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Follow-up dental examination a day after apicoectomy using the store-and-forward method

Kontrolni postoperativni pregled dan posle apikotomije „store-and-forward" metodom

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Abstract

Background/Aim. Although apicoectomy is performed routinely and yields excellent results, a close patient observation during the postoperative course is desirable in order to avoid possible complications. The aim of this study was to investigate the adequacy of postoperative control visits a day after surgery using the store-and-forward telemedicine method compared to the clinical in-person controls. **Methods.** A total of 122 apicoectomies were performed during 115 dental surgery interventions. The follow-up dental examination a day after apicoectomy consisted of reviewing extraoral and intraoral photographs on the internet and reviewing responses to the questionnaire. After that, patients were examined in-person. Cohen's kappa („store-and-forward" method) coefficient, diagnostic sensitivity (SE), sensitivity (SP), and efficiency (EFF) were determined. Statistical comparisons were performed using the Z-test, and nonparametric characteristics were tested using McNemar's χ^2-test at the statistical significance cut-off value of $p = 0.05$. **Results.** There were 106 (92%) patients seen at the control dental examination. The agreement between in-person and store-and-forward telemedicine method was found in 104 (98%) cases. The obtained agreement values (K = 0.85, S = 0.99, SP = 0.86, EFF = 0.98) indicated an almost complete diagnostic agreement. **Conclusion.** Based on the internet transmission of patients' digital photographs and accompanying patient medical history records, the study showed that the in-person control dental examinations a day after surgery can be successfully replaced with the remote store-and-forward method of telemedicine.

Key words:
apicoectomy; dental root; dentistry; oral surgical procedures; sensitivity and specificity; telemedicine.

Apstrakt

Uvod/Cilj. Mada se apikotomija rutinski izvodi i daje veoma uspešne rezultate, neophodno je kod pacijenta adekvatno ispratiti postoperativni tok zbog eventualnih komplikacija. Cilj ovog istraživanja bio je da se ispita pouzdanost postoperativne kontrole dan posle intervencije „store-and-forward" metodom u odnosu na „in-person" kontrolu na klinici. **Metode.** Urađene su ukupno 122 apikotomije tokom 115 hirurških operacija. Kontrolni pregled dan posle apikotomije urađen je pregledom ekstraoralnih i intraoralnih fotografija pacijenta preko interneta i pregledom datih odgovora na upitnik, kao i naknadnim pregledom pacijenta „in-person". U cilju procene pouzdanosti „store-and-forward" metode određeni su parametri saglasnosti sa "in-person" metodom: Cohen-ov kappa (κ) koeficijent, dijagnostička senzitivnost (SE), specifičnost (SP) i efikasnost (EFF). Statističko poređenje vršeno je Z-testom, a testiranje neparametarskih obeležja McNemar-ovim χ^2 testom za prag značajnosti od $p = 0.05$. **Rezultati.** Na kontrolni pregled javilo se 106 (92%) pacijenata. Slaganje između „in-person" direktnog pregleda i „store-and-forward" metode telemedicine nađeno je kod 104 (98%) pacijenata. Dobijene vrednosti saglasnosti bile su κ = 0,85, SE = 0,99, SP = 0,86, EFF = 0,98, što ukazuje na skoro potpunu dijagnostičku saglasnost. **Zaključak.** Bazirana na internet prenosu digitalnih fotografija pacijenta i pratećih anamnestičkih podataka, ova studija je pokazala da se kontrolni pregled „in-person", dan posle izvršene apikotomije, može adekvatno zameniti udaljenim „store and forward" telemedicinskim pregledom.

Ključne reči:
apikotomija; zub, korenski kanal; stomatologija; hirurgija; oralna, procedure; senzitivnost i specifičnost; telemedicina.

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Introduction

An ideal method of telemedicine would be almost identical to the one described several thousand years ago: an individual with a disease, regardless of his/her whereabouts, contacts the physician (his/her words reaching the physician faster than light), and the physician (using a magic cure) heals the patient from a large distance[1]. Although having been sought for thousands of years, we are still thriving to reach the ideal method.

Dental treatment, which has been greatly improved in the recent decades, has made the preservation of many natural teeth possible with minimal collateral damage [2]. Apicoectomy (periapical surgery) is a combined method, representing the last line of defence of a natural tooth before extraction. Apicoectomy is indicated when non-surgical approaches of endodontics are unable to preserve the tooth, and it is performed routinely in appropriate cases [3, 4]. Apicoectomy itself is an oral surgery approach that removes the apical portion of the dental root and the adjacent tissue all the way to the healthy tissue, with a success rate ranging from 65% to 95.2%, depending on various factors, such as the type of indication for surgery, tooth type, patient's age, etc. [5–7].

Apicoectomy is usually performed under local anaesthesia, in a single surgical session, after which postoperative therapy is always prescribed to the patient and he/she is discharged from the clinic. Certain discomforting sensations are often felt after the surgery, usually implying postoperative pain, swelling, difficulty swallowing, and similar [8]. A control dental follow-up examination is therefore necessary, for which an appointment has to be made. At this examination, a dental surgeon usually establishes local and general findings after surgery. Although a level of discomfort is usual and expected after apicoectomy, some minor or major postoperative complications may occur as well. Based on the aforementioned control examination, an insight is made, and decisions are agreed upon on the continuation, change, or supplementation of the prescribed postoperative therapy [9–15]. Because of the importance of the follow-up of the postoperative course, this control dental follow-up examination is strongly recommended a day after periapical surgery [16].

Our study aimed to investigate the validity of the remote postoperative control examination a day after dental apicoectomy, using the store-and-forward method.

Methods

In the period from 2016 to 2018, this experimental randomized study, performed at the Faculty of Medicine in Kosovska Mitrovica, Serbia, included 97 randomly selected patients of both genders, aged 14 to 77 years (mean age, 37 years; range, 14–77 years). The study was approved by the Ethics Committee of the Faculty of Medicine in Kosovska Mitrovica. There were 34 men and 63 women. There were 122 apicoectomies in total, out of which 70 were performed in the upper jaw and 52 in the lower jaw, 37 (53%) incisors and canines, [25 (36%) premolars and 8 (11%)] molars, [23 (44%) incisors and canines, 22 (42%) premolars and (13%)] molars. There were 60 (49%) incisors and canines in total, 47 (39%) premolars and 15 (12%) molars. The reasons for apicoectomy were as follows: a) periapical disease of the permanent tooth after the failure of endodontic treatment; b) periapical disease of the tooth which had been prosthetically or conservatively managed and the removal of which was not easily feasible; c) radiotransparent lesion of 8 mm or more in size; d) forced root canal filling or the presence of a foreign body which could not be removed in an orthograde fashion; and e) other indications (the patient insisting on endodontic-surgical management in a single session, dental root fracture in the apical third, etc.) [17].

There were 131 dental roots with performed apicoectomy, out of which 107 (82%) were filled in an orthograde and 16 (12%) in a retrograde fashion. Reintervention was done in 8 (6%) cases.

There were 115 apicoectomies, out of which sulcular flap was used in 25 (22%) cases, triangular flap in 21 (18%), trapezoidal flap in 25 (22%), semilunar flap in 25 (22%), submarginal scalloped flap in 6 (5%), submarginal straight flap in 10 (9%), and vertical flap in 3 (3%) cases (acc. Eskici) [18].

Out of 115 performed apicoectomies, control follow-up examination was done in 106 (93%) cases a day after surgery, while in 9 (7%) cases, the patients did not show up for the follow-up examination. The control examination a day after apicoectomy was performed in the following way. Patients were seen by a dentist who did not perform the periapical surgery. Three extraoral photographs were taken of the patient's head: one facial and two *en face* bilaterally, as well as one intraoral photograph focusing on the area of the apicoectomy, with lips and cheeks retracted by an assistant. The photographs were taken using Samsung S7 Galaxy EDGE mobile phone (SM-G935F), measuring 2595 × 1458 pixels, with a horizontal and vertical resolution of 150 dpi and 24 bits and sRGB colour representation, in jpg format. The photographs were taken using the flashlight, regardless of the lighting conditions in the examination room. The distance between the patient and the camera was 5–10 cm for the intraoral photo and 30–50 cm for the extraoral photo. Patients were also asked to respond to a questionnaire that consisted of the following seven questions: How are you today? Do you have any pain? Do you take your prescribed therapy regularly? Is your swelling enlarging or reducing? Was there any bleeding? Are there any discomforts or similar complaints? If there are, name and describe them? Other comments? [8, 10–13,16].

The photographs taken were uploaded to a web server [the web server represented an internally developed ASP.NET Internet application, at the web address *teleapicoectomy.xpa3.com*, the access to which was authorized, authenticated, and protected using a 256-bit SSL (Secure Sockets Layer) security protocol]. The web server application made a recording for the postoperative follow-up control examination, written down in the Microsoft SQL Server 2014 Express database. Three

individual jpg files were uploaded and recorded onto the SSD server disk, with each file getting a unique name based on the generation of GUID value [19] and jpg file extension. The names of the files generated were thus written into the database table, serving as a reference for subsequent access to these files. Into the other database fields, responses to the questionnaire were entered, as well as other associated service information (upload information, such as date, time, user, and similar). Data collection and the upload were thus completed.

A digital telemedical control examination followed after that. An oral surgeon accessed the server application at the web address *teleapicoectomy.xpa3.com*, and after authentication and authorization, under a 256-bit security protocol, examined the patient virtually, based on the four photographs and the questionnaire responses presented to him/her on the HTML page of the browser. A click on the photograph opened it in a separate window – it was possible to enlarge or additionally manipulate the photo in other ways. Based on the performed digital examination, the oral surgeon established the teledentistry status of the patient in question, i.e. his/her postoperative diagnosis. After the digital follow-up control examination, the oral surgeon directly (in-person) examined the patient in the dental examination chair for about 10 min. Thereafter, the oral surgeon established the postoperative status of the patient again for postoperative diagnosis.

The degree of diagnostic accuracy was determined in accordance with the following scale: correct – if the telemedicine postoperative diagnosis was identical to the primary diagnosis or was an acceptable differential diagnosis, and incorrect – if the telemedicine postoperative diagnosis completely differed from the primary diagnosis, or the diagnosis was not established at all.

Statistical data processing and the analysis of the obtained results was performed using the Med Calc version 18.6 for Windows and DAG (diagnostic and agreement statistics software) [20]. The agreement between examinations was obtained as the ratio of the number of examinations with an agreement and the total number of examinations. Sensitivity (SE), specificity (SP), and efficiency (EFF) were also measured. The degree of the obtained agreement between examinations using the method of telemedicine was established using the Cohen's kappa (κ) coefficient. Kappa coefficient for the confidence interval of 95% was presented in accordance with the Landis and Koch scale (Table 1). Statistical significance of the differences between the correct and incorrect diagnoses, accuracy, SE and SP, and comparisons of all the obtained values were performed using the Z-test, and testing for nonparametric characteristics, which was done using McNemar's chi-squared (χ^2) test (contingency table 2×2) at the significance threshold of $p = 0.05$.

Table 1

Kappa coefficient and degree of diagnostic agreement (Landis and Koch)

Kappa coefficient	Degree of agreement
< 0	No agreement
0.01–0.20	Slight agreement
0.21– 0.40	Sufficient agreement
0.41–0.60	Moderate agreement
0.61–0.80	Considerable agreement
0.81–0.99	Almost complete agreement
1	Complete agreement

Results

Out of 115 apicoectomies, 106 (92%) were subjected to the follow-up control examination a day after the intervention, while 9 (8%) did not (Table 2).

Oral surgeons reported general and local findings in 99 (94%) cases out of 106 cases using both methods (telemedicine and in-person), with the previously prescribed postoperative therapy to be continued without any changes. Out of that, the findings were identical (in order) in 98 (92%) cases, while in one case, telemedicine findings showed continuance and compliance with the prescribed therapy, and in-person findings showed that postoperative antioedematous therapy could be withdrawn. Furthermore, in one case, telemedicine indicated the need for antibiotic and antioedematous therapy to be increased, and the in-person method showed that the findings were in order, without the need to correct the therapy.

In 7 (7%) cases, both methods indicated a need for changing the postoperative therapy. Nevertheless, 6 out of 7 (86%) cases were identical, while 1 (14%) case was

Table 2

General data on patients and apicoectomies

Parameters	Overall, n/N (%)	Men, n/N (%)	Women, n/N (%)
Patients	97/97 (100)	34/97 (35)	63/97 (65)
Apicoectomies	115/115 (100)	38/115 (3)	77/115 (67)
Apicoectomies subjected to control examination			
yes	106/115 (92)	35/106 (33)	71/106 (67)
no	9/115 (8)	3/9 (33)	6/9 (67)

n – number of cases; N – total number.

Table 3

Agreement between two methods (in-person and telemedicine) in relation to prescribed postoperative therapy after control examination

Parameters	In-person n/N (%)	Telemedicine n/N (%)
Analyzed cases	99/106 (93)	99/106 (93)
prescribed therapy	98/99 (99)	98/99 (99)
identical findings	1/99 (1)	1/99 (1)
Additional treatments suggested	7/99 (7)	7/99 (7)
removal of one or more sutures	1/7 (14)	1/7 (14)
drain placement	1/7 (14)	1/7 (14)
correction of antibiotic therapy	6/7 886)	7/7 (100)
correction of antioedematous therapy	3/7 (43)	2/7 (29)

n – number of cases; N – total number.

differently assessed by different methods. The difference was reflected in different assessments of the size and characteristics of postoperative oedema and in the consequential correction of postoperative therapy (Table 3).

Out of 106 control follow-ups, the agreement of in-person direct examination and the store-and-forward method was found in 104 (98%) cases (Table 4). The obtained agreement values were as follows: kappa = 0.85, SE = 0.99, SP = 0.86, EFF = 0.98, indicating an almost complete diagnostic agreement (Table 5). Diagnostic differences between these two methods were not statistically significant.

Table 4

Agreement (kappa)

Telemedicine	In-person		
	0	1	
0	98	1	99 (93.4%)
1	1	6	7 (6.6%)
	99 (93.4%)	7 (6.6%)	

Weighted Kappa: 0.84704; Standard error: 0.10617; 95% confidence interval: 0.63896 – 1.00000.

Table 5

Agreement statistics

Sensitivity = 0.99 (95% CI: 0.95–1.00)
Specificity = 0.86 (95% CI: 0.42–1.00)
Efficiency (Correct classification rate) = 0.98 (95% CI: 0.93–1.00)
Cohen's Kappa = 0.85 (95% CI: 0.64–1.06)
This kappa indicates almost perfect agreement.
Test of Ho: Kappa = 0: z = 8.72, *p* = 0.0000 t.t.t.
Observed agreement = 0.98 (95% CI: 0.93–1.00)
Chance agreement = 0.88 (95% CI: 0.00–0.00)
Positive agreement = 0.99 (95% CI: 0.98–1.00)
Negative agreement = 0.86 (95% CI: 0.66–1.05)

CI – confidence interval.

Discussion

The focus of our research was the real possibility of a remote follow-up of the patient's recovery a day after oral surgery, apicoectomy. Based on the internet transmission of digital photographs of the studied patients and their responses to the questionnaire, our study showed that the in-person follow-up examination could be successfully replaced with the remote store-and-forward telemedical examination, with considerable time-saving effect for both the patient and his/her dentist.

In fact, the primary concern of a dentist after apicoectomy is the postoperative recovery of the patient. This involves the exclusion of postoperative complications, or if they still occur, their timely diagnosis and adequate therapeutic management. Timely and proper postoperative diagnosis prevents the progress of possible postoperative complications and speeds up the patient's recovery all the way until he/she is completely healed [16]. Our study demonstrates that the telemedical approach can be used to follow up the patient and to adequately assess the need for postoperative therapy correction. It should be mentioned that there were no misdiagnoses of postoperative complications or the need for additional treatment corrections when the telemedical approach was used. In cases when telemedical postoperative control examination after apicoectomy indicates complication development or the need for therapy correction, oral surgeons may react remotely and correct the therapy or, if needed, refer the patient for hospital treatment.

The concept represents an advancement of the initial idea that teledentistry is primarily intended to help dentists manage patients remotely [21]. In fact, in an age of smartphones with quality cameras widely available and widespread internet access, an idea readily comes to mind that patients may take a couple of selfies, write a few comments about their condition, and thus report their postoperative status to the dentist without leaving their home (naturally, with some appropriate instructions or perhaps a step-by-step tutorial).

We were unable to find any studies in the literature investigating the possibility of using telemedicine in the follow-up after oral surgery (nor after dental treatments for that matter). However, there are several studies dealing with the postoperative recovery of patients in other medical disciplines. A study investigating the online postoperative recovery of general surgery patients of the Vanderbilt University Medical Center, and patients who underwent elective laparoscopic cholecystectomy, laparoscopic ventral hernia repair, umbilical hernia repair, or inguinal hernia repair, showed that for 68% of doctors and patients, online follow-up of postoperative recovery was equal to the visits to the clinic, while 24% of doctors and patients preferred visits to the clinic, and 8% preferred online examinations [22]. A

systematic review protocol analysis of 1,413 studies of postoperative follow-up of discharged patients identified 7 studies dealing with a potential replacement of follow-up clinic visits with phone communication or online video-conference calls. The study found a high degree of satisfaction of both patients and doctors and a high degree of success of the telemedical approach as an alternative to postoperative clinical examination [23]. Telemedicine can be successfully used in covering intensive care unit (ICU) beds during the postoperative period[24]. Telerehabilitation is recommended for patients after total knee arthroplasty, showing better results compared to the face-to-face rehabilitation approach [25]. Telemedicine has definitely come forth as a future method in the postoperative follow-up of surgically treated patients.

On the other hand, dentistry has its specific aspects. The reliability of transferring and reviewing digital photographs that illustrate the status of the mouth cavity and teeth for the purpose of diagnosing numerous dental and mouth cavity conditions has been confirmed in a number of studies [26–30].

Telemedical follow-ups after apicoectomy have numerous associated benefits for both the patient and his/her oral surgeon. Some of them are as follows: a newly operated patient does not have to go through the trouble of visiting their oral surgeon for control follow-up examination (in many cases patients are at remote locations, and then they can continue recovering without the need for transportation). Expenses are then reduced and valuable time is saved for both the patient and his/her surgeon [31]. Oral surgeons may plan their operations for the last days of the week, and follow up their patient's recovery *via* the Internet even out of the office. Patients are allowed to travel after the surgery (they are not bound by the obligation to visit the clinic), to continue with their professional activities, etc.

In the near future, a complete shift to the telemedical approach could be envisaged for patient follow-up visits after apicoectomy, with establishing photography standards and defining precisely the questionnaire on patient's condition after this oral surgery.

Future research should be directed towards the telemedical control of the postoperative course in other routine dental surgery treatments, primarily complicated dental extractions, surgical dental extractions, and out-patient recovery follow-up in cases of odontogenic infections [28, 29]. The need for in-person control examinations will be considerably reduced, relieving from this burden both the patient and his/her dentist in the days immediately following oral surgery.

Conclusion

Comparing the follow-up examinations using the store-and-forward and in-person methods a day after apicoectomy, the obtained results showed an almost complete agreement, suggesting that this telemedical approach could be safely used to perform the above follow-up examinations.

Declaration of conflicting interests

The author(s) declare no conflicts of interest with respect to the research, authorship, and/or publication of this article.

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