ORİJİNAL MAKALE / ORIGINAL ARTICLE
Balıkesir Sağlık Bilimleri Dergisi / BAUN Sağ Bil Derg
Balıkesir Health Sciences Journal / BAUN Health Sci J
ISSN: 2146-9601- e ISSN: 2147-2238
Doi: https://doi.org/10.53424/balikesirsbd.1062218

3-Year Survival of Resin Restorations of Severely Damaged Permanent Molars in Children

Ceylan Çağıl ERTUĞRUL [1]

[1] Pamukkale University, Faculty of Dentistry, Department of Pediatric Dentistry

Geliş Tarihi / Received: *24.01.2022,* ***Kabul Tarihi / Accepted:*** *29.03.2022*

ABSTRACT
Objective: Aim of this retrospective study was to determine survival rates of direct composite resin (DCR) restorations of permanent first molars (PFMs) with excessive material loss at the end of 3 years. **Material and Methods:** Children between the ages of 7-14 whose PFMs had 3-surfaced DCR restoration were included. Survival rates of the restorations after 3 years were evaluated using The United States Public Health Service criteria and the presence of symptoms indicating irreversible pulp damage such as spontaneous pain, percussion, abscess in the related teeth were examined clinically and radiographically. Chi-square and Kruskal Wallis analyzes were used for the statistical analysis. **Results:** Totally 58 DCR restorations of 34 patients who agreed to come for the control after 3 years were examined. The survival rate of restorations was 70.69%. Findings indicating irreversible pulp damage were found in 15.5% of the restorations examined. **Conclusion:** Survival rate of DCR restorations applied to PFMs with excessive material loss is not satisfactory after 3 years, however it is thought that DCR applications will continue in PFMs with excessive material loss thanks to the developments in adhesive systems and composite resins. Therefore, long-term randomized controlled clinical studies on this subject should be continued.
Keywords: Composite Resins, Dental Caries, Dental Restoration, Permanent.

Çocuklarda Aşırı Madde Kayıplı Daimi Molarların Rezin Restorasyonlarının 3 Yıllık Sağ Kalımı

ÖZ
Amaç: Bu retrospektif çalışmanın amacı, aşırı madde kayıplı daimi birinci büyük azılara uygulanan direkt kompozit rezin (DKR) restorasyonların 3 yıl sonundaki sağ kalım oranlarının belirlenmesidir. **Gereç ve yöntem:** Araştırmaya aynı hekim tarafından daimi birinci büyük azılarına 3 yüzlü DKR restorasyon uygulanmış 7-14 yaş aralığındaki çocuklar dahil edilmiştir. Restorasyonların 3 yıl sonundaki sağ kalım değerlendirmesinde United States Public Health Service (USPHS) kriterleri kullanılmış ve ilgili dişlerde spontan ağrı, perküsyon hassasiyeti, apse gibi geri dönüşümsüz pulpa hasarını işaret eden semptomların varlığı incelenmiştir. Verilerin istatistiksel analizinde Ki-kare ve Kruskal Wallis analizleri kullanılmıştır. **Bulgular:** Üç yıl sonundaki kontrol randevusuna gelmeyi kabul eden toplam 34 hastanın daimi birinci büyük azı dişlerine yapılmış 58 DKR restorasyon klinik ve radyografik olarak incelenmiştir. Restorasyonların sağ kalım oranı %70.69'dur. İncelenen restorasyonların %15.5'inde geri dönüşümsüz pulpa hasarını ve kök kanal tedavisi ihtiyacını gösteren bulgular saptanmıştır. **Sonuç:** Aşırı madde kayıplı daimi birinci büyük azı dişlerine uygulanan DKR restorasyonların 3 yıl sonundaki sağ kalım oranının tatmin edici olmadığı ancak, adeziv sistemler ve kompozit rezinlerdeki gelişmeler sayesinde aşırı madde kayıplı genç daimi posterior dişlerde DKR uygulamalarının devam edeceği düşünülmektedir. Bu nedenle konuyla ilgili uzun vadeli, randomize, kontrollü klinik çalışmalar sürdürülmelidir.
Anahtar Kelimeler: Kompozit Dental Rezin, Diş Çürükleri, Diş Restorasyonu, Kalıcı.

Sorumlu Yazar / Corresponding Author: Ceylan Çağıl ERTUĞRUL, Pamukkale University, Faculty of Dentistry, Department of Pediatric Dentistry, Denizli, Türkiye.
E-mail: ceylancagil@hotmail.com

Bu makaleye atıf yapmak için / Cite this article: Ertuğrul, C. Ç. (2022). 33-year survival of resin restorations of severely damaged permanent molars in children. *BAUN Health Sci J, 11*(3), 347-353.
https://doi.org/10.53424/balikesirsbd.1062218

INTRODUCTION

Permanent first molars are the earliest erupted permanent teeth in the jaws, and they are often mistaken for primary teeth by young children and their parents, therefore it is observed that these teeth are not given enough attention because of considering that they will change with their succedanous permanent teeth anyway. Dental caries able to occur and progress easily in these teeth due to reasons such as food and bacterial accumulation because of the inability of the young children to perform oral hygiene practices adequately, incomplete enamel maturation of the newly erupted first permanent molar tooth, and the deprivation of mechanical cleaning due to chewing during the period until the tooth comes into occlusion (Fejerskov et al., 1984; Carvalho et al., 1989).

Direct composite resin (DCR) restorations, indirect composite resin restorations and prefabricated crowns prepared with various materials are used in the treatment of carious lesions of young permanent first molars with excessive material loss in pediatric patients. Direct posterior restorations are restorative procedures that are routinely preferred in public dental health institutions today, due to the fact that they are more practical and more economical due to the possibility of finishing the treatment in a single session, and they require less preparation on the tooth (ADA, 2003). Although the common opinion in the literature was direct applications of resin-containing composite materials is ideal for use in small and medium sized cavities (ADA, 1998), afterwards with the reporting that the long-term clinical follow-up results of indirect and direct restorations do not differ significantly, the interest in direct composite resin applications has increased in large restorations including the tubercle tips (Denehy & Cobb, 2004; Deliperi & Bardwell, 2006a). With the widespread use of composite resins, the longevity of posterior composite resin restorations and the awareness of potential failure reasons have come into question (Zotti et al., 2021). In studies investigating the survival time of composite resins in posterior restorations, survival rates over a 5-year period have been reported ranging from 55% to 95% (Hickel & Manhart, 2001).

Another important issue in the restoration of permanent first molars with excessive material loss and deep dentin caries is the protection of pulp vitality. In a study investigating the 3-year follow-up results of indirect pulp capping treatments in permanent molars, the rate of cases without clinical and radiographic pulpal pathology was reported as 93% (Gruythuysen et al., 2010). It is stated that when an accurate diagnosis is made with a detailed clinical and radiographic evaluation, success rates ranging from 73% to 95% are obtained in indirect pulp treatments (Fuks, 2000).

In this retrospective study, which includes the clinical and radiographical evaluation of direct composite resin restorations of permanent first molars with excessive material loss due to deep dentin caries in pediatric patients, it was aimed to examine the survival rates of the restorations and to evaluate the possible irreversible pulp damage symptoms of the related teeth at the end of 3 years.

MATERIALS AND METHODS

Case selection

Three-surface direct composite resin restorations applied to the permanent first molars of children aged 7-14 years, who are systemically healthy, able to provide the necessary cooperation with the dentist (with Frankl Scales 3 or 4) for a successful dental treatment and have similar oral hygiene habits (brushing their teeth with fluoride toothpaste at least once a day), were included in the study. The inclusion criteria of restorations were as follows:

•To include 3 surfaces of the tooth and to have a size that exceed 2/3 of the distance between the buccal and lingual tubercle tips in the buccolingual direction,

•No molar incisor hypomineralization in restored teeth,

•No sign of direct pulp exposure and/or irreversible pulp damage in the restored teeth,

•Absence of any radiographic pathology indicating damage to the root pulp such as loss of lamina dura, periapical radiolucency or lesion, internal or external resorption,

•Having been performed by the same physician in the year 2018.

Power analysis was not performed in the study because the sample group of the study included all the cases within the specified time interval and criteria.

Clinical and radiographical data of the included patients and restorations were obtained from hospital database and anamnesis forms, and patients were invited for clinical examination in order to investigate the survival of restorations after 3 years.

Clinical procedure

All restorations examined in the study were made by a specialist physician in the pediatric dentistry clinic of a university hospital. After the application of local anesthesia, isolation measures were taken with cotton rolls and saliva suction and all carious tissues were removed under water cooling at the enamel level by using high speed rotary diamond burs and at the dentin level using a low-speed rotary instrument with tungsten carbide rotary burs and hand excavators when it was necessary. At the bottom of the cavity closest to the pulp horns, an indirect pulp capping material containing calcium hydroxide (Dycal, Dentsply, Milford, DE, USA.) was used. Glass ionomer cement (Ionofil Molar, VOCO, Cuxhaven, Germany) as the base cement, Clearfil SE Bond (Kuraray Noritake Dental Inc., Okayama, Japan.) as the adhesive agent, and Clearfil Majesty posterior composite resin (Kuraray Noritake Dental Inc. Okayama, Japan.) as the restoration material were used. Composite resin material was placed in the cavity in layers of 2 mm thickness in accordance with the manufacturer's instructions, and each layer was polymerized with an LED light device for 20 seconds. Restorations were polished using diamond finishing burs and silicone polishing rubbers after occlusion control.

3-Year control visits

Restorations were examined clinical and radiographically by the same physician who performed the restorations at the end of 3 years. United States Public Health Service (USPHS) criteria (Cvar & Ryge, 2005) (Table 1) were used in the clinical evaluation of the restorations. Among the restorations, those got A and B scores from the USPHS color match, marginal discoloration and anatomical form criteria, A score from the marginal adaptation and secondary caries criteria were considered successful in terms of survival. The presence of clinical symptoms in the involved teeth, such as provoked or spontaneous pain, percussion tenderness, abscess, fistula which are indicating irreversible pulp damage and the need for root canal treatment, were determined by periapical radiographic examination in addition to clinical inspection.

Statistical analysis

Data were analyzed with the SPSS package program (SPSS v23.0, SPSS Inc., Chicago, IL, USA). Categorical variables were given as numbers and percentages, and the differences between categorical variables were analyzed with Chi-square analysis, and data that did not meet the prerequisites of parametric tests were examined with the Kruskal-Wallis test.

Ethical considerations

Ethical approval of this retrospective study was received from the Faculty of Medicine Clinical Research Ethics Committee (date: 10.09.2019 number: 15) and written informed consent which is stating that their data could be used for scientific purposes was obtained from the parents of all patients who participated in the study.

Table 1. USPHS Clinical evaluation criteria and scoring (Cvar & Ryge, 2005).

Criteria	A	B	C	D
Color match	No difference in color or transparency between restoration and tooth	A deviation within the natural tooth color and transparency values	A deviation other than the natural tooth color and transparency values	
Marginal discoloration	No discoloration at the restoration and tooth interface	A discoloration at the restoration and tooth interface that does not progress towards the pulp	A discoloration at the restoration and tooth interface that progress towards the pulp	
Anatomical form	Restoration in continuity with tooth anatomy	Acceptable restoration that is not identical to the anatomical form	Insufficient anatomical form with exposed dentin	
Marginal adaptation	No visible gap at the restoration and tooth interface	There is little visible gap between restoration and tooth interface, the probe is inserted	Probe progresses to dentine or restoration base	Restoration lost or mobile
Seconder caries	No caries	Caries present		

RESULTS

Totally 58 composite resin restorations made on the permanent first molars of 34 patients who agreed to come for the control appointment at the end of 3 years were examined clinically and radiographically.

Table 2. Clinical success rates of restorations according to USPHS criteria.

Criteria	A n (%)	B n (%)	C n (%)	D n (%)
Anatomical form	26 (44.83)	26 (44.83)	6 (10.34)	-
Marginal adaptation	41 (70.69)	9 (15.52)	7 (12.07)	1 (1.72)
Seconder caries	55 (94.83)	3 (5.17)	-	-

Mean age of the patients at the control visit was 13.5 and 22 (64.7%) of them were female and 12 (35.3%) were male. Of the restorations examined, 22.4% were applied to the right upper 1st molar, 22.4% to the left upper 1st molar, 27.6% to the left lower 1st molar, and 27.6% to the right lower 1st molar tooth.

All restorations evaluated as successful according to anatomical form, marginal adaptation and secondary caries criteria received an A or B score from the color match and marginal discoloration criteria, therefore color match and marginal discoloration were not considered as decisive criteria for clinical failure and survival. The survival rate of the restorations examined with this method was determined as 70.69%.

The clinical success rates of restorations according to USPHS criteria is shown in Table 2. Symptoms indicating irreversible pulp damage and the need for root canal treatment were found in 15.5% (9 teeth) of the restorations. In two cases, it was determined that crown restorations were performed due to clinical failure of the restorations, and there was no irreversible pulp damage and need for root canal treatment in the related teeth, and these restorations were considered unsuccessful in terms of survival. As a result of the statistical analysis of the data, it was determined that there was no significant difference between the jaw (upper or lower) on which the restorations were made and the survival rates (p=0.242), no significant relationship between the tooth number and the clinical success of the restoration applied (p=0.702), and between the tooth number and the cases with irreversible pulp damage (p=0.836).

DISCUSSION

It is desired that the restorative materials used in the posterior teeth have advantages such as being resistant to chewing pressure and occlusal forces, long manipulation time, easy to use and reasonable application time. In addition to these properties, composite resins which have strong aesthetic properties, are the most widely used materials in the restoration of posterior teeth today (Zotti et al., 2021; Leprince et al., 2013; Jang et al., 2015).

As well as material-specific factors, clinical success and survival time of posterior restorations are also affected by dental factors such as the applied tooth, depth and size of the restoration, relationship with the pulp, and patient-specific factors such as age, chewing habits, oral hygiene, frequency of dental visits, and caries activity (Hickel & Manhart, 2001).

In addition, in a study of Sonkaya et al. (Sonkaya et al., 2021) from Turkey, it was found that factors such as the type of health institution in which the restoration was applied and the experience of the practicing physician also affect the clinical performance of posterior restorations and it has been reported that the highest success is seen in those performed by physicians working in university hospitals (Sonkaya et al., 2021). The direct composite restoration failure rate of 50.8% determined by Sonkaya et al. (Sonkaya et al., 2021) is higher than our results and the reason for this situation may be the examination of restorations made by a physician in only one university hospital in our study, although they included samples from all health institutions in our country in their study.

The restoration survival rate of 70.69% at the end of 3 years in our study is not compatible with the annual failure rate of 1-4% found in systematic reviews of direct composite restorations (Demarco et al., 2012; Heintze & Rousson, 2012). This may be due to the evaluation of the clinical success of only 3-surface composite restorations of the teeth with excessive material loss in this study, and reporting the results of all cavity types, that is, restorations with a higher chance of success in mentioned systematic reviews.

In a study investigating the 17-year follow-up results of composite restorations, it was found that restoration fractures were the primary causes of failure in the first 5 years, and it has been reported that secondary caries emerged as the main cause of failure in the 6-17-year period. (Brunthaler et al., 2003). In the same study, it was found that none of the factors such as the isolation of the operation area with cotton rolls or rubber-dam, the skill of the dentist, the type of bonding agent or the filler properties of the composite resin material had a significant effect on the failure rates, however, restoration size (Class II restorations) has been reported to have a significant effect on clinical failure (Brunthaler et al., 2003). In another study, it was reported that restoration fractures or losses in the first 5-year observation and secondary caries in the 5-10-year observation period were the main failure factors (Gaengler et al., 2001).

As a result of the present study, similarly, the primary failure causes were adaptation problems and partial restoration losses in the way that the probe could be inserted at the tooth and restoration interface or exposed the dentin, and secondary caries was not the leading cause of failure.

Indirect composite resin restorations are one of the alternative treatment methods to direct composite resin restorations in the restorations of permanent molars with excessive material loss. In the in-vitro study of Kuijs et al., it was reported that ceramic, indirect composite and direct composite resin adhesive restorations with tubercle replacement showed comparable fracture resistance and similar reasons for failure (Kuijs et al., 2006). Some clinical studies have also supported this laboratory study (Pallesen & Qvist, 2003; Thordrup et al., 2001).

In a literature review, it was reported that no significant difference was found in the 3-year clinical performance of posterior direct and indirect composite resin restorations (Hickel & Manhart, 2001). Furthermore, in a recent study it was reported that, after 2 years indirect composite restorations created using the CAD-CAM system and DCR restorations have success rates of 90% and 93.3%, respectively and presented similar and good clinical behavior for all the properties analyzed (Rocha Gomes Torres et al., 2021). However, in the last 20 years, the opinion that indirect restorations can be a better alternative than direct composite restorations have

become widespread (Galiatsatos et al., 2022; Ravasini et al., 2018; Koyutürk et al., 2013).

In a recent study, it was stated that the marginal integrity was not impaired in indirect restorations even during the 20-year follow-up period, and therefore the incidence of secondary caries was lower than in direct restorations (Ravasini et al., 2018). In a study conducted in pediatric patients as a result of 2-year follow-up of indirect and direct composite resin restorations, no significant difference was found between the two techniques in terms of any of the USPHS criteria evaluated, however, at the end of 6 months, it was stated that there was more staining at the margins of direct composite resin restorations as a result of staining with basic fuchsin (Koyutürk et al., 2013).

In a clinical study including 3-year follow-up of restorations, it was reported that indirect composite inlays (93%) and direct composites (87%) showed similar clinical success rates, but indirect inlays showed significantly better results in anatomical form criteria (Manhart et al., 2000). Furthermore, as a result of a recent study in which indirect inlay and onlay restorations were followed for 9 years, a high success rate of 85% was reported (Galiatsatos et al., 2022).

From the research results, it is understood that the clinical success of direct composite restorations is comparable to indirect restorations, but indirect restorations show more satisfactory performances, especially in terms of anatomical form, marginal leakage and secondary caries. Another alternative treatment method to direct and indirect composite restorations of young permanent posterior teeth with extensive crown destruction is stainless steel crown (SSC) applications (Heidari et al, 2019; Sigal et al., 2020). Although there are many sources in the literature on the use of SSC on primary posterior teeth, long-term clinical studies investigating its use in young permanent teeth are few (Heidari et al, 2019; Sigal et al., 2020; Felemban et al., 2021). The reason for this may be the generally temporary use of SSCs in young permanent teeth until the individual aesthetic crown restorations are made.

The long-term success of SSC restorations applied to permanent posterior teeth of 10-15 year-old adolescents has been reported as 86.1% (Felemban et al., 2021).

As a result of a study comparing the clinical success of SSC, amalgam and direct composite resin restorations applied to permanent posterior teeth, the highest success rate was found in SSC (88.1%), then in amalgam (59.3%) and the lowest was in direct composite restorations (41.2%) (Sigal et al., 2020). Researchers stated that PCCs can be a long-term and effective treatment option for the restoration of carious lesions involving 3 or more surfaces of permanent posterior teeth and/or for the replacement of failed conventional restorations (Sigal et al., 2020). In the accessible literature, studies investigating the long-term clinical success of direct composite restorations of carious lesions causing excessive crown destruction of permanent molars in pediatric patients are rare (Zotti et al, 2021). For this reason, it is thought that our study which examines the 3-year survival of direct composite restorations of teeth with excessive material loss in children aged 7-14 years, will contribute to the literature.

Limitation of the study

Although it is known that indirect restorations or stainless-steel crowns perform better than direct restorations especially in terms of anatomical form, marginal leakage and secondary caries for extremely damaged permanent teeth with the criteria specified in the study, direct composite resin restorations are preferred due to financial inadequacies and limited time for restoration during routine dental treatments in public university hospitals. Therefore, direct restorations have been evaluated in this study.

CONCLUSION

Survival rate of DCR restorations applied to PFMs with excessive material loss is not satisfactory after 3 years, however it is thought that the popularity of DCR among dentists will continue in permanent first molars with excessive material loss thanks to the developments in adhesive systems, composite resins and light-curing technology. Therefore, long-term randomized controlled clinical studies on this subject should be maintained.

Acknowledgement

We would like to thank Asst. Prof. Dr. Hande Şenol from Pamukkale University Faculty of Medicine, Department of Biostatistics for the statistical analysis of our study.

Conflict of Interest

The author declares no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Author Contributions

Plan, design: CÇE; **Material, methods and data collection:** CÇE; **Data analysis and comments:** CÇE; **Writing and corrections:** CÇE.

REFERENCES

ADA Council on Scientific Affairs (2003). Direct and indirect restorative materials. *Journal of the American Dental Association* (1939), *134*(4), 463-472. https://doi.org/10.14219/jada.archive.2003.0196

Brunthaler, A., König, F., Lucas, T., Sperr, W., & Schedle, A. (2003). Longevity of direct resin composite restorations in posterior teeth. *Clinical Oral Investigations*, *7*(2), 63-70. https://doi.org/10.1007/s00784-003-0206-7

Carvalho, J. C., Ekstrand, K. R., & Thylstrup, A. (1989). Dental plaque and caries on occlusal surfaces of first permanent molars in relation to stage of eruption. *Journal of Dental Research*, *68*(5), 773-779. https://doi.org/10.1177/00220345890680050401

Cvar, J. F., & Ryge, G. (2005). Reprint of criteria for the clinical evaluation of dental restorative materials. 1971. *Clinical Oral Investigations*, *9*(4), 215-232. https://doi.org/10.1007/s00784-005-0018-z

Deliperi, S., & Bardwell, D. N. (2006a). Direct cuspal-coverage posterior resin composite restorations: A case report. *Operative Dentistry*, *31*(1), 143-150. https://doi.org/10.2341/04-177

Demarco, F. F., Corrêa, M. B., Cenci, M. S., Moraes, R. R., & Opdam, N. J. (2012). Longevity of posterior composite restorations: not only a matter of materials. *DentalMmaterials* : official publication of the Academy of Dental Materials, *28*(1), 87-101. https://doi.org/10.1016/j.dental.2011.09.003

Denehy, G., & Cobb, D. (2004). Impression matrix technique for cusp replacement using direct composite resin. *Journal of Esthetic and Restorative Dentistry* : official publication of the American Academy of Esthetic Dentistry *16*(4), 227-234. https://doi.org/10.1111/j.1708-8240.2004.tb00040.x

Fejerskov, O., Josephsen, K., & Nyvad, B. (1984). Surface ultrastructure of unerupted mature human enamel. *Caries Research*, *18*(4), 302–314. https://doi.org/10.1159/000260781

Felemban, O., Alagl, H., Aloufi, W., & El Meligy, O. (2021). Success Rate of Stainless-steel Crowns Placed on Permanent Molars among Adolescents. International journal of clinical pediatric dentistry, 14(4), 488-491. https://doi.org/10.5005/jp-journals-10005-1982

Fuks A. B. (2000). Pulp therapy for the primary and young permanent dentitions. *Dental Clinics of North America*, *44*(3), 571–vii.

Gaengler, P., Hoyer, I., & Montag, R. (2001). Clinical evaluation of posterior composite restorations: the 10-year report. *The Journal of Adhesive Dentistry*, *3*(2), 185–194.

Galiatsatos, A., Galiatsatos, P., & Bergou, D. (2022). Clinical Longevity of Indirect Composite Resin Inlays and Onlays: An Up to 9-Year Prospective Study. European journal of dentistry, 16(1), 202-208. https://doi.org/10.1055/s-0041-1735420

Gruythuysen, R. J., van Strijp, A. J., & Wu, M. K. (2010). Long-term survival of indirect pulp treatment performed in primary and permanent teeth with clinically diagnosed deep carious lesions. *Journal of Endodontics*, *36*(9), 1490-1493. https://doi.org/10.1016/j.joen.2010.06.006

Heidari, A., Shahrabi, M., Hosseini, Z., & Sari, N. M. (2019). Periodontal Assessment of Permanent Molar Teeth Restored with Stainless Steel Crown in Terms of Pocket Depth, Bleeding on Probing, Gingival Color and Inflammation. *International Journal of Clinical Pediatric Dentistry*, *12*(2), 116-119. https://doi.org/10.5005/jp-journals-10005-1607

Heintze, S. D., & Rousson, V. (2012). Clinical effectiveness of direct class II restorations - a meta-analysis. *The Journal of Adhesive Dentistry*, *14*(5), 407-431. https://doi.org/10.3290/j.jad.a28390

Hickel, R., & Manhart, J. (2001). Longevity of restorations in posterior teeth and reasons for failure. *The Journal of Adhesive Dentistry*, *3*(1), 45–64.

Jang, J. H., Park, S. H., & Hwang, I. N. (2015). Polymerization shrinkage and depth of cure of bulk-fill resin composites and highly filled flowable resin. *Operative Dentistry*, *40*(2), 172-180. https://doi.org/10.2341/13-307-L

Koyutürk, A. E., Ozmen, B., Tokay, U., Tuloglu, N., Sari, M. E., & Sonmez, T. T. (2013). Two-year follow-up of indirect posterior composite restorations of permanent teeth with excessive material loss in pediatric patients: a clinical study. *The Journal of Adhesive Dentistry*, *15*(6), 583–590. https://doi.org/10.3290/j.jad.a30897

Kuijs, R. H., Fennis, W. M., Kreulen, C. M., Roeters, F. J., Verdonschot, N., & Creugers, N. H. (2006). A comparison of fatigue resistance of three materials for cusp-replacing adhesive restorations. *Journal of Dentistry*, *34*(1), 19–25. https://doi.org/10.1016/j.jdent.2005.02.010

Leprince, J. G., Palin, W. M., Hadis, M. A., Devaux, J., & Leloup, G. (2013). Progress in dimethacrylate-based dental composite technology and curing efficiency. *Dental Materials* : official publication of the Academy of Dental Materials, *29*(2), 139–156. https://doi.org/10.1016/j.dental.2012.11.005

Manhart, J., Neuerer, P., Scheibenbogen-Fuchsbrunner, A., & Hickel, R. (2000). Three-year clinical evaluation of direct and indirect composite restorations in posterior teeth. *The Journal of Prosthetic Dentistry*, *84*(3), 289-296. https://doi.org/10.1067/mpr.2000.108774

Pallesen, U., & Qvist, V. (2003). Composite resin fillings and inlays. An 11-year evaluation. *Clinical Oral Investigations*, *7*(2), 71–79. https://doi.org/10.1007/s00784-003-0201-z

Ravasini, F., Bellussi, D., Pedrazzoni, M., Ravasini, T., Orlandini, P., Meleti, M., & Bonanini, M. (2018). Treatment Outcome of Posterior Composite Indirect Restorations: A Retrospective 20-Year Analysis of 525 Cases with a Mean Follow-up of 87 Months. *The International Journal of Periodontics & Restorative Dentistry*, *38*(5), 655-663. https://doi.org/10.11607/prd.3471

Rocha Gomes Torres, C., Caroline Moreira Andrade, A., Valente Pinho Mafetano, A. P., Stabile de Abreu, F., de Souza Andrade, D., Cintra Mailart, M., Aun de Barros Lima Rocha Campello de Souza, M. L., Guimarães Alarça Nunes, L., Ariel Rodrigues de Araújo, C., Di Nicoló, R., & Bühler Borges, A. (2021). Computer-aided design and computer-aided manufacturing indirect versus direct composite restorations: A randomized clinical trial. Journal of esthetic and restorative dentistry : official publication of the American Academy of Esthetic Dentistry ... [et al.], 10.1111/jerd.12820. Advance online publication. https://doi.org/10.1111/jerd.12820

Sigal, A. V., Sigal, M. J., Titley, K. C., & Andrews, P. B. (2020). Stainless steel crowns as a restoration for permanent posterior teeth in people with special needs: A retrospective study. *Journal of the American Dental Association* (1939), *151*(2), 136-144. https://doi.org/10.1016/j.adaj.2019.10.002

Sonkaya, E., Akbıyık, S. Y., Bakır, E. P., & Bakır, Ş. (2021). Posterior Direkt Restorasyonlarda Nerede Başarısızlık Yaşıyoruz? *Düzce Üniversitesi Sağlık Bilimleri Enstitüsü Dergisi*, *11*(2), 242-249.

Statement on posterior resin-based composites. ADA Council on Scientific Affairs; ADA Council on Dental Benefit Programs. (1998). *Journal of the American Dental Association* (1939), *129*(11), 1627-1628.

Thordrup, M., Isidor, F., & Hörsted-Bindslev, P. (2001). A 5-year clinical study of indirect and direct resin composite and ceramic inlays. *Quintessence International* (Berlin, Germany : 1985), *32*(3), 199–205.

Zotti, F., Falavigna, E., Capocasale, G., De Santis, D., & Albanese, M. (2021). Microleakage of Direct Restorations-Comparisonbetween Bulk-Fill and Traditional Composite Resins:Systematic Review and Meta-Analysis. European journal of dentistry, 15(4), 755–767. https://doi.org/10.1055/s-0041-1724155