CHAPTER 5

DISCUSSION

IPT, one treatment in the group of incomplete caries removal technique, has been an alternative choice of treatment in primary teeth diagnosed as deep dental caries or reversible pulpitis for many years[5, 6, 13, 17, 29]. IPT has been reported to have high success rates, favorable long-term clinical and radiographic outcomes[8, 18-22]. Moreover, when compared to other treatments in the group of complete caries removal technique, IPT reduces the incidence of pulp exposure which may result in higher long-term survival rate. However, in this study 9.30% of accidental pulp exposure occurred in the IPT group compared to none in the MCR with $RMGI_{B/L}$ and MCR with $RMGI_{L}$ groups. This result is similar to that of the previous IPT studies which showed that IPT resulted in approximately 5-8% of accidental pulp exposures[2, 18, 54]. These exposures may be the consequence of the fact that operators don't have reliable guides to determine the distance of carious dentin from the pulp while peforming IPT. Bjorndal et al.[3] has proved in their study with permanent teeth that any treatments after pulp exposure gave a lower overall pulp survival than the teeth with unexposed pulp. Therefore, when appropriate, pulp exposure may be avoided by performing MCR instead of IPT technique.

Besides not knowing the distance between carious lesion and dental pulp while performing IPT, it also has long been controversial regarding the amount of carious tissue that should be removed or left and its effect on the treatment success[4, 38-40].

This study was designed to directly test this unknown answer. The results of this study showed that there was no statistically significant difference in the success rates of the IPT compared to the MCR with $RMGI_{B/L}$ groups. This confirmed our prediction that the amount of caries left has no influence on the success rate as long as the carious lesion is sealed.

Actually, numerous separating previous incomplete caries removal studies have shown success of different levels of caries removal including the maximal caries removal, e.g., IPT and stepwise excavation, and the minimal caries removal, e.g., Ultraconservative treatment and Hall technique. In IPT and stepwise excavation, previous studies demonstrated that the aggressive caries turned into the slowly progressive carious lesions when they were reopened after a period of sealing. There were also reductions of number of residual bacteria[4, 38-42] as well as modifications of color and consistency of residual carious dentin into the darker, harder, and drier one resembling an inactive carious lesion[25, 31, 39, 40, 42, 43]. This phenomenon also evidenced in our study. After 14 months of the MCR with $RMGI_{B/L}$ treatment, one tooth was extracted due to its excessive mobility. The tooth was later sectioned and found the dentin to be as previously reported. When caries process is arrested, pulp-dentin complex can heal itself and the living odontoblast can form tertiary dentin to protect dental pulp. Wambier et al.[39] also found that residual carious dentins have more compact collagen fiber and narrower dentinal tubules after a period of cavity sealing. Moreover, Marchi et al.[45] and Franzon et al.[46] showed that microhardness of the remaining carious dentin had increased when compared to that of the active carious lesion. Furthermore, the classic study of Mertz-Fairhurst et al.[70] in permanent teeth similarly showed that good sealed restoration after Ultraconservative

treatment, the procedure that only minimal caries was removed, was also effective in preventing further progression of caries process after 10-year follow-up. Recently, Hall technique performed with no caries removal in primary teeth correspondingly showed successful outcomes[71-73]. Even though there have been some existing evidences regarding the success of treatment with different amount of caries removal, there were no prospective studies that directly compare the success rates between the treatments with different levels of caries removal within the same study like ours. From our result, it can be assured that if the lesion is sealed, the difference in the amount of dentin caries removal does not seem to affect the success of treatment.

Another problem relating to IPT technique is the essential of base material used. Some authors believed in the importance of base materials in providing antibacterial effect, enhance remineralization, promote hardening consistency of the remaining carious dentin and stimulate tertiary dentin formation[5, 40, 42, 53, 54, 78]. However, the true mechanism and effects of these materials on success rate are unknown. Several lining and base materials have been used in dental treatment such as calcium hydroxide, zinc oxide eugenol, zinc phosphate, polycarboxylate, GI, RMGI, etc.[79] Calcium hydroxide has been the material of choice to use in deep cavity for a long time due to its high pH, approximately 12, which is considered to be bactericidal. Calcium as well as hydroxyl ions affect on the pulpal healing by forming pulp matrix mineralization[79, 80]. However, it was not chosen to use in this study because calcium hydroxide has high solubility, low compressive resistance and no adherence to dentin[81]. For GI, it has more favorable biocompatible properties over that of calcium hydroxide. It adheres to the tooth structure, release fluoride and has cariostatic effect. However, GI is susceptible to moisture contamination, dehydrates during the early

stages, has low early mechanical strengths and set slowly from only acid-base chemical reaction[82]. The base material that we chose in this study was RMGI. It was developed by adding a hydrophilic resin component to GI to improve the mechanical properties in bonding with tooth structure. It has the same desirable biocompatible (fluoride release and cariostatic effect) and adhesive properties as GI[53]. RMGI has a dual setting reaction through both acid-base chemical reaction and polymerization by light-activated. Additionally, when compared to GI, RMGI also presents better properties such as higher moisture resistance, longer working time, long-term fluoride release, more strength and long durability[53, 55, 83, 84]. Moreover, Duque et al.[42] found that using RMGI, similar to calcium hydroxide, can reduce the number of cariogenic bacteria in the remaining carious dentin after cavities were sealed with IRM for 3 months. They concluded that both calcium hydroxide and RMGI had exhibited effective antimicrobial activity. However, some authors concerned of the potential acid-base chemical reaction that may be harmful to dental pulp. But from a systematic review of Mickenautsh et al.[78], there were no differences of dental pulp reaction between calcium hydroxide and RMGI. Thus, RMGI can be considered one choice of the preferred base materials in the primary dentition and used widely in pediatric dentistry.

Nevertheless, some previous studies expressed that other qualities of base material is not essential in IPT if the lesion has good seal[18-22]. There were studies that showed no statistically significant difference of the success rates between the IPT treated with and without lining or base material[20, 22]. In the study of Al-Zayer et al.[19], they emphasized that double seal with RMGI over calcium hydroxide gave satisfactory sealing and improved success rate of IPT treatment. While Falster et

al.[20] and Casagrande et al.[22] agreed that calcium hydroxide is not necessary in IPT treatment. In our study, the MCR with $RMGI_{B/L}$ and MCR with $RMGI_{L}$ groups had more amount of remaining carious dentin which made we wondered of the role of base material in this two treatment groups and also questioned that if only RMGI luting cement would be sufficient in sealing the lesions. From this study, there was no statistically significant difference of the success rates between the MCR with $RMGI_{B/L}$ and MCR with $RMGI_{L}$ groups. Therefore, it can be concluded from those previous studies and confirmed by our study that the role of the base material did not have an effect on the success rate if the lesion is well sealed from biofilm[18-22].

Failure of restorations often results in compromised sealing leading to both unsatisfactory clinical and radiographic outcomes of pulp treatment[19, 49, 53, 54]. In leak restorations, biofilm may drive the inactive lesions into the active one. Clinicians may choose to perform composite resin restorations in non-extensive dental caries without pulp treatment. However, this application must be taken with cautions when performing incomplete caries removal technique because some authors found that microtensile bond strength of carious dentin was lower than that of sound dentin[85, 86]. In extensive carious lesions with or without pulp treatment, SSC is acceptable to be the treatment of choice that results in less restoration failures. Likewise, SSC was chosen as a definitive restoration in this study because it has durability, long lifespan, adequately protect the remaining tooth structure and prevent marginal leakage[48, 50-52]. No matter how much tooth structure remains, SSC provides good retention with only slight microleakage[87]. From literature review, good seal is a key factor to high success rate[1, 6, 14, 15, 17, 31]. Thus, choosing the appropriate luting cement plays an important role in adding good marginal sealing along the interface

between the tooth and SSC to diminish microleakage and penetration of bacteria. There are many kinds of luting cement such as polycarboxylate, zinc phosphate, GI, RMGI and resin cement[56, 88]. In pediatric dentistry, RMGI luting cement is widely used because it has superior physical and mechanical properties over the GI luting cement[89]. It is easy to manipulate and has good retention due to its hybrids formation. The cariostatic potential due to fluoride release occurs in glass-ionomer phase meanwhile higher strength, lower solubility and good adhesion to tooth structure occurs in resin phase of RMGI luting cement[56, 88, 89]. Other luting cements are not routinely used in pediatric patients because they (polycarboxylate and zinc phosphate luting cement) have no adhesive properties and low tensile strength, expensive cost per unit and difficult to remove excess luting cement (resin luting cement)[88]. Memarpour et al.[90] tested microleakage of adhesive and nonadhesive luting cements and found that polycarboxylate luting cement has the greatest microleakage and RMGI with bonding agent has the lowest microleakage. Moreover, it is not necessary to use resin luting cement in pediatric patient because marginal microleakage of RMGI and resin luting cements are not different[91]. However, none of the luting cements can completely seal SSC margins[90, 91]. Even though the $RMGI_L$ with SSC coverage seemed to be adequate for sealing the remaining carious lesion in primary teeth at a short period of follow-up of our present study, the long-term sealing ability of this luting cement may need to be further investigated.

The overall result showed that MCR with $RMGI_{B/L}$ and MCR with $RMGI_L$ can be used in treating deep dentin carious lesion similar to IPT. Besides reduction in pulp exposure when compared to IPT, MCR with $RMGI_{B/L}$ and MCR with $RMGI_L$ have other advantages such as reductions in treatment steps, chair time and cost.

Moreover, less pain involves because no pulp exposures occur. Although the success rates in all groups have no statistically significant difference, there were three teeth of radiographic failures in the MCR with $RMGI_L$ group (11.5%) at 7 months follow-up period. This number of failure is considered to be less than that of IPT (17.65%)[92], FC pulpotomy (16.00%)[93] at 6 months follow-up period and similar to that of Hall technique (11.36%) at 23 months follow-up period[72]. These failures may be the result of false diagnosis of preoperative status. In this study, we carefully selected teeth according to inclusion criteria using routine methods that derive from obtaining subjective symptoms, clinical and radiographic examinations. However, problems exist regarding this routine process. First, it is difficult to obtain reliable information about pain from children[29, 94]. Most of their parents also do not know their true symptoms and could not be specific of the location of tooth pain. Additionally, symptoms ineffectively help in diagnosis because the absence of clinical symptoms sometimes may be the result of silently developing pulp necrosis. Regarding the limitations of the clinical examination, some clinical presentations of teeth may represent several different status of pulp tissue. There was a study showing that clinical and histological status of teeth may not always relate (cited in McDonald et al.)[29]. Moreover, while performing treatments with incomplete caries removal such as IPT and MCR, the caries is intentionally left over the pulp to ovoid pulp exposure. Therefore, the real pulp status obtained from direct visual will never be achieved. In radiographic examination, we used both bitewing and periapical radiographs to confirm the depth of caries and pathologic lesions of tooth. The interpretation of the radiographs plays a crucial role in the tooth selection in this study. Bitewing radiograph, the most common method used to diagnose the depth of carious lesion,

has high sensitivity for detecting cavitated surfaces[95]. Nevertheless, the process of caries diagnosis on these radiographs cannot be predicted with certainty. Remaining dentin thickness seen below carious lesion in radiograph may not reflect the real thickness because radiographic diagnosis of caries frequently underestimates the true lesion depth[96, 97]. Moreover, we found that it was challenging to interpret periapical radiograph of primary teeth, especially in maxilla, due to anatomy overlapping. Therefore, diagnosis limitations must be kept in mind when treating teeth with incomplete caries removal methods.

Even though the false diagnosis was blamed to be the cause of failure in this study, the true reasons may need to be further investigated. If the future results reveal failures within a short period of follow-up and the success becomes stable over a longer period, it may be postulated that failures are probably from false diagnosis. This same event has been proved to be true with IPT[8]. On the other hand, if the failures increase with the longer follow-up time, it may be assumed that failures are likely to result from the treatment itself.

Although not statistically significant, it is obvious that all failures were in the MCR with $RMGI_L$ group. Another possible reason of this failure may come from different properties between RMGI base material and RMGI luting cement. Even though the basic ingredients may be similar, there may be some unrevealed components that may result in differences in mechanical, chemical and physical properties.

Besides the different properties between RMGI base material and luting cement mentioned above, the technique sensitivity of mixing and cementation steps may also influence the success of treatment. In the mixing step, dentist should strictly follow

manufacturer's instruction to achieve the best material properties possible. In the cementation step, we were unfortunately unable to check the sealing quality of the luting cement either clinically or radiographically. Moreover, in uncooperative patient, salivary contamination may occur while cementing SSC. These technique sensitivities may therefore lead to microleakage and inadequate seal between tooth surface and SSC margin, especially when RMGI base was not used and the quality of sealing depended mainly on RMGI luting cement.

Even though the success rate of incomplete caries removal in primary teeth in this study is quite impressive, cautions must be taken when apply this technique in permanent teeth. Unlike SSC in primary teeth, full coverage may not always be used in permanent teeth treated with incomplete caries removal due to its high cost and uncertain success of pulp treatment. Moreover, long life spans of permanent dentition may put the tooth to a risk of higher restoration failures which may lead to progression of caries.

Conclusion

At a relatively short period evaluation, this study demonstrated that clinical and radiographic successes of IPT, MCR with $RMGI_{B/L}$ and MCR with $RMGI_{L}$ were similar in managing deep caries and reversible pulpitis in primary molars. Neither the amount of caries removal nor base materials had an influence on the success rates of incomplete caries removal technique. Although there was no statistically significant difference in the success rates of each incomplete caries removal technique, the MCR with $RMGI_{B/L}$ seemed to give the best outcome because no pulp exposures and no failures occurred. Therefore, the results of this study suggested that MCR with

$RMGI_{B/L}$ may be an alternative when treating primary molar with deep caries and reversible pulpitis.

Further research suggestions

The results of this study have shown promising results of incomplete caries removal technique. Nonetheless, long-term evaluation of treated teeth, effects on permanent teeth, influences of both liner/base materials and luting cement on the remaining carious lesion, the histological change of pulpal response, and the immune defense mechanism will need to be further investigated.