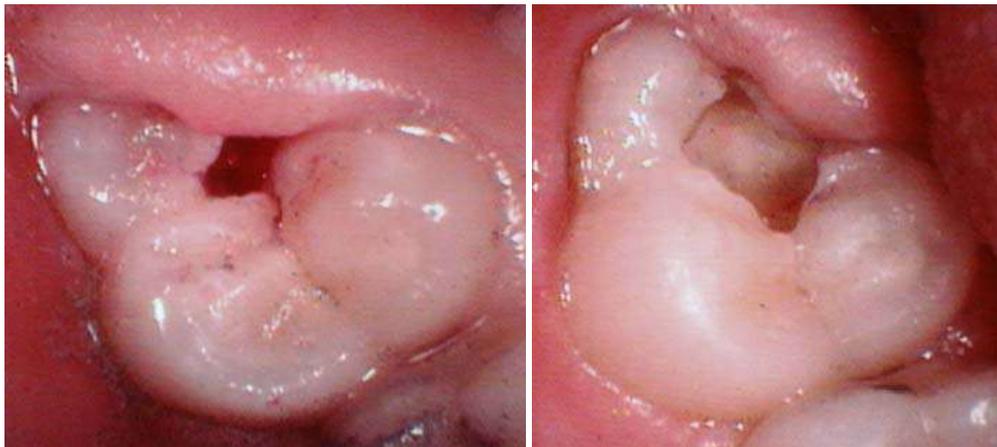


Continuing with how new technologies have impacted into routine care, Julian Holmes looks at one area of dental care that can be difficult and frustrating for both practitioners and patients alike – the erupting molars that come through with active caries already on the go. Here Julian looks at the research that has looked at aspects of this type of decay, and proposes a simple and effective treatment modality. It is one that you can put into every day practice after reading this article!

**Independent Seminars are running an all-day meeting in London.** Dr Amarjit Gill, Prof Edward Lynch and Dr Tracey Bell will be exploring how dental care is changing and how it may look in 2020. Professor Lynch will be presenting some of the recent research into the use of ozone at this meeting, and the course can be accessed with this link;

[http://www.independentseminars.co.uk/content/seminars\\_detail.php?id=1835](http://www.independentseminars.co.uk/content/seminars_detail.php?id=1835)

## Treating the Partially Erupted Dentition



**Fig 1&2.** Partially Erupted Molars Showing Caries. Images used with permission

### Prevention of Caries

Infection prevention is the ultimate goal of every clinician and health care worker – be they medical, dental or veterinary. Dental caries can be considered an infection, albeit a very complex one, involving over 450 different species of bacteria and tooth surfaces in a mature active lesion. Research has shown that the majority of topically and systemically applied anti-microbials do not work effectively, as the colonization of the tooth surface develops an outer protein layer called the pellicle. The pellicle prevents anti-microbials from attacking the bacterial colonies, and thus accelerating the establishment of the acid niche environment.

Research has shown that caries up until now has been; poorly diagnosed; involves amputation or ‘drill n’ fill’; poorly accepted by public; the public ‘expect’ a filling if they have decay; restorative care has been characterized by being poorly executed by dentists; the average filling lifetime is low;

Dentists 'expect' to drill a hole and fill it; that is after all what the dental institutions around the world still continue to teach, resulting in increasing spiral of costs to managed and privately funded dental health care. The end result is larger, more complex and costly restorative care. Ultimately this is often followed by the requirement for root canal therapy to attempt to save the dead tooth and/or extractions.

Studies have shown that due to the chemical immaturity of the newly erupted enamel, almost all molar occlusal caries is initiated in this long eruption period, typically from 12 to 18 months. Incisors & premolars have a short eruption period and consequently show a low incidence of caries as discussed by Carvalho *et al* (1989) and Per Axelsson. (2000.)

Bacteria are present in the oral environment and cover all surfaces of teeth. There is a balance of mineral loss and mineral uptake by the tooth surface. The balance is altered by the buffering capacity of saliva, the pH of the saliva, food, drinks; the pH of the 'normal' bacterial community; the oral hygiene status; systemic illnesses; and lastly physical characteristics such as crowded teeth, or the host's decreased ability to perform routine maintenance and oral hygiene. Hygiene plays a major role and is influenced by many factors, often outside the scope of the general dental practitioners control, such as; Patient's choice – avoidance of fluoride tooth pastes or rinses, inability to use floss, or where there is severe crowding, inter-dental brushes cannot be successfully used without causing trauma to the soft tissue.

Where the balance shifts towards acidic pH and debris collection, oral bacteria form a niche environment that leads to predominantly acid forming bacteria. This causes demineralisation of the surrounding enamel, and dentine, leading to the formation of a cavity. The cavity forms a protected environment for this rapidly evolving bacterial colony. Oral hygiene, high-dose fluoride, chlorhexidine, chlorates, do not RELIABLY prevent or reverse caries and this was reviewed by Holmes in 2003.

There are a number of pharmaceutical agents that have been studied that can be used in dental care to reduce or arrest the carious process. It is stressed that there is no one single agent, and caries prevention, arrest and reversal has to be seen in a broader spectrum of professional and at-home care.

Fluoride anion is an agent which has both an anti-plaque benefit, and a direct interaction with teeth and saliva. The first fluoride-containing dentifrice was introduced in 1955, using stannous fluoride. Stamm, Banting, 1980; Brustman, 1986; Burt *et al*, 1986; Hunt *et al*, 1989; Stamm *et al*, 1990 showed fewer root carious lesions in adults benefiting from fluoridated water supplies. Al Joburi, Koulourides, 1984; Teranaka, Koulourides, 1987; Almqvist, Lagerlof, 1993; Wefel *et al*, 1995; ten Cate *et al*, 2001 have proven an increased resistance to the dissolution of root surfaces by immersion in various fluoride concentrations.

Billings *et al*, 1985 found that daily use of a self-applied 1% (w/w) NaF gel in a customised tray for 2 years inhibited new lesions and arrested up to 70% of all incipient and 20% of shallow root carious lesions. Schaeken *et al*, 1991 applied Duraphat to the root surfaces of patients surgically treated for advanced periodontal disease and proved a reduction in the incidence of root caries in the test group.

De Los Santos *et al*, 1994 studied the effect of a chewing gum, which contained 0.1 mg fluoride per stick. After chewing five sticks of the chewing gum daily for 21 days, there were higher degrees of remineralisation and high levels of fluoride than in control lesions.

Chlorhexidine is a bisguanide with broad-spectrum antimicrobial properties (Maltz *et al*, 1981; Kristofferson, Bratthall, 1982; Zickert *et al*, 1982; Schaeken *et al*, 1984; Johnson, Gjermo, 1989; Kidd, 1991; Emilson, 1994; Pizzo *et al*, 2001). There may be some potential problems with anti-microbial agents such as chlorhexidine including the following: The development of resistance in the target micro-organisms, which could become more common with the wider and more frequent use of anti-microbial (Matthijs, Adriaens, 2002); Opportunistic pathogens becoming established as a result of the disruption of the microflora of the oral cavity and the gastro-intestinal tract; Brown staining may appear on the pellicle

and tongue if 0.2% of chlorhexidine digluconate mouthrinse is used twice a day for more than three weeks (Kidd, 1991; Sanz *et al.*, 1994; Addy *et al.*, 1995; Ernst *et al.*, 1998); Chlorhexidine may only be effective on selective micro-organisms (Ayhan *et al.*, 1999; Achong *et al.*, 1999).

These problems make these bisguanides unsuitable for long-term daily use (Lang, Brex, 1986; Marsh, 1992). In conclusion, the use of anti-microbial such as chlorhexidine fails to give a definitive solution for the management of caries.

Silver nitrate (AgNO<sub>3</sub>) is a colourless and crystalline compound. Toolson, Smith (Toolson, Smith 1978) reported that patients with carious lesions who were treated with a fluoride solution and/or silver nitrate had a significant decrease in caries when compared to those who received no treatment.

Klein *et al.*, (1999) compared four pharmaceutical regimes for inhibiting carious lesions for a period of 6 weeks. These agents were silver nitrate, silver fluoride/stannous fluoride, silver diamine fluoride and chlorhexidine. The authors demonstrated that carious lesions treated with either silver fluoride/stannous fluoride or silver nitrate had 29% and 19% less lesion progression, respectively compared to control group.

However, results from silver diamine fluoride and chlorhexidine failed to differ significantly from those in the control group.

So having laid out the problems the dental community face, what is the current and recent research showing the dental team? Recent research suggests the following, and sadly it does not make great reading! Fluoride delays the onset of decay to late teens; Dentists are masters of the process of amputation of the diseased tissue; There are a number of technologies to dismantle and destroy tooth material such as Chemo-Mechanical (Carisolv), air abrasion, diamond and metal burs, and lasers to name a few; The average life-cycle in state-funded dental care is just 12-18 months;

Research shows tooth tissue can remineralise in the right environment, BUT it is unpredictable in general dental practice; There are no studies that show remineralised areas of tooth tissue are subsequently involved in further decay; Research has shown that it is possible to prevent caries; Prevention or improved oral hygiene alone will not arrest or reverse caries predictably (Nyvad B *et al.*, 1986, Papas *et al.* 1999, Holmes 2003).

In the vast majority of dental practices, not just in Europe and the USA, but throughout the world, the primary method to reverse the effects of decay remains 'drill and fill' or dental amputation. The entry of a patient into the cycle of drill and fill is irreversible. Once a hole is drilled into a tooth, the patient always will have it. No matter how good a clinician each dentist perceives themselves to be, any restorative material will fail at some time.

The teeth most at risk were identified by Carvalho *et al.* in 1989. The mixture of the erupting dentition and young children pose a challenge to the dental clinician. The eruption of the complete crown of the dentition into the oral cavity – incisal edges or occlusal surface, except molar teeth, is relatively fast; usually over a period of 4 to 6 weeks for the pre-molar teeth for example.

In comparison, the eruption of molar teeth – both deciduous and permanent – is slow. These teeth can take 6 to 18 months or longer in some cases, to erupt into a position where routine oral hygiene facilitates plaque control and caries prevention. The lower 8's can take years to erupt into position, and often erupt into impacted positions where routine oral hygiene cannot be effective.

The morphology of molar teeth makes them more susceptible to caries initiation in their occlusal fissures. Bagramian *et al.* (Bagramian *et al.*, 1979) observed that permanent first molars in younger children appear to be highly susceptible to caries. The chemistry responsible for this observation was recently discussed by Knight in 2004. Two previous studies by the authors (Bagramian *et al.*, 1976; Bagramian *et al.*, 1978) showed that several preventive methods used in combination could reduce dental caries in children

residing in a fluoridated area. These preventive methods included dental health education, prophylaxis, pit and fissure sealants, topical fluoride and restorative care.

Prophylaxis, sealant and fluoride procedures were repeated every 6 months. Sealants were applied to all fully erupted caries free posterior teeth in the mouth. Supervised toothbrushing, flossing, and use of disclosing agents were carried out in the classrooms. First-year caries increment data in permanent teeth (Bagramian *et al*, 1976) indicated a high degree of success.

A series of papers by Carvalho *et al* (Carvalho *et al*, 1989; Carvalho *et al*, 1991; Carvalho *et al*, 1992) showed that erupting molar teeth are more likely to develop dental caries, due to favourable conditions for plaque accumulation and due to the length of the eruption time.

The occlusal surfaces of partly and fully erupted first right permanent molars were examined with respect to the occurrence and distribution of plaque and dental caries in a group of 57 six- to eight-year-old children (Carvalho *et al*, 1989). Detailed mapping of plaque showed a clear pattern of preferential locations related to the macromorphology of the occlusal surfaces, and revealed reduction in the frequency of thick plaque accumulation in the fully erupted teeth.

This indicated that erupting teeth were more likely to develop dental caries, due to favourable conditions for plaque accumulation. Occlusal surfaces of permanent teeth in children in the treatment group, contrasted to those in children in the comparison group, showed an average reduction in caries of 84%. Three-year results (Bagramian *et al*, 1978) showed a reduction of occlusal caries increments of nearly 73% for both 1st and 6th school grades.

Although at baseline examination there was no statistically significant difference between the two groups in the mean decay, missing and filled (DMF) teeth and surface scores, the difference in mean increments at the end of 3 years was statistically significant (P less than 0.01). Percent reductions in caries increment for permanent first molars in 1st graders were 65.6 for DMF teeth and 66.7 for DMF surfaces. At the end of the 3 year study period, the figures for treated 6th graders was 77.5% in DMFT and 79.2% DMFS as compared to 71% and 58.3% for previously erupted teeth.

In 1991 Carvalho *et al* (Carvalho *et al*, 1991) reported the results of a treatment program designed to control occlusal caries on the basis of intensive patient education and professional tooth cleaning. The sample consisted of 56 6-8-yr-old children with their permanent right first molars in different stages of eruption. Data from the program were compared with previous data recorded in a similar sample of children (Carvalho *et al*, 1989). After 1 yr the majority of children in the study group had their permanent right first molars in full occlusion.

A significant decrease of surfaces with easily detectable plaque and an increase of surfaces without plaque were observed. The proportion of arrested lesions increased and active enamel lesions had decreased. Fissure sealing was only needed in two teeth in contrast to more than 2/3 of molars in a comparable sample of children. This oral hygiene program was judged to be an efficient alternative to fissure sealing in preventing occlusal caries in erupting teeth.

Carvalho *et al* published their 3-year results (Carvalho *et al*, 1992) with the same group of subjects. The control group had fissure sealing (control group) only. After 1 yr a significant reduction of occlusal surfaces with visible plaque was noted in the study group as well as an increased proportion of arrested lesions. These results were maintained after 2 and 3 yr; ten (9%) teeth were sealed and one filled during the study period. Examination of record data in the control group over a 3-yr period revealed that 76 (65%) first molars were sealed and 7 (6%) were filled.

During the first year 1/3 of the children in the study group needed 5-6 recall visits, whereas in the following period all children were only seen 1-4 times in the study period. In contrast, 50% of the

children in the control group needed 5-6 recalls in the 3rd yr. This data indicated that professional care for erupting teeth on an individual basis had a long-term effect on occlusal surfaces. The oral hygiene protocol required less clinical time than the traditional application of sealants.

Treatment in the general dental practice is often required and attempted when a child is brought into a dental clinic in pain. Mansour, Cox described dento-facial pain as a common presentation in general practice (Mansour, Cox, 2006), and more than 50% of cases arise from dentally related pathology. The emotions of anxiety and fear do not lead willingly to co-operation and willing acceptance of treatment (Coriat, 1946; Kleinknecht *et al*, 1973; Freeman, 1991; Freeman *et al*, 2002; Dahnhardt *et al*, 2003; Domingo *et al*, 2004).

These emotions are often echoed or supported by the child's carer or parents who accompany them into the clinic (Freeman *et al*, 2002). Fear has also been shown to be based on previous memory of painful dental treatment (Kleinknecht *et al*, 1973; Freeman, 1991; Freeman *et al*, 2002). Any treatment modality that avoids the need for injections (Moore *et al*, 1996) would therefore be welcomed, provided that treatment was predictable for both the clinician and the patient and carer(s).

Frequently the diagnosis of occlusal caries is less than straightforward. Writing in 1993, Chan found caries does not always appear as a cavity in the tooth, but lay lie beneath intact enamel or on surfaces between teeth (Chan, 1993). Diagnosis in the erupting dentition is made more difficult by the presence of soft tissue flaps, or opercula, or poor access and vision in the distal areas of the dental arch.

The partially erupted tooth presents two opportunistic areas of infection; first the partially covered, protected complex tooth occlusal fissure surface and secondly, the surrounding soft tissue. Segura *et al* presented a case where a periapical radiograph of a partially erupted first molar showed caries (Segura *et al*, 1998). At eruption enamel consists of carbonated apatite crystals that are prone to acid attack, demineralisation and decay (Knight, 2004). Exposure to fluoride from saliva, preventive applications and dentifrices increases the resistance of apatite crystals that form tooth enamel, to decay post-eruption.

Prevention of caries has shown mixed success. Two previous studies using oral hygiene regimes by Bagramian *et al* (Bagramian *et al*, 1976; Bagramian *et al*, 1978) showed that several preventive methods including intensive patient education and professional tooth cleaning used in combination with fissure sealants could reduce dental caries in children. In 1991 Carvalho *et al* (Carvalho *et al*, 1991) reported the results of a treatment program designed to control occlusal caries on the basis of intensive patient education and professional tooth cleaning.

This oral hygiene program was judged to be an efficient alternative to fissure sealing in preventing occlusal caries in erupting teeth. This was echoed in the results at 3 years (Carvalho *et al*, 1992). However Arrow (Arrow, 1997) suggested that the 12-month results from his study showed there was no statistically significant difference between the caries-preventive effects of a professional tooth cleaning and oral health education program or a program based on selective fissure sealing and application of topical fluorides. However it has to be stressed that studies carried out elsewhere have not been able to repeat the Scandinavian success. In a review, Holmes in 2003 found that prevention or improved oral hygiene alone will not arrest or reverse caries predictably (Nyvad B *et al*, 1986, Papas *et al* 1999, Holmes 2003).

Marinho *et al* (Marinho *et al*, 2003) reviewed fluoride mouthrinses for preventing dental caries in children and adolescents. They concluded that the supervised regular use of fluoride mouthrinse and rinsing frequency are associated with a clear reduction in caries increment in children.

There is a great deal of research to show the role of micro-organisms and dental pathology. The combined pathology of caries and soft tissue infection present a challenge to treatment modalities. The

presence of enamel decalcification, fissure caries, and soft tissue infection may require a combined approach of anti-microbials for the soft tissue infection and restorative care to treat the caries.

The mixed dentition stage poses additional challenges when viewed in terms of the young age of children. Not only does the erupting tooth surface become covered in plaque, infected and caries initiated, but the surrounding eruption cyst becomes a focal area for infection too. Various workers have isolated a number of pathogens in caries and soft tissue pathologies. In 1995, Bratthall *et al* (Bratthall *et al*, 1995) isolated mutans streptococci from carious lesions. This was repeated in 1997 by Twetman, Petersson (Twetman, Petersson, 1997) In 2005 Brailsford *et al* (Brailsford *et al*, 2005) reported Streptococci mutans, Actinomyces israelii, Streptococcus oralis, and Streptococcus salivarius.

Brailsford *et al* (Brailsford *et al*, 2005) investigated the relationship between microflora, eruption status and caries status in the first permanent molar of young children (177 children aged 6-7 years). Logistical regression analysis revealed significant association between white spot lesions in partially erupted teeth and increased numbers of Streptococcus oralis, Streptococci mutans and Streptococcus salivarius whereas the presence of Actinomyces naeslundii was associated with health.

Significantly greater numbers and proportions of S. oralis and S. salivarius were isolated from partially erupted teeth with white spot lesions whereas Streptococcus mutans was isolated in significantly greater numbers and proportions from fully erupted molars with white spots. This study suggested that organisms other than Streptococci mutans are associated with caries development in erupting permanent molar teeth.

Basic research and clinical evidence suggest that the prevalence of Treponema denticola, together with other proteolytic gram-negative bacteria in high numbers in periodontal pockets, may play an important role in the progression of pocketing around a tooth (Sela *et al*, 2001). The accumulation of these bacteria and their products in the pocket may render the surface lining periodontal cells highly susceptible to lysis and damage. T. denticola has been shown to adhere to fibroblasts and epithelial cells, as well as to extracellular matrix components present in periodontal tissues, and to produce several deleterious factors that may contribute to the virulence of the bacteria.

These bacterial components include outer-sheath-associated peptidases, chymotrypsin-like and trypsin-like proteinases, hemolytic and hemagglutinating activities, adhesins that bind to matrix proteins and cells, and an outer-sheath protein with pore-forming properties.

Pericoronitis is an infectious disease usually associated with erupting permanent molar teeth. It can be either acute (serous and suppurative) or chronic. Pain is usually the predominant symptom in acute stages, whereas chronic forms of the disease may display very few symptoms. Both present exudate. The infection is multi-microbial, predominantly caused strictly by betalactamase-producing anaerobic microorganisms (Gutierrez-Perez, 2004).

Treatment measures are symptomatic, antimicrobial and surgical. Antimicrobial treatment is indicated for preoperative prophylaxis when there is a high risk of postoperative infection and, during the acute stages of suppurative pericoronitis when surgery must be postponed.

If the erupting follicle remains untreated, the potential sequelae were investigated by Takai *et al* (Takai *et al*, 2005). These workers examined the incidence and bacteriology of bacteraemia associated with various oral and maxillofacial surgical procedures. In particular, tooth extraction resulted in a higher incidence of bacteraemia compared with other surgical procedures. The incidence of bacteraemia was not affected by oral hygiene or gingival inflammation.

When tooth extraction was examined, there was no statistical difference in the incidence of bacteraemia

with respect to the number of teeth extracted or the method of extraction. Extraction of teeth with odontogenic infection, which included periodontitis, periapical infection, and pericoronitis, did however produce a significantly increased incidence of bacteraemia compared with infection-free teeth ( $P < .01$ ). Viridans streptococci were the predominant group of bacteria isolated from the bacteraemias.

Modern health care now faces the problem of bacterial strains which are resistant to a wide variety of products. In a world where the life expectancy has been lengthened by pharmaceuticals, micro-organisms are now faced with the ultimate multi-choice of host. The micro-organisms' host is beset with immunological conditions that lower the innate immune system's ability to contain and repel infection. It is an era of opportunistic infection, and as their hosts tend to live in crowded surroundings, conditions are perfect for micro-organism cross infection, evolution and survival.

Treatment measures are symptomatic, antimicrobial and surgical (Gutierrez-Perez, 2004). Antimicrobial treatment is indicated for preoperative prophylaxis when there is a high risk of postoperative infection and, during the acute stages of suppurative pericoronitis when surgery must be postponed. With the potential for development of resistant forms of microorganisms, the indiscriminate use of antibiotics for dental pain should be avoided (Rodriguez, Sarlani, 2005).

The Goal is Infection Prevention.

Products like Recaldent® that contains CPP-ACP (casein phosphopeptide – amorphous calcium phosphate) make an important contribution to protecting the oral environment in a wide range of situations where a mineral imbalance may arise (Holmes, Lynch, 2003). This was based on a paper that was published in 2004 by Knight (Knight, 2004).

Recaldent® is derived from the milk protein, casein (Casein Phosphopeptide or CPP), which carries calcium and phosphate ions 'stuck' to it, in the form of Amorphous Calcium Phosphate (ACP). It is presented as a water based, sugar free dental topical crème. The complex CPP-ACP is an ideal delivery system for bio-available calcium and phosphate ions in both acidic and basic pH environments. The first product for professional use to contain the CPP-ACP technology was GC Tooth Mousse. There is no reason why at some time in the future, the CPP-ACP technology could not be incorporated into a glass ionomer restorative material (Holmes, Lynch, 2003).

Knight expounded on his theory that at eruption, the enamel for the newly erupted tooth was composed of carbonated apatite. Carbonated apatite is easily dissolved by acid attack, and is prone to decay processes. As a tooth erupts, as soon as a cusp breaks into the oral cavity, it becomes infected within the developmental cyst. Bagramian *et al* (Bagramian *et al*, 1979) had commented that permanent first molars in younger children appear to be highly susceptible to caries.

Carvalho *et al* showed that erupting teeth were more likely to develop dental caries, due to favourable conditions for plaque accumulation (Carvalho *et al*, 1989). As the space around the erupting tooth becomes further infected as oral debris accumulates over the tooth surface, the research showed most fissures have a degree of decay present. Once the enamel surfaces are exposed to fluoride in saliva, the enamel becomes more resistant to acid attack and decay by the formation of fluor-apatite (Knight, 2004).

Knight looked at past research that showed fissure sealants were lost relatively quickly for a variety of reasons. A recent paper suggests that resin-based sealants do not perform well in comparison to glass ionomer-based sealants (Antonson *et al*, 2006). The study by Antonson *et al* showed 100% retention of the glass ionomer sealants after the entire period of aging and toothbrush-abrasion, compare to a 37.5% failure for the resin-based system.

As both groups demonstrated similar wear rates Antonson *et al* concluded that the glass ionomer advantages of fluoride release and the simpler placement technique outweighed acid-etched bonded resin-based systems. Knight postulated that if teeth are fissure sealed to early (Knight, 2004) no fluorapatite has been allowed to form in the enamel now covered by the sealant. The carbonated apertite enamel surface, or more specifically, the margin of the sealant, is further weakened by the acid-etch technique used to secure the sealant. Plaque generated acid attack at the sealant margins leads to micro-failure, allowing the ingress of bacterial substrates below the sealant.

The development and/or continuation of a carious lesion is one of slow but determined progression, leading to the 'bombed-out' hollow molar. It is now generally accepted that the acid-niche environment is not destroyed by the preparation techniques of sealant placement. Indeed, the acid treatment may encourage the niche development!

Bacteria trapped in the deeper, inaccessible areas of the fissures will remain. In the 1980's, it was assumed that these micro-organisms, deprived of substrate, would remain quiescent or die. Due to faulty preparation, inadequate extension into the palatal and buccal grooves, and the profession's inability until recently to sterilise the complete fissure morphology and extent, these small carious lesions remained active.

Application of a fluoride releasing glass ionomer allows a constant fluoride release into the fissure pattern and has been commented by various researchers (Kidd 1973). The potential issue of patient and parental non-compliance over oral hygiene issues is avoided as a product like Fuji VII or Triage as it is more widely known. Fiji Triage releases up to 6 times the concentration of fluoride than other glass ionomers, and only a single application may be required.

Holmes and Lynch postulated that if this treatment were combined with ozone treatment prior to the placement of the glass ionomer sealant and the incorporation of Recaldent® CPP-ACP (Holmes and Lynch, 2003), the potential result would be zero cavities once the molar tooth had fully erupted for inspection.

The integration of ozone into the treatment was supported by the paper by Holmes, showing the predictability of ozone treatment and caries reversal in 100% of treated cases (Holmes, 2003) and Recaldent® CPP-ACP has been shown to release calcium and phosphates in acidic conditions in the oral cavity (Antonson *et al*, 2006, Reynolds, 1997, Reynolds *et al*, 1999 and Mazzaoui *et al*, 2003).

Research has shown that dental caries is a bacterial infection that is transmissible (Featherstone, Roth, 2003). Vertical and horizontal transmission of oral bacteria has been described from mother to infant (vertical transmission), and in infant crèches (horizontal transmission) (Berkowitz, 2003). The combined pathology of caries and soft tissue infection present a challenge to treatment modalities. The presence of enamel decalcification, fissure caries, and soft tissue infection may require a combined approach of anti-microbials for the soft tissue infection and restorative care to treat the caries.

Some workers have suggested that caries in the deciduous dentition can be left untreated and unrestored. Although the study by Tickle *et al* was preliminary in nature, no clear benefit could be found in filling deciduous molar teeth against leaving carious teeth unfilled, if avoidance of extraction was the desired outcome. The treatment philosophy of dentists was a major factor in determining extraction or exfoliation outcome (Tickle *et al*, 1999).

Levine *et al* examined case notes from children receiving regular preventive care. A group of 1,159 (74%) teeth were exfoliated without causing pain. In a second group of 1,409 teeth, 18% gave pain and were extracted or treated. The carious teeth most likely to cause symptoms were found to be molars that developed cavities with pulpal involvement by the age of 3 years, 34% of which caused pain.

The conclusion of this study was that the majority of unrestored carious deciduous teeth remain symptomless until shed for children regularly receiving regular preventive dental care (Levine *et al*, 2002).

Most dental problems can be prevented with regular dental care and steps to minimize risks of oral trauma (Douglass, Douglass, 2003). For patients at risk, oral infections, or susceptibility to exterior infections may play an important role in the risk associated with other pathologies. A 2001 study showed in a high-risk paediatric cardiac surgical group that 30 percent of subjects had seen a dentist regularly, 44 percent practiced daily oral hygiene and 18 percent knew about bacterial endocarditis (Hayes, Fasules, 2001). Local dentists performed invasive procedures on 52 percent without antibiotic prophylaxis. Dental disease was diagnosed in 84 percent 209 patients: 78 percent gingivitis; 29 percent caries; 7 percent dental abscess; 1 percent periodontal abscess; 2 percent pericoronitis.

Oral infections have been postulated to produce cytokines that may contribute to the pathogenesis of coronary heart disease (Janket *et al*, 2004). Their hypothesis was that by estimating the combined production of inflammatory mediators attributable to several oral pathologies, they could explain coronary heart disease with better precision.

#### Treatment Trends

Varnishes were considered as an option for prevention of fissure caries (Bratthall *et al*, 1995; Araujo *et al*, 2002). However some studies showed when used alone, these varnishes were of no therapeutic value (Fennis-le *et al*, 1998). Sealing newly erupted first molars with high-filled glass ionomer (Taifour *et al*, 2003) may be a caries-preventive measure for high-risk children. Others (Marinho *et al*, 2003) suggested that the supervised regular use of fluoride mouthrinse is associated with a clear reduction in caries increment in children.

With the advent of resin bonding, sealants became a recommended procedure to prevent caries of the occlusal surfaces of permanent molars (Ahovuo-Saloranta *et al*, 2004). Others (Marinho *et al*, 2004) showed that fluoride toothpastes, mouthrinses and gels appear to have a similar degree of effectiveness for the prevention of dental caries in children.

Beiruti *et al* (Beiruti *et al*, 2006) concluded that the caries-preventive effect of high-viscosity glass ionomer sealants was between 3.1 and 4.5 times higher than that of composite resin sealants after 3-5 years. Antonson *et al* (Antonson *et al*, 2006) showed that FujiVII's fluoride release and simpler technique, especially with newly-erupting molars, has advantages. This paper built on previous studies by Reynolds, 1997, Reynolds *et al*, 1999 and Mazzaoui *et al*, 2003.

A minority of workers have suggested that lasers could be used to sterilise soft tissue lesions found in the erupting dentition (Kato *et al*, 2003; Lu, Fang, 2004). However, issues of investment costs will determine the entry of this technology into general dental practice.

Delgado-Angulo *et al* showed that in a multivariate context, socio-economic status, oral hygiene condition, and gender had an impact on decay (Delgado-Angulo *et al*, 2006). It has already been noted that the treatment philosophy of dentists has been shown to be a major factor in determining the type of treatment offered (Tickle *et al*, 1999).

#### **Treating the Erupting Dentition.**

The partially erupted molar tooth presents initially as a single cusp penetrating through into the oral cavity through the gingival mucosa.

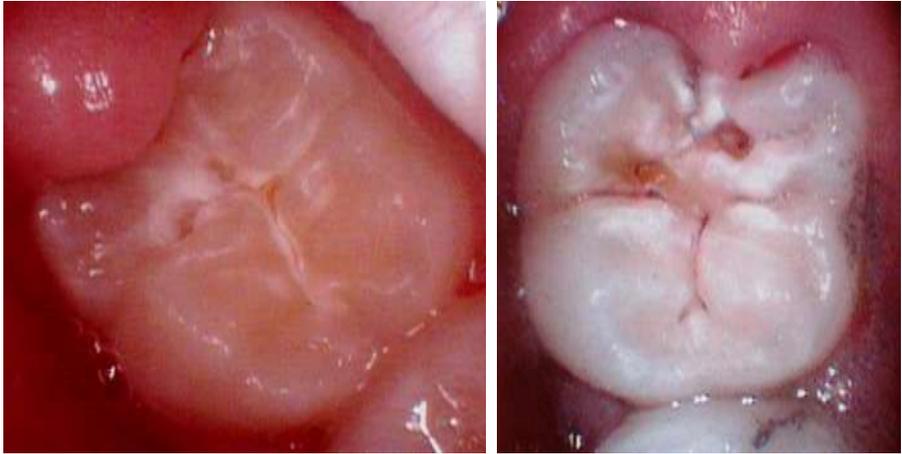
**Fig 3&4.** Partially Erupted Molars Showing Plaque & Fissure Caries. Image used with permission



The eruption area is often inflamed, sore to touch, and patients tend to avoid cleaning due to pain. Oral debris and bacteria enter below the tissue and colonise the tooth surface, initiating the formation of the acid niche.

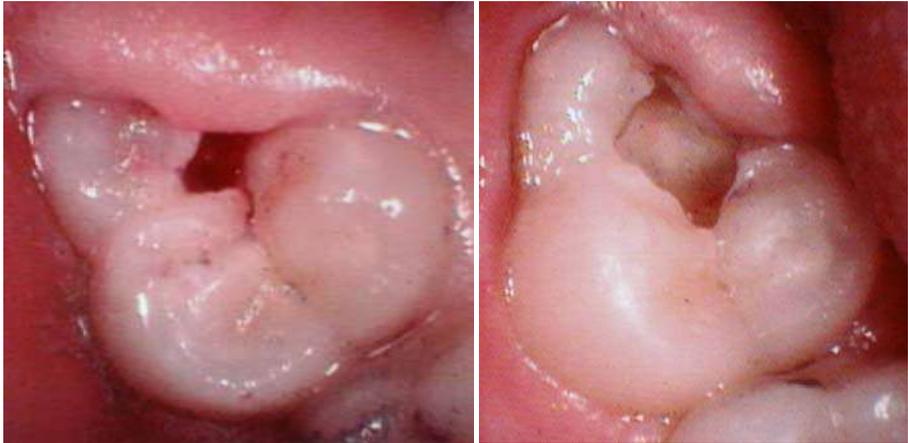
As eruption proceeds, the occlusal surface of the tooth becomes increasingly exposed. However, bacterial contamination and infection has taken place at the initial penetration through the protective mucosa. Fissure caries is initiated soon after mucosal penetration and these teeth often erupt with carious lesions in situ.

**Fig 5,6.** Partially Erupted Molars Showing Fissure Caries. Images used with permission



If treatment is left too late, even before full eruption into the oral cavity and into full functional occlusion, the carious lesions will be extensive, and in some instances extensive restorative care will be required or extraction (Segura *et al*, 1998). The use of resin-bonded systems presents issues with isolation, preparation and adequate extension into all fissures for long-term positive results.

**Fig 7,8.** Partially Erupted Molars Showing Caries. Images used with permission



Glass ionomers are not so technique sensitive, and the use of Fuji Triage and Recaldent® CPP-ACP (Casein Phosphopeptide - Amorphous Calcium Phosphate) has been suggested by various researchers for the preventative treatment of the partially erupted molar tooth (Knight, 2004; Holmes, Lynch, 2003).



**Fig 9. Eruption Caries Shown with Caries Dyes**

Images used with permission

### **Treatment of the Newly Partially Erupted Molar Tooth;**

Readers will know that I have been involved in the ozone research since it's inception at Belfast University in the late 1990's with Professor Edward Lynch. The papers that were published from 2000 onwards showed that the predicatable elimination of the acid niche is key in the arrest and reverse of active lesions.

Some ozone units require a seal to be made around the lesion to be treated, and often this precludes treatment. Various arguments are put forward for a vacuum delivery system, such as the CurOzone HealOzone system, or a 'free-flow' system, such as the Grey Cell Enterprises CMU3 and 4 systems. Which ever system you either have or decide to use, the results are the same.

In my practice, I use the CMU3. This is a system I am very familiar with and I have used this for the last 6-8 years in various builds.



**Fig 10. GCE CMU3 clinical tip with Ultradent delivery tip in place**

The preventative treatment with ozone is simple. An Ultradent irrigation tip is placed on the GCE-CMU3 hand piece clinical tip. This tip is then placed below the mucosal surface covering the partially erupted molar into the central area of the occlusal surface. The GCE-CMU3 is activated for 60-seconds, with high-volume suction held close to the artially erupted molar tooth, without actually touching the mucosa if possible.

A mineral or fluoride wash can be infused below the mucosal tissue to aid remineralisation with an Ultradent 1.2ml syringe with the same tip in place.

Fuji Triage is then placed under the oppurculum onto the treated tooth surface. The ozone application sterilises the tooth surface, the mineral wash accelerates the surface re-mineralisation, and the Fuji Triage releases minerals into the tooth surface to prevent the formation of enamel caries. The ozone and mineral wash can be repeated at 4-month intervals if required.

The whole process takes about 2 minutes, it is fast, painless, simple and very effective preventive system for children, and adults alike. It can be used for impacted 8's where removal has been advised but refused by the patient, or as a holding treatment before planned removal.

### Patients at Later Stages of Tooth Eruption;

As the molar erupts further into the oral cavity and more of the occlusal surface becomes visible, plaque can be removed prior to ozone treatment with care. The use of compressed air systems should be used *with care* as emphysema in the surrounding tissue could be caused by inadvertent use of pressurised powder-based cleaning devices.

Use of the KaVo DIAGNOdent after plaque removal will reveal any sites of active demineralisation or caries requiring treatment. The preventative treatment with ozone is still simple even at later stages of eruption. An Ultradent irrigation tip is placed on the GCE-CMU3 hand piece. This tip is then placed below any remaining mucosal surface covering the erupting molar and the GCE-CMU3 activated for 60 seconds. The Ultradent irrigation tip is removed from the mucosal pocket, and from the GCE-CMU3 hand piece.

The exposed tooth surface is then treated with ozone direct from the GCE-CMU3 hand piece. The GCE-CMU3 is activated for 60-seconds for each application, with high-volume suction held close to the partially erupted molar tooth, without actually touching the mucosa if possible. Any areas of caries can be easily treated using air abrasion or fine fissureotomy burs, 60-seconds of ozone to sterilise the lesions, a mineral wash to start the remineralisation process, and a glass ionomer sealant, such as Fuji Triage, to restore the treated fissures.



**Fig 11-13.** Molar Lesion from preparation to fill with Fuji Triage



**Fig 14.** GC Fuji VII / Triage

Fuji Triage is available in the original pink, and now white colours. Most dentists seem to have an issue with the pink colour; however the pink has distinct advantages; I 'sell' the pink colour by telling my patients that I have carried out a specialised treatment for the treated teeth, and the pink colour denotes that this tooth has to be reviewed and examined specifically to see if the treatment has been successful on a tooth that has been marked as 'at-risk'.

**Fig 15.** 6-month review showing Fuji Triage in place





**Fig 10.** GC Tooth Mousse



**Fig 11.** GCE CMU3 Dental Ozone Device

## Review and Re-Treatment

Use of the KaVo DIAGNOdent will reveal any sites of active demineralisation or caries that may have developed since the last examination and /or review. Plaque and debris should be removed prior to the KaVo DIAGNOdent assessment of the molar surface.

Any areas of caries can be easily treated using air abrasion, 60-seconds of ozone to sterilise the lesions, a mineral wash to start the remineralisation process, and re-application of Fuji Triage to restore the treated fissures.

Where localised tissue removal can accelerate the full eruption of the tooth, local anaesthetics and either electro-surgery or a fine rotary diamond can be used to remove and re-shape the tissue to allow full visualisation and oral hygiene. However, I would caution readers at this stage, as the emphasis on this treatment protocol is one where treatment to date has been non-invasive and painless.

## Expected Results

The expected and observed results are a marked decrease in the incidence of decay, that follow the published research from Europe (Abu-Salem *et al*, 2003; Baysan, Lynch 2001; Holmes 2003; Holmes, Lynch, 2003). These studies have shown conclusively that the use of ozone in dental care is effective as a non-destructive method to manage decay and its destructive effects.

The use of ozone has been shown to be the ideal way to manage anxiety of patients – young and old - and their carers (Dahnhardt *et al*, 2003; Domingo *et al*, 2004). The effects of ozone reduce tooth destruction in routine preparation (Clifford, 2004; Holmes, 2004; Holmes, Lynch, 2004) and ozone reduces the time and the cost of dental care (Domingo, Holmes, 2004; Johnson *et al*, 2003).

Ozone has been shown to reduce pulp death and the necessity of endodontic treatment (Holmes, 2004). Published research has shown that ozone does not interfere with dental material bond strengths, and there is evidence that it increases material retention (Abu-Naba'a *et al*, 2004; Campbell *et al*, 2003; Holmes, 2004). Holmes, Lynch in 2003 postulated that ozone treatment below the operculum, followed by Fuji Triage placed onto the molar occlusal surface, combined with Recaldent® CPP-ACP (Casein Phosphopeptide - Amorphous Calcium Phosphate) could make an important contribution to protecting the oral environment in a wide range of situations where a mineral imbalance may arise (Holmes, Lynch, 2003).

Julian Holmes discloses that he has a financial interest in GCE and products made. He has no financial interest in GC. Some images have been supplied by Graeme Milicich BDS, New Zealand and are used with permission

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