamel resistance to pressure and as a result it could possibly lead to enamel fractures near the filling borders. Higher concentration of polymer leads to higher shrinkage, and negative consequences could be avoided by curing from two light sources, or using "soft-start" polymerization, pulsed laser or blue super-bright light emitting diodes as well as by incremental placement and polymerization of composite resins (12,13,14,15,16).

• *Thermal properties*

Thermal conduction is higher in composite materials which contains more inorganic filler because conductivity of the inorganic phase is higher than the organic.

- ***Water absorption***

Water absorption is higher by those materials which have more polymer than inorganic particles. Macrofillers absorb water 0.3-0.6 mg/cm^2, while microfillers 1.2-2.2 mg/cm^2 and expand more when they are exposed to water (10).

- ***Solubility***

Solubility in water varies from 0.01 to 0.06 mg/cm^2. Inadequately polimerized resin shows higher solubility and water absorption what could clinically be manifested as early filling discoloration (10).

- ***Mechanical properties***

Mechanical properties are better in composite materials with more inorganic filling. The Hardness of the filling chrysalis should not be greater than the hardness of hydroxilapatite chrysalis which is 3.39 GPa in human enamel. Composite resins for posterior filling should have the same or higher modulus of elasticity than the module of elasticity of the tooth. In composite materials with low modulus of elasticity fractures occur because of mechanical deformations. Hardness of the material depends on the size, shape and inorganic particle distribution.

- ***Radioopacity***

Typical fillings: quartz, silica, are not radioopaque. Standard reference for radioopacity is the amount of aluminium (1).

- ***Biocompatibility***

Composite materials are potential irritants and in a deeper cavity Ca-hydroxide and glassionomer cements or dentine adhesive should be used.

- ***Colour***

Apart from the very important influence of aesthetics, colour is an important factor for light penetration during polymerization (composite materials of darker shades absorb more blue light than light shades of composites).

- ***Cytotoxicity***

In vitro experiments showed that unpolymerized component of composite resins are more cytotoxic than polymerized components. However, using visible light and incremental technique composite materials become less irritable for pulp tissue. Monomer cytotoxicity decreases during polymerization and after the optimal polymerization it is not toxic. Pulp irritation is mostly caused by bacteria invasion through the microleakage and not toxicity of the material. However, response of the pulp decreases in time (17,18).

- ***Postoperative sensitivity***

Postoperative sensitivity may be caused by composite resin shrinkage during polymerization and as a consequence, adhesive fractures between the tooth surface and resin or cohesive fractures in the material, dentine or enamel may occur.

- ***Bonding to the tooth structure***

Composite material bonding to etched enamel is 100-200 MPa. Adhesion is a result of mechanical retention of polymer matrix or bonding agents to the etched enamel. To achieve adequate bonding with dentine, dentine adhesive should be used (19).

Conclusion

Today, because of the better physical and mechanical properties of composite resins, the most important factor for clinical filling durability is handling of the material and knowledge of the dentist. For good composite filling adequate conversion with low polymerization stress is most important, which is connected with the choice of light source, composite material, cavity preparation and incremental placement.

When all of these factors are taken into account, composite fillings in the posterior region are as good as amalgam fillings.