

THOMAS VON ARX<sup>1</sup>  
SIMONE F. M. JANNER<sup>1</sup>  
STEFAN HÄNNI<sup>2</sup>  
MICHAEL M. BORNSTEIN<sup>3,4</sup>

<sup>1</sup> Department of Oral Surgery and Stomatology, School of Dental Medicine, University of Bern, Switzerland

<sup>2</sup> Private practice in Endodontology, Bern, Switzerland

<sup>3</sup> Oral and Maxillofacial Radiology, Applied Oral Sciences & Community Dental Care, Faculty of Dentistry, The University of Hong Kong, Prince Philip Dental Hospital, Hong Kong SAR, China

<sup>4</sup> Department of Oral Health & Medicine, University Center for Dental Medicine Basel UZB, University of Basel, Basel, Switzerland

#### CORRESPONDENCE

Prof. Dr. Thomas von Arx  
Klinik für Oralchirurgie und Stomatologie  
Zahnmedizinische Kliniken der Universität Bern  
Freiburgstrasse 7  
CH-3010 Bern  
Tel. +41 31 632 25 66  
E-mail:  
thomas.vonarx@zmk.unibe.ch

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## Bioceramic root repair material (BCRRM) for root–end obturation in apical surgery

An analysis of 174 teeth after 1 year

#### KEYWORDS

Apical surgery  
Root–end filling  
BCRRM  
1–year follow–up

#### SUMMARY

The objective of this paper was the analysis of the 1–year outcome of teeth treated with apical surgery and a recently introduced bioceramic root repair material (BCRRM) for root–end filling. Patients were consecutively enrolled from 2015 to 2017. Apical surgery included the modern technique, i.e. the use of a surgical microscope, ultrasonic preparation of a root–end cavity, and retrofilling with BCRRM. The cohort comprised 150 patients with 174 treated teeth. Patients were recalled one year after surgery for a clinical and radiographic re–examination. Three experienced observers evaluated the periapical radiographs with regard to periapical healing utilizing the healing criteria established by RUD ET AL. (1972) and MOLVEN ET AL. (1987). Based on the clinical findings and the radiographic assessment, healing

was judged as successful, uncertain, or failed. Study parameters included gender, age, type of treated tooth, and type of BCRRM (regular vs. fast set putty). At the 1–year follow–up, 170 teeth could be reexamined (drop–out rate 2.3%). Healing outcome was categorized as successful in 94.1%, uncertain in 4.1%, and failed in 1.8%. No significant differences were observed when comparing the success rates among the different subcategories of study parameters. The lowest success rate was noted in mandibular premolars (86.7%) but without reaching statistical significance. In conclusion, BCRRM appears to be a biocompatible root–end filling material showing excellent 1–year results. The success rate was similar to recently reported success rates for BCRRM in apical surgery.

## Introduction

Apical surgery is a treatment option for maintenance of teeth presenting with persistent or recurrent endodontic disease. A key element of apical surgery is the tight sealing of the cut root face using a root-end filling material. In the early 1990s, mineral trioxide aggregate (MTA) was developed at the Loma Linda University in California/USA as a calcium silicate-based cement (CSBC) for, *inter alia*, root-end filling (VON ARX 2016). Given the excellent experimental and clinical results obtained with MTA, researchers were encouraged to investigate modifications of CSBC for endodontic applications. Novel formulations should be less expensive than MTA and improve the handling characteristics, shorten the setting time, avoid tooth discoloration, but still have excellent radiopacity (PARIROKH & TORABINEJAD 2014).

One of these recent CSBC formulations is bioceramic root repair material (BCRRM) manufactured by Brasseler, Savannah, Georgia, USA, and marketed as EndoSequence® (USA) or Total Fill® (outside USA). Chemically, BCRRM is composed of zirconium oxide, calcium silicate, tantalum oxide, calcium phosphate, as well as filler and thickening agents (PARIROKH & TORABINEJAD 2014). The first paper about BCRRM was published by DAMAS ET AL. 2011, demonstrating that BCRRM had a similar cytotoxicity level compared to MTA. In the meantime, preclinical and experimental studies have documented the excellent sealing ability, material stability and biocompatibility of BCRRM (CHEN ET AL. 2015; DE OLIVEIRA ET AL. 2018; TORABINEJAD ET AL. 2018). So far, three clinical studies have evaluated the outcomes of BCRRM as a root-end filling material in apical surgery (SHINBORI ET AL. 2015; ZHOU ET AL. 2017; SAFI ET AL. 2019). Although all studies concluded that BCRRM is a suitable and promising material for root-end obturation, there is a need for further clinical data including larger patient cohorts.

The primary objective of this analysis was the clinical and radiographic healing assessment of consecutively treated teeth one year after apical surgery using BCRRM for root-end filling. Secondary objectives included the statistical analysis of the effects of age, gender, type of treated tooth, and type of BCRRM on the healing outcome.

## Materials and methods

Patients were prospectively enrolled from January 2015 to December 2017. They had all been referred by their private dentists. All patients were informed about the surgical procedure and treatment alternatives. They signed a consent form according to the declaration of Helsinki (www.wma.net). Out of 188 teeth, 14 teeth were excluded for further analysis (Tab. I). All patients were recalled by letter one year after apical surgery for a clinical and radiographic follow-up. No compensation was offered for attending the 1-year re-examination that was, however, free of charge.

### Surgical procedure

All patients were treated by the same surgeon. All apical surgeries were carried out in a dedicated surgical room using a surgical microscope (Möller Denta 300, Haag-Streit International, Köniz, Switzerland; or Zumax OMS 2350, Zumax Medical Co., Suzhou/Jiangsu, China). Prior to the intervention, patients rinsed their mouth with an antiseptic solution (chlorhexidine-digluconate 0.2%). Local anesthesia included articaine 4% and epinephrine 1:100,000 (Ultracain DS forte, Sanofi-Aventis GmbH, Frankfurt, Germany). Following flap elevation, bone

**Tab. I** Numbers of treated and reexamined patients and teeth

	Patients	Teeth
Enrolled	161	188
Excluded <sup>†</sup>	11	14
Included	150	174
Drop-out cases*	4	4
Reexamined at 1 year	146	170

<sup>†</sup> Reasons for exclusion were teeth presenting through-and-through lesions (N = 7), apico-marginal defects (N = 6), or root perforation (N = 1).  
\* One patient could not be contacted; one patient didn't want to attend because of medical issues; two patients had developed vertical root fractures and the teeth were extracted before the 1-year control.

was removed with rotary instruments to expose the root apex. The periapical pathologic tissue was curetted out with surgical spoons and periodontal curettes. Root-ends were resected 3 mm from the apex with a fluted fissure bur as perpendicular as possible relative to the long axis of the root. Hemostasis of the bony crypt was obtained with placement of hemostatic agents (Expasyl™, Produits Dentaires Pierre Roland, Merignac, France; and/or Stasis®, Gingi-Pak, Camarillo CA, USA). Subsequently, a class-1 cavity was prepared into the root-end to a depth of 3 mm using an ultrasonic microtip (Endo Success Apical Surgery Kit, Satelec Acteon, Merignac, France). Root-end filling was accomplished with BCRRM putty (TotalFill®, Brasseler, Savannah GA, USA). The putty was applied in small portions and condensed with pluggers. A rigid endoscope (Hopkins Tele Oscope, K. Storz GmbH, Tuttlingen, Germany) was used for inspection of the cut root face, the retrograde cavity and the finished root-end filling. After thorough cleaning and rinsing of the surgical site, wound margins were re-approximated with single interrupted sutures (Seralon® 5-0, 6-0, or 7-0, Serag-Wiessner GmbH, Naila, Germany). Wet gauze was placed on the flap for slight compression for a duration of 30 minutes. Medication included non-steroidal analgesics (ibuprofen, dosage according to body weight) and chlorhexidine-digluconate 0.2% mouth rinse. Sutures were removed usually 4 to 7 days after surgery. At the same time, a postsurgical radiograph was taken.

### Follow-up examination

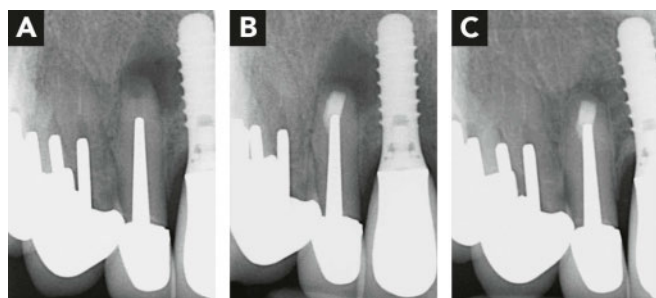
The clinical examination after one year included:

- Inspection and palpation of the treated tooth and the previous surgical site;
- Percussion and mobility testing of the treated tooth;
- Periodontal probing of the treated tooth.

Clinical signs and symptoms of persistent infection were pain, fistula, apico-marginal communication, and/or swelling.

### Radiographic assessment

Non-standardized periapical radiographs were taken pre- and postoperatively as well as one year after surgery. Three experienced observers, who had not been involved in the treatment of the patients, independently assessed the 1-year follow-up radiographs with regard to periapical healing according to the criteria described by RUD ET AL. (1972) and MOLVEN ET AL. (1987): complete healing, incomplete healing (scar tissue formation),



**Fig. 1** Apical surgery of the right maxillary lateral incisor in a 62-year-old female. (A) preoperative radiograph, (B) postoperative radiograph, (C) 1-year radiograph. The case was classified as successful.



**Fig. 2** Apical surgery of both buccal roots of the left maxillary first molar in a 39-year-old female. (A) preoperative radiograph, (B) postoperative radiograph, (C) 1-year radiograph. The case was classified as successful.



**Fig. 3** Apical surgery of the left mandibular second premolar in a 57-year-old female. (A) preoperative radiograph, (B) postoperative radiograph, (C) 1-year radiograph. The case was classified as successful.



**Fig. 4** Apical surgery of both roots of the right mandibular first molar in a 37-year-old female. (A) preoperative radiograph, (B) postoperative radiograph, (C) 1-year radiograph. The case was classified as successful.



**Fig. 5** Apical surgery of the mesial root of the right mandibular first molar in a 42-year-old male. (A) preoperative radiograph, (B) postoperative radiograph, (C) 1-year radiograph. The case was classified as uncertain.

uncertain healing, and unsatisfactory healing. In teeth with apical surgery on multiple roots, the worst healing category was used for categorizing the radiographic healing of the respective tooth.

Each observer performed two evaluations of all cases – at least four weeks apart – to determine the intraobserver agreement. The second ratings of the three observers were used for further analysis of healing and of interobserver agreement according to the following rules:

- Full agreement: all three observers had the same rating;
- Partial agreement: two out of three observers had the same rating;

- No agreement: each observer had a different rating of the healing. The rating of the “middle” observer was used for the final analysis.

Overall healing was divided as follows:

- *Success*: no clinical signs/symptoms and complete or incomplete radiographic healing (Fig. 1–4);
- *Uncertain*: no clinical signs/symptoms and uncertain radiographic healing (Fig. 5);
- *Failure*: no clinical signs/symptoms and unsatisfactory radiographic healing, as well as all cases presenting clinical signs/symptoms irrespective of the radiographic healing classification.

### Subcategories of study variables

- *Gender*: male, female
- *Age*: two age groups (<45 years, ≥45 years; age threshold chosen according to VON ARX ET AL. 2010)
- *Type of treated tooth*: six tooth groups (maxillary anteriors = incisors and canines, maxillary premolars, maxillary molars, mandibular anteriors, mandibular premolars, mandibular molars)
- *Type of BCRRM*: regular putty (used from January 2015 to September 2016), fast set putty (used from October 2016 to December 2017)

### Statistics

The data was first analyzed descriptively. Intraobserver as well as interobserver agreement were assessed by Cohen’s and Fleiss’ kappa tests, respectively (LANDIS & KOCH 1977). In patients having multiple teeth treated with apical surgery, one single tooth was randomly selected (QuickCalc, GraphPad Software Inc, La Jolla, USA) for further statistical analysis of the variables per subcategory. Separate Fisher’s exact tests were performed to test if the subcategories might influence the outcome (successful vs. failed/uncertain cases). All of the tests were two-tailed tests with the 0.05 significance level performed by IBM SPSS Statistics for Windows Version 26 (IBM Corp., Armonk, NY, USA).

### Results

At the 1-year follow-up, 170 teeth could be reexamined in 146 patients (59 males and 87 females). Four teeth were lost for follow-up (= drop-out rate of 2.3%). The mean age was 56.0±14.1 years (range 25 to 82 years). Kappa-values for intraobserver agreement of radiographic healing were 0.628 (substantial agreement). Kappa-values for interobserver agreement were 0.493 (moderate agreement). Nevertheless, in 78.6% all three observers had the same rating of radiographic healing. In 20.8%, the ratings of two observers concurred, and in only one case (0.6%), each of the three observers had a different rating.

Overall healing outcome was judged as successful in 94.1%, uncertain in 4.1%, and failed in 1.8% (Tab. II). Success rates with regard to the different subcategories are presented in Table III. No significant differences were observed when comparing the success rates among the subcategories. The lowest success rate was noted in mandibular premolars (86.7%) but without reaching statistical significance.

### Discussion

This analysis evaluated the 1-year outcome of teeth treated with apical surgery and BCRRM for root-end filling. So far,

Radiographic healing	Clinical situation	N	Healing classification	N	Percentage
Complete	without signs	145	successful	160	94.1
Incomplete	without signs	15			
Uncertain	without signs	7	uncertain	7	4.1
	with signs	1	failed	3	1.8
Unsatisfactory	–	0			
No 1-year radiograph, since the teeth had been removed before the 1-year follow-up (recurrent infection with swelling)		2			
Total	–	170	–	170	100

		N	N successful	% successful	p-value (for N = 146, 137 “success” vs. 9 “uncertain and failure cases”)	p-value (for N = 140, 137 “success” vs. 3 “failure cases”, excluding “uncertain cases”)
					Fisher’s exact test	Fisher’s exact test
All		146	137	93.8	NA	NA
Gender	Male	59	54	91.5	0.485	1.000
	Female	87	83	95.4		
Age group	Age <45 years	36	35	97.2	0.453	0.573
	Age ≥45 years	110	102	92.7		
Tooth group	Maxillary anteriors*	42	40	95.2	0.514	0.124
	Maxillary premolars	21	21	100		
	Maxillary molars	28	25	89.3		
	Mandibular anteriors*	4	4	100		
	Mandibular premolars	15	13	86.7		
	Mandibular molars	36	34	94.4		
BCRRM	Regular putty	68	64	94.1	1.000	0.602
	Fast set putty	78	73	93.6		

\*Anteriors = incisors and canines

it is the clinical study with the largest cohort of patients with a 1-year follow-up documentation of BCRRM for root-end filling (Tab. IV). The success rate of 94.1% is similar to the success rates (92–94.4%) of previous short-term follow-up studies about the use of BCRRM in apical surgery (SHINBORI ET AL. 2015; ZHOU ET AL. 2017; SAFI ET AL. 2019). Two of those studies compared BCRRM to MTA in a randomized clinical trial, and both studies reported similar success rates for the two root-end filling materials (ZHOU ET AL. 2017; SAFI ET AL. 2019). In addition, Safi and co-workers assessed the radiographic healing two- (periapical radiographs, PA) and three-dimensionally (cone beam computed tomography, CBCT). BCRRM exhibited success rates of 92% versus 84% comparing PA and CBCT, thus resulting in a difference of 8%. Other studies have corroborated that CBCT imaging shows lower success rates than PA (CHRISTIANSEN ET AL. 2009; TANOMARU-FILHO ET AL. 2015; VON ARX ET AL. 2016; SCHLOSS ET AL. 2017).

The strengths of the present paper include the large number of treated cases (174 teeth), a very low rate of drop-out cases (2.3%), a single and experienced surgeon performing all surgeries, and three qualified observers evaluating the follow-up radiographs. Weaknesses are that the radiographic healing was only assessed two-dimensionally (mesio-distal plane), and that information about non-surgical retreatment before surgery was either not available or not reliable.

The statistical analysis of the success rates with regard to the different study variables showed no significant effects on the healing outcome. As a post-hoc power analysis based on the success rate of 93.8%, the studied sample size (N = 146) can only have 80% power to detect around 15–20% of difference at the 0.05 significance level. That means if the success percentage difference is not larger than around 20%, then no significant results can be found, as demonstrated in Table III.

Tab. IV Summary of clinical studies on apical surgery using BCRRM for root-end filling

Authors/year	Study type (treatment period)	Setting/country/ N surgeons	BCRRM	Follow-up	N initial	N final	Drop-out rate	Healing criteria N observers	Outcome
SHINBORI ET AL. 2015	Retrospective cohort (2009–2013)	Private endodontic office/USA/1 surgeon	Endo Sequence (Brasseler)	12–33 months (mean 14.5)	Unknown	113 teeth (94 patients)	Unknown	Rud/Molven 2 observers	81.4% healed 10.6% healing 8% non-healing (92% success)
ZHOU ET AL. 2017	RCT* (2012–2015)	Dental hospital/ China/1 surgeon	iRoot BP Plus (BioCeramix)	1 year	120 teeth	71 teeth	40.8% (49 teeth)	Rud/Molven 2 observers	74.6% healed 19.8% healing 5.6% non-healing (94.4% success)
SAFI ET AL. 2019	RCT* (2011–2014)	University clinic/USA/ multiple surgeons (postgraduate residents)	Endo Sequence (Brasseler)	15 months	Unknown+	63 teeth	Unknown+	PA: Rud/Molven CBCT: modified PENN 3D criteria 3 observers	PA: 92% success CBCT: 84% success
Present paper	Prospective cohort (2015–2017)	University clinic/ Switzerland/1 surgeon	TotalFill (Brasseler)	1 year	174 teeth (150 patients)	170 teeth (146 patients)	2.3% (4 teeth)	Rud/Molven 3 observers	94.1% successful 4.1% uncertain 1.8% failed

BCRRM = bioceramic root repair material  
 \* Randomized clinical trial comparing BCRRM and MTA (results of MTA are not shown)  
 + Initially, 243 teeth were included (MTA or BCRRM, N per group not specified); the final sample was 120 teeth (57 MTA, 63 BCRRM); overall drop-out rate 123/243 = 50.6%

From a clinical standpoint, the BCRRM material is easier in handling and application, compared, for example, to MTA. Since the putty material is premixed, it always has the same consistency, is ready to be placed into the root-end cavity, and is less likely to be washed out when rinsing the surgical site before wound closure.

From a biological perspective, it was recently demonstrated in an in vitro study using a murine osteoblast precursor cell line that BCRRM had excellent biocompatibility, even at high concentrations. Furthermore, the material significantly enhanced osteoblastic differentiation, highlighting the osteogenic potential (GIACOMINO ET AL. 2019). These in vitro findings were corroborated in a dog study (CHEN ET AL. 2015). Six months after apical surgery, histologic assessment demonstrated no or only minimal inflammatory response of the tissues adjacent to the treated root ends, coverage of the resected surface and of the BCRRM material with mineralized cementum-like tissue, and periodontal ligament-like tissue in the vicinity of the resected root ends. Due to these inductive material characteristics, PARIROKH ET AL. (2018) suggested the term “bioactive endodontic cements (BEC)” instead of referring to the cements based on their chemical compositions.

In conclusion, BCRRM is a biocompatible root-end filling material showing excellent 1-year results after apical surgery. Long-term studies will reveal if the premixed material will live up to the high expectations.

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## Conflict of interest

The authors declare that there are no conflicts of interest related to this review.

## Zusammenfassung

### Einleitung

Die apikale Chirurgie ist eine Option zur Erhaltung von Zähnen mit persistierender oder rezidivierender endodontischer Infektion. Ein entscheidender Faktor für den Erfolg der apikalen Chirurgie ist die retrograde Füllung zur Abdichtung des Pulpakanalsystems an der Resektionsfläche. Die erfolgreiche Anwendung von Mineral Trioxide Aggregate (MTA) als retrogrades Füllmaterial seit den frühen 1990er Jahren hat die Entwicklung biokompatibler Verschlusszemente für die apikale Chirurgie weiter gefördert. Einer dieser neusten Zemente ist Bioceramic Root Repair Material (BCRRM). Das primäre Ziel dieser Analyse war die klinische und radiologische Auswertung von mit BCRRM behandelten Zähnen ein Jahr nach apikaler Chirurgie. Sekundär sollten Alter, Geschlecht, behandelter Zahn und Typ des BCRRM (= Studienparameter) als mögliche beeinflussende Faktoren statistisch analysiert werden.

## Material und Methoden

Von Januar 2015 bis Dezember 2017 wurden 188 Zähne (bei 161 Patienten) mit apikaler Chirurgie/BCRRM behandelt. Die

Patientenaufklärung und Rekrutierung erfolgte gemäss den Richtlinien der Helsinki-Deklaration ([www.wma.net](http://www.wma.net)). Für die weitere Analyse wurden 14 behandelte Zähne aus folgenden Gründen ausgeschlossen: Wurzelperforation, tunnelierende Läsion, apiko-marginale Läsion. Insgesamt konnten 174 Zähne von 150 Patienten evaluiert werden. Alle Eingriffe erfolgten durch den gleichen Operateur, in einem chirurgischen Operationsaal und mittels mikrochirurgischem Vorgehen (Mikroskop, Mikrospritzen für die retrograde Aufbereitung, endoskopische Kontrollen nach Resektion, Retropräparation und Retrofüllung). Beim verwendeten BCRRM-Füllmaterial handelte es sich um TotalFill® («regular or fast set putty») der Firma Brasseler, Savannah/Georgia, USA. Alle Patienten wurden nach einem Jahr für eine klinische und radiologische Kontrolle aufgebeten. Die 1-Jahres-Röntgenbilder wurden von drei erfahrenen Examinatoren unabhängig voneinander nach den Kriterien von RUD ET AL. (1972) und MOLVEN ET AL. (1987) analysiert. In Zusammenhang mit dem klinischen Befund wurde dann jeder behandelte Zahn als Erfolg, als unsicher oder als Misserfolg bewertet. Statistisch wurden die Übereinstimmungen der radiologischen Bewertungen pro Examinator, aber auch unter den drei Examinatoren sowie die oben erwähnten Studienparameter als mögliche beeinflussende Faktoren analysiert.

## Resultate

Bei der Jahreskontrolle konnten insgesamt 170 Zähne bei 146 Patienten beurteilt werden (entspricht einer Ausfallrate von nur 2,3%). Das Durchschnittsalter der Patienten war  $56 \pm 14,1$  Jahre. Die Heilung wurde in 94,1% als Erfolg, in 4,1% als unsicher, und in 1,8% als Misserfolg bewertet. Die statistische Analyse ergab keine signifikanten Unterschiede für die Variablen der Studienparameter Alter, Geschlecht, Zahntyp und BCRRM. Die geringste Erfolgsrate zeigte Unterkieferprämolaren (86,7%).

## Diskussion

Die vorliegende prospektive 1-Jahres-Analyse zeigte eine ähnliche Erfolgsrate (94,1%) wie die bisherigen publizierten Erfolgsraten (92–94,4%) von klinischen Studien über BCRRM als Verschlusszement in der apikalen Chirurgie. Die Stärken der vorliegenden Arbeit umfassen die bisher grösste publizierte Fallzahl zu BCRRM, die sehr tiefe Ausfallrate nach 1 Jahr, nur ein Behandler und drei nicht in die Chirurgie involvierte, erfahrene Examinatoren zur Auswertung der 1-Jahres-Röntgenbilder. Als Schwächen müssen die nur zweidimensionale radiologische Beurteilung der periapikalen Ausheilung und fehlende Angaben, ob die bestehende Wurzelkanalfüllung vor der Chirurgie revidiert worden war, genannt werden. Aus klinischer Sicht ist das vorangemischte BCRRM im Vergleich zu MTA einfacher im Handling bzw. in der Applikation. Bisherige In-vitro- und tierexperimentelle Studien bestätigen zudem die hohe Biokompatibilität von BCRRM.

## Résumé

### Introduction

La chirurgie apicale est une option pour préserver les dents présentant une infection endodontique persistante ou récurrente. La fermeture hermétique à rétro du système canalaire est un facteur décisif pour le succès de l'apicectomie. L'application réussie de l'agrégat minéral de trioxyde (MTA) en tant que matériau d'obturation rétrograde depuis le début des années 1990 a favorisé le développement d'autres ciments biocompatibles pour la chirurgie apicale. Un de ces nouveaux ciments est le

matériau de réparation prémélangé en biocéramique (BCRRM). L'objectif principal de cette analyse était l'évaluation clinique et radiographique des dents traitées au BCRRM un an après la chirurgie apicale. Deuxièmement, l'âge, le sexe, le type de dent traitée et le type de ciment utilisé (= paramètres de l'étude) ont été analysés statistiquement comme facteurs d'influence potentiels.

## Matériels et méthodes

De janvier 2015 à décembre 2017, 188 dents (chez 161 patients) étaient traitées avec apicectomie et BCRRM. Le recrutement ainsi que l'information préopératoire se sont déroulés conformément aux directives de la déclaration d'Helsinki ([www.wma.net](http://www.wma.net)). Pour l'analyse, 14 dents traitées ont été exclues pour les raisons suivantes: perforation radiculaire, lésion communicante palato-labiale, lésion apico-marginale. Au total, 174 dents de 150 patients ont pu être évaluées. Toutes les procédures ont été effectuées par le même chirurgien, dans une salle d'opération chirurgicale et au moyen de procédures microchirurgicales (microscope, micro-embouts pour préparation rétrograde, examen endoscopique après résection, préparation rétrograde et obturation de la cavité). Le matériau d'obturation utilisé était le TotalFill® («regular putty» ou «fast set putty») de Brasseler, Savannah/Georgia, USA. Tous les patients ont été convoqués pour un contrôle clinique et radiologique après un an. Les radiographies ont été analysées indépendamment par trois examinateurs expérimentés selon les critères de RUD ET AL. (1972) et MOLVEN ET AL. (1987). En conjonction avec les résultats cliniques, chaque dent traitée a ensuite été classée comme succès, douteuse ou échec. Statistiquement, les corrélations des scores radiologiques pour chaque examinateur, mais aussi entre les trois examinateurs, ainsi que les paramètres de l'étude susmentionnés ont été analysés comme facteurs d'influence possibles.

## Résultats

Un total de 170 dents ont été évaluées chez 146 patients (ce qui équivaut à un taux de perte de cas de seulement 2,3%). L'âge moyen des patients était de  $56 \pm 14,1$  ans. La guérison a été jugée réussie dans 94,1% des cas, douteuse dans 4,1% et comme échec dans 1,8%. L'analyse statistique n'a révélé aucune différence significative pour les variables de l'étude: âge, sexe, type de dent et de matériau BCRRM. Le taux de succès le plus bas a été observé chez les prémolaires de la mâchoire inférieure (86,7%).

## Discussion

L'analyse prospective sur un an a montré un taux de succès similaire (94,1%) aux taux de succès publiés antérieurement (92 à 94,4%) pour le BCRRM en tant que matériau d'obturation rétrograde. Les points forts de la présente publication sont: elle comprend le plus grand nombre de cas jamais publiés pour le BCRRM, très peu de dents perdues au suivi, traitements effectués par un seul chirurgien, évaluation des radiographies d'un an par trois examinateurs expérimentés. Les points faibles de l'étude sont: évaluation de la guérison périapicale uniquement sur la base de radiologies bidimensionnelles et le manque d'information sur la question si l'obturation du canal radiculaire existante a été révisée avant la chirurgie apicale. D'un point de vue clinique, le matériau de réparation prémélangé en biocéramique (BCRRM) est plus facile à manipuler resp. à appliquer que le MTA. De plus, des études in vitro et animales antérieures ont confirmé la haute biocompatibilité du BCRRM.

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