



Evaluation of telemedicine in the management of dentogenous infections

Procena primene telemedicine u zbrinjavanju dentogenih infekcija

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Abstract

Introduction/Aim. The first written evidence of telemedicine dates back to the times of Sava Nemanjić (the end of 12th and the beginning of 13th century). Nowadays, the use of telemedicine in Serbia gains momentum, and the cause of this lies in the creation of a central telemedicine system XPA3 Online and the establishment of the Center for Telemedicine at the Faculty of Medicine, University of Priština/Kosovska Mitrovica, Kosovska Mitrovica, Serbia. Dentogenous infections are among the most urgent conditions in dentistry, which may have even a fatal outcome. The aim of this study was to assess the possibility of using telemedicine methods in the pathology of dentogenous infections. **Methods.** This experimental randomized study included 414 patients with suspected dentogenous infection. The patients were enrolled at 7 sites, with systematic photograph-taking, collection, and digitalization of the available anamnestic and laboratory data, tests, and x-rays. Together with clinical findings, the data were uploaded on the XPA3 Online central telemedicine system; after that, 10 teleconsultants reviewed the material, set the diagnosis, and gave their opinion about the treatment. The agreement was determined using the Cohen's kappa (κ) coefficient, as well as diagnostic sensitivity (SE), specificity (SP), and efficacy (EFF). Statistical significance and comparisons were done using the χ^2 -test, and testing non-parametric properties using the McNemar's χ^2 -test for the significance threshold of $p = 0.05$. **Results.** The results describing agreement of telemedicine diagnosis of the areas primarily involved with infection compared to clinical inspection, indicate an almost complete diagnostic agreement ($\kappa = 0.971$). Diagnostic agreement as to the type of infection was also almost complete ($\kappa = 0.951$), and a similar value was obtained also for the treatment agreement ($\kappa \geq 0.892$). **Conclusion.** The method of telemedicine provides us with a tool to make a correct clinical diagnosis of dentogenous infections equally well as in real time, as well as to get a deeper and wider insight into their nature and to suggest adequate treatments.

Key words:

dental informatics; remote consultation; focal infection, dental; treatment outcome.

Apstrakt

Uvod/Cilj. Prvi zapisi o primeni telemedicine u Srbiji datiraju iz vremena Save Nemanjića (kraj XII i početak XIII veka). Danas, primena telemedicine u Srbiji naglo raste, a uzrok leži u stvaranju centralnog telemedicinskog sistema XPA3 Online i formiranju telemedicinskog centra Medicinskog fakulteta Univerziteta u Prištini/Kosovska Mitrovica, Srbija. Takođe, dentogene infekcije spadaju u najurgentnija stanja u stomatologiji, koja mogu da imaju i letalan ishod. Cilj rada bio je da se ispituju mogućnosti primene telemedicine kod patologije dentogenih infekcija. **Metode.** Urađena je eksperimentalna randomizirana studija na 414 pacijenata kod kojih je postojala sumnja na prisustvo dentogene infekcije. Pacijenti su primani na sedam lokacija, pri čemu su rađena sistematska fotografisanja, sakupljanje i digitalizacija dostupnih anamnestičkih i laboratorijskih nalaza, testova, kao i radioloških snimaka. Sve je to zajedno sa kliničkim nalazom prosleđivano na XPA3 Online centralni telemedicinski sistem, nakon čega su deset telekonsultanata pregledali materijal, postavljali dijagnozu i davali terapijsko mišljenje. Određena je saglasnost Cohenovim kappa (κ) koeficijentom, dijagnostička senzitivnost (SE), specifičnost (SP) i efikasnost (EFF). Statistička značajnost i poređenja vršena su χ^2 -testom, a testiranje neparametarskih obeležja McNemmar-ovim χ^2 kvadrat testom za prag značajnosti od $p = 0.05$. **Rezultati.** Rezultati slaganja telemedicinskih dijagnoza primarno zahvaćenih prostora infekcijom u poređenju sa kliničkim pregledom ukazuju na postignutu skoro potpunu dijagnostičku saglasnost ($\kappa = 0,971$). Slaganje za vrstu infekcije ukazuje takođe na skoro potpunu dijagnostičku saglasnost ($\kappa = 0,951$), a o predloženoj terapiji slaganje je slično ($\kappa = 0,892$). **Zaključak.** Primenom telemedicine može se podjednako dobro, kao i kliničkim pregledom u realnom vremenu, postaviti ispravna dijagnoza infekcija, sagledati njihova problematika i mogućnosti terapije.

Ključne reči:

informatika, stomatološka; konsultacije na daljinu; infekcija, fokalna, zubna; lečenje, ishod.

Introduction

The first evidence about distant medical consultations (teleconsultations) in the history of Serbia dates back to the time of Sava Nemanjić (the end of 12th and the beginning of 13th century), and writings described two such cases: immediately before the resignation of the Grand Prince Nemanja and succession of the throne by his middle son Stefan, Nemanja fell seriously ill, and his delegation was sent to Sava, his youngest son, a monk in the Hilandar Monastery (Mount Athos, Greece) to come and spend his father's last hours with him. Instead, Sava gave the instructions to the delegates which herbs his father was to take, what to do, and how to pray; in short, he did not come back with them. Firmly believing in the consultation given and praying to the Holy Mountain Protectors, he sent a message to his father to transfer power to the next generation as soon as he was well again, to join Sava on the Holy Mountain and repent for the sins made in worldly life and while in power, and to devote his life to the living God and Holy Mother of God. The success of this teleconsultation was proven by the rapid recovery of Nemanja, his becoming a monk, and permanent moving to the Holy Mountain to join his son Sava. The second distant consultation occurred when Sava's brother, King Stephan fell ill while Sava was abroad. Sava gave his instructions to the brother's messengers, which successfully cured him, accompanied by prayers, and Sava himself came later on to see the healing of the future monk Simon¹⁻⁵.

In 2011 telemedicine in Serbia rapidly developed, triggered by the creation and initial use of the central telemedicine system XPA3 Online (XPA3 Online, Niš, Serbia) and by the foundation of the Telemedicine Center of the Faculty of Medicine University of Priština/Kosovska Mitrovica, Serbia. The system is based on one of the most up-to-date forms of application services, with ultra high speed Internet above, and Microsoft Windows 2008 R2 OS and Microsoft SQL Server 2008 R2 data base below. The system manages and co-ordinates provider services for short message service (SMS) information, for rapid and short phone calls, automated receipt and processing of photographs, images, various text formats (.docx., pdf., html., txt), automated conversion of video formats (.mp4., avi., mov i dr.) into the widely accepted .flv format, and also receives almost whole patient history. The system is accompanied by a number of ready physicians of almost all specialties, most of which are teachers, associates, principal physicians, and so on. If a physician needs specialist help or interspecialist consultation, he posts a telemedicine request using his/her personal computer or Internet-connected smartphone, and gets the requested consultation in time. In addition to its ability to offer up-to-date and rapid teleconsultation support, the system is equipped with the peripherals for scientific monitoring and analysis, providing researchers with already processed data and access resources. Based on such support of an artificial intelligence system on XPA3 Online, we were able to obtain, in an economical way, a number of results describing the quality of Internet-based telemedicine consultation in different areas of interest.

On the other hand, dentogenous infections represent one of the most urgent conditions in the practice of dentistry, the management of which requires proper training and collaboration of different specialties and which, if managed inadequately or late, can lead even to a fatal outcome⁶⁻⁸. Since such patients require a prompt response and permanent specialist observation, the problem of patient management in cases of inaccessibility of adequate specialist services should be resolved. These situations involve e.g. soldiers in the field, bed-ridden or immovable individuals, those with special needs, individuals in remote and unaccessible geographical areas, or physical inaccessibility of specialists from any reason⁹. We have had the situations that, due to restricted traffic in the region of Kosovo and Metohija, the patients with dentogenous infections could not reach the specialists of oral surgery/otorhinolaryngology/maxillofacial surgery, and their management had to be undertaken by untrained dentists/physicians; the posttreatment recovery was controlled from a distance.

Having knowledge about the natural course of inadequately treated or untreated dentogenous infections, and bearing in mind the possibility of infection spread into the adjacent anatomical spaces, thus creating most severe disease forms and complications (such as *Angina Ludovici* or cavernous sinus thrombosis), there is the question of how and to what extent the physicians in distant areas (assisted by modern telemedicine systems) can help in the management of such cases. In particular, there is the question of reliability of distant diagnosis and treatment plan in patients with dentogenous infections.

The aim of this study was, therefore, to assess the possibility of using of modern telemedicine methods in the management of patients with dentogenous infections and find an answer if we can make a clinically reliable diagnosis, and evaluate the primary treatment indicated in such cases (extraction of the causal tooth, incision, need for hospital admission and antibiotic therapy administration).

Methods

This experimental randomized study enrolled 414 patients, aged 12 to 83 years, of both genders, with suspicious dentogenous infection as assessed by the physician in charge. The patients were clinically admitted at 4 main sites in Serbia: Kosovska Mitrovica, Niš, Belgrade, Novi Sad, two sites in Bosnia and Herzegovina (Republic of Srpska: Banja Luka and Trebinje), and in Montenegro (Podgorica). They were all clinically examined by the specialists in oral surgery, otorhinolaryngology, and maxillofacial surgery.

Depending on the quality of equipment, analog ortopans were used with the Tubus 85kV R 76 20 15 mA 50–60 Per, filter 1,2 mm Al image quality, the recordings of which were digitalized into JPEG 2048 × 1536 before transmission, while digital ortopans with the image quality 19 sec/10 mAs at 63–81 kV were stored in TIFF 998 × 494. Digital cameras and mobile phones are used to photograph. The patients had cameras with the resolution from 3.1 to 8.0 megapixels. The patients were photographed en face and

bilaterally (en face with head turned upwards, bilaterally with head maximally extended backwards and to the side); extraoral edema was also photographed, if present; inner structures of the mouth cavity, and upper and lower jaw teeth were photographed in the extent possible using only digital camera (without any additional tools for intraoral photography); intraoral edema was also photographed, if present. In summary, each of the patients had ortopan taken, as well as the above photographs. The data were stored either in the physicians' PCs or in their smartphones. The physicians accessed the Internet *via* their PCs or smartphones in different ways (ADSL access with 512/128 kbps to 6/1 mbps; global municipal wireless connection at 5 GHz at 2/2 mbps; or *via* standard mobile access, WCDMA 3G and HSDPA 3G UMTS, with EDGE access if there were no 3G networks). After a successful Internet connection, they accessed the application system of the Center for Telemedicine, University of Priština/Kosovska Mitrovica (www.xpa3.com) and passed the authentication and authorization phases (protected with a 128 bit Secure Sockets Layer (SSL) security protocol. Opening a new digital telemedicine request, the physicians entered patient personal information, patient history, as well as the available anamnestic information such as laboratory findings, hospital discharge documents, and other relevant patient data. Attached to the request, there were the files containing photographs and x-rays, together with proper clinical findings, both general and individual, accompanying each of the images. Such a teledentistry request was then sent to the system, and the system in a minute contacted specialist teleconsultants (TCs) with SMS messages, and some of them, additionally, were contacted by phone. Each of the teleconsultants had in the received SMS message the subject of teleconsultation, assessed request urgency (describing the levels as normal or urgent), and expected time to response (30 minutes to 6 hours, depending on the case). Teleconsultants then accessed the Internet system at www.xpa3.com, reviewed the received request, and responded giving their opinion, suggestion, and possible outcome of recommended therapy. Each of the patients was clinically examined, with diagnosis being made in real time (Figures 1, 2).

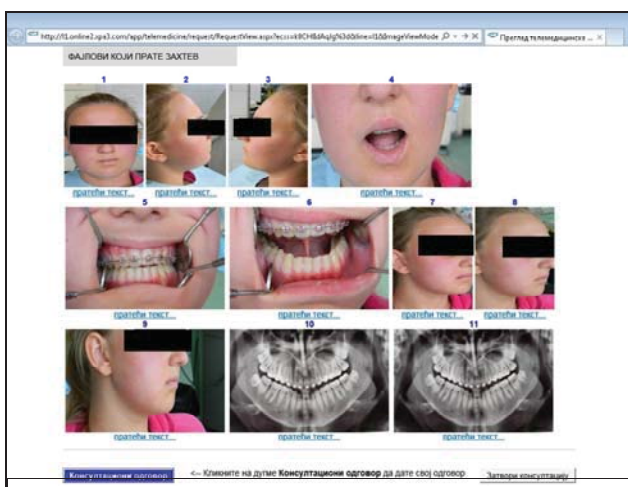


Fig. 1 – A newly received teleconsultation request in the XPA3 Online system.

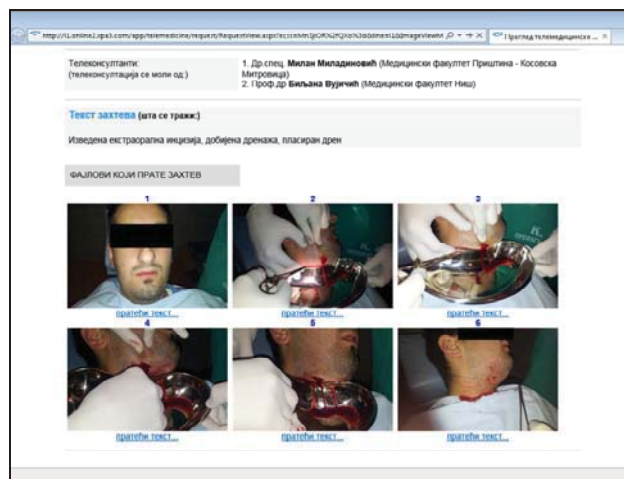


Fig. 2 – XPA3 Online teleconsultation: Dentogenous infection with serious general status of the patient, where teleconsultants unanimously suggested extraoral incision, which was performed and the results of which were sent to them.

The degree of diagnostic accuracy was determined using the following scale: correct – if a telemedicine diagnosis is identical to the primary one, or if it is made and is acceptable as a differential diagnosis, and incorrect – if a telemedicine diagnosis differs completely from the primary one, or if the diagnosis has not been made.

In a similar way, the degree of precision of the treatment plan was determined, too, describing it as correct/incorrect. Statistical data processing and analysis of the obtained results were performed using the Diagnostic and Agreement Statistics (DAG) Software http://www.mhri.edu.au/biostats/DAG_Stat and software package SPSS for Windows version 16.

Agreement among the teleconsultants was obtained dividing the number of patients with the achieved agreement with the total number of examined patients. The following elements were determined: sensitivity (SE), specificity (SP), and efficacy (EFF). The degree of achieved agreement between teleconsultants using the method of telemedicine was expressed as the Cohen's *kappa* (κ) coefficient. The *kappa* coefficient for the confidence interval of 95% was presented according to the Landis and Koch scale (Table 1). Statistical significance of the differences between correct and incorrect diagnoses, planned interventions (yes/no; extractions, incisions, hospitalizations, antibiotic therapy), precision, sensitivity, and specificity, and comparison of all the obtained values were done using the *z*-test, and testing for non-parametric characteristics was done using the McNemar's χ^2 -test (contingency table 2×2) for the threshold of significance at $p = 0.05$.

Table 1
Kappa coefficient (*k*) and degree of diagnostic agreement (Landis i Koch)

κ	Agreement degree
< 0	No agreement
0.01–0.20	Insignificant agreement
0.21– 0.40	Sufficient agreement
0.41–0.60	Moderate agreement
0.61–0.80	Significant agreement
0.81–0.99	Almost complete agreement
1	Complete agreement

Results

Overall 414 patients were examined and 414 diagnoses were made. All the received photographs, x-rays, and other documents, were declared as usable by the teleconsultants. Out of 414 (100%) patients, teleconsultants stated that there was no dentogenous infection in 18–22 (4.35–5.31%) cases. They established that the most common area involved with dentogenous infection was the submandibular region, in 84–93 (20.29–22.46%) cases, followed by submental, in 63–69 (15.22–16.67%) cases, and buccal space, in 57–66 (13.77–15.94%) cases (Table 2). As the type of infection, teleconsultants identified abscess in 328–333 (79.23–80.43%) cases, while phlegmon was diagnoses in 47–51 (11.35–12.32%) cases (Table 2). Trismus was found in 31–34 (7.49–8.21%) cases (Table 2). Regarding treatment, the teleconsultants suggested 233–241 (56.28–58.21%) extractions, 159–187 (38.41–45.17%) incisions, hospital admission in 42–49 (10.14–11.84%) patients, and antibiotic treatment in 398–406 (96.14–98.07%) cases (Table 2). As the type of necessary incision, intraoral incision was recommended in 113–126 (67.66–67.38%) cases, and extraoral one in 50–60 (31.45–32.62%) cases (Table 2).

The highest degree of teleconsultant agreement as to the primary spaces involved with infection was achieved between TC1 and TC2 ($\kappa = 0.911$), and the lowest degree between TC6 and TC8 ($\kappa = 0.827$). Regarding differential diagnosis abscess/phlegmon, the highest degree of agreement existed between TC8 and TC9 ($\kappa = 0.933$), and the lowest degree between TC5 and TC10 ($\kappa = 0.889$). As for trismus, the best agreement existed between TC1, TC2, TC3, TC4, TC7, TC8, TC9, and TC10 ($\kappa = 1.000$), with the deviation with TC5 and TC6 ($\kappa = 0.600$).

The highest degree of diagnoses agreement of primary infection-involved spaces related to clinical examination was present in TC1 with 2 erroneous diagnoses (0.48%), and the lowest degree was found in TC3 and TC5 with 6 erroneous diagnoses (1.45%), for statistical processing of the results (Table 7 and Table 1), $\kappa = 0.971$, SE = 98.5%, SP = 98.5%, EFF = 98.5%, indicating almost a complete diagnostic agreement. As to the type of infection, the highest agreement with clinical examinations was found for TC1, with 2 erroneous diagnoses (0.48%), and the lowest agreement was observed for TC6, with 10 erroneous diagnoses (4.14%), for statistical processing of the results (Table 1), $\kappa = 0.951$, SE = 97.6%, SP = 97.6%, EFF = 97.6%, indicating almost complete diagnostic agreement. As for trismus, the highest degree of agreement with clinical examination was observed for TC1, TC2, TC3, TC4, TC7, TC8, TC9 and TC10, without any diagnostic errors, and the lowest for TC5 and TC6, with 1 error each (0.41%). Diagnostic differences were not statistically significant.

Regarding the suggested therapy (Table 2), the highest degree of agreement was observed between TC2 and TC10, as well as between TC4 and TC6 ($\kappa = 0.919$), the lowest degree between TC5 and TC7 ($\kappa = 0.892$), while the opinions were somewhat different regarding the choice of intra- or extraoral incision approach (Table 2).

Discussion

The purpose of this paper was to assess the possibility of using modern methods of telemedicine in the management of patients with dentogenous infections, and to answer to the questions: if we can make a clinically reliable diagnosis at a distance, and are we able to assess the primary treatment indicated in such cases (extraction of the causal tooth, incision, need for hospital admission, and antibiotic therapy).

Almost a completely achieved agreement in making the diagnosis of primary involved spaces ($\kappa = 0.971$) and that concerning the type of infection ($\kappa = 0.951$) and the presence of trismus ($\kappa = 1.000$ in 80% of TCs and $\kappa = 0.600$ in 20% of TCs), open the possibility of reliable distant patient management. The results showed that using the method of telemedicine we can make clinically acceptable diagnosis of dentogenous infections, and that the method can replace real time diagnostic evaluation, i.e. direct visual/tactile diagnostic approaches. Regarding the basic therapy assessment, almost a perfect agreement was achieved too ($\kappa > \text{or} = 0.892$), indicating the possibility of distant counselling as to the primary treatment approaches, with clear statements about the necessity of hospital admission of patients with dentogenous infections.

One of the striking advantages was the fact that 98% of teleconsultation requests were responded to in the requested time span (30 min to 6 h), which indicated that telemedicine consultation can be a valuable tool for saving the time to specialist examination. Patients were placed in the right management track in a short time, saving valuable time in cases of emergency, which can be of a decisive influence regarding the development and outcome of infection. The results confirmed that “store and forward” telemedicine system resolves the need of physicians for consultation in a cheap, effective, and rapid way, in this case in the pathology of dentogenous infections.

We have not encountered in the literature any studies dealing with the validation of telemedicine diagnosis and assessment of therapy for dentogenous infections, but there were studies which evaluated telemedicine agreements in the related fields. Thus Salazar-Fernandez et al.¹⁰ in their large study of telemedicine consultations in the diseases of temporomandibular joint found that using the store and forward telemedicine method, the opinion of a specialized consultant can be obtained in an effective and efficacious way, suggesting that the method should have been more widely used by oral and maxillofacial surgeons. Hecce et al.¹¹, suggested that using the store and forward telemedicine method the pathology of third molars could be effectively assessed within the pre-surgical treatment, avoiding thus numerous preliminary hospital visits by the patient. Duka et al.¹², comparing the diagnoses of third molar pathology using telemedicine and conventionally, found that the problems could be adequately evaluated by both approaches. Ignatius et al.¹³, in their 13 months’ study of the possibility of distant diagnosis and distant planning of prosthetic solutions in patients requiring prosthetic or oral rehabilitation treatment, concluded that teleconsultations were successful in 24 out of 27 cases. Brüllmann et al.¹⁴, in their study of recognition of

Table 2

Parameters	TC1		TC2		TC3		TC4		TC5		TC6		TC7		TC8		TC9		TC10																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
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Involved space																						sublingual	11	2.66	11	2.66	10	2.43	12	2.90	10	2.42	13	3.14	9	2.17	12	2.90	11	2.66	11	2.66	11	2.66	submental	66	15.94	64	15.46	66	15.94	65	15.70	67	16.18	65	15.70	68	16.43	69	16.67	63	15.22	63	15.22	63	15.22	63	15.22	submandibular	89	21.50	90	21.74	93	22.46	93	22.46	84	20.29	87	21.01	92	22.22	89	21.50	93	22.46	93	22.46	85	20.53	85	20.53	<i>Angina Ludovici</i>	8	1.93	8	1.93	8	1.93	7	1.69	7	1.69	7	1.69	7	1.69	9	2.17	7	1.69	7	1.69	8	1.93	8	1.93	pterygomandibular	24	5.80	22	5.31	22	5.31	24	5.80	26	6.28	23	5.56	22	5.31	25	6.04	25	6.04	25	6.04	22	5.31	22	5.31	buccal	61	14.73	62	14.98	66	15.94	65	15.70	64	15.46	58	14.01	60	14.49	60	14.49	60	14.49	57	13.77	65	15.70	65	15.70	submasseteric	4	0.97	5	1.21	2	0.48	3	0.72	7	1.69	2	0.48	2	0.48	3	0.72	3	0.72	5	1.21	5	1.21	5	1.21	fosse canine	41	9.90	41	9.90	39	9.42	43	10.39	39	9.42	39	9.42	42	10.14	44	10.63	38	9.18	37	8.94	44	10.63	44	10.63	abscess of the tongue	2	0.48	2	0.48	1	0.24	2	0.48	2	0.48	2	0.48	2	0.48	2	0.48	2	0.48	2	0.48	1	0.24	2	0.48	palatal abscess	36	8.70	36	8.70	33	7.97	36	8.70	35	8.45	38	9.18	33	7.97	36	8.70	36	8.70	36	8.70	35	8.45	35	8.45	frontal upper fornx	27	6.52	27	6.52	29	7.00	24	5.80	27	6.52	26	6.28	28	6.77	29	7.00	30	7.25	30	7.25	26	6.28	26	6.28	absence of dentogenous infection	18	4.35	20	4.83	19	4.59	18	4.35	21	5.07	22	5.31	22	5.31	19	4.59	20	4.83	22	5.31	21	5.07	21	5.07	other	27	6.52	26	6.28	26	6.28	22	5.31	24	5.81	29	7.02	25	6.05	25	6.05	21	5.07	27	6.51	27	6.51	27	6.51	Total	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	Type of infection																						abscess	330	79.71	332	80.19	332	80.19	333	80.43	329	79.47	328	79.23	330	79.71	331	79.95	331	79.95	331	79.95	330	79.71	330	79.71	phlegmon	50	12.08	48	11.59	50	12.08	47	11.35	51	12.32	49	11.84	48	11.59	49	11.84	51	12.32	51	12.32	51	12.32	51	12.32	absence of infection	18	4.35	18	4.35	19	4.59	18	4.35	21	5.07	22	5.31	19	4.59	20	4.83	18	4.35	18	4.35	21	5.07	21	5.07	other	16	3.86	16	3.86	13	3.14	16	3.86	13	3.14	15	3.62	17	4.11	14	3.38	14	3.38	14	3.38	12	2.90	12	2.90	Total	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	Trismus presence																						yes	33	7.97	33	7.97	33	7.97	33	7.97	32	7.73	34	8.21	33	7.97	33	7.97	33	7.97	33	7.97	33	7.97	33	7.97	no	381	92.03	381	92.03	381	92.03	381	92.03	382	92.27	380	91.79	381	91.79	381	92.03	381	92.03	381	92.03	381	92.03	381	92.03	Total	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	Therapy																						required extraction	233	56.28	233	56.28	236	57.00	234	56.52	239	57.73	237	57.25	239	57.73	241	58.21	239	57.73	239	57.73	238	57.49	238	57.49	required incision	167	40.34	168	40.58	183	44.20	159	38.41	173	41.79	187	45.17	173	41.79	173	41.79	178	43.00	181	43.72	177	42.75	177	42.75	required hospitalization	44	10.63	42	10.14	42	10.14	47	11.35	45	10.87	47	11.35	44	10.63	44	10.63	46	11.11	46	11.11	43	10.39	43	10.39	required antibiotic therapy	399	96.38	401	96.86	400	96.62	398	96.14	404	97.58	402	97.10	398	96.14	406	98.07	400	96.62	401	96.62	401	96.62	401	96.62	Incision approach																						intraoral	113	27.29	114	27.53	124	29.95	109	26.33	118	28.50	126	30.43	120	29.00	124	30.19	122	29.47	122	29.47	122	29.47	122	29.47	extraoral	54	12.99	54	12.99	59	14.25	50	12.08	55	13.29	61	14.73	53	12.79	53	12.79	54	13.04	59	14.25	55	13.29	55	13.29	Total	167	40.34	168	40.58	183	44.20	159	38.41	173	41.79	187	45.17	173	41.79	173	41.79	178	43.00	181	43.72	177	42.75	177	42.75	Diagnosis																						correct	412	99.52	411	99.28	408	98.55	410	99.03	408	98.55	409	98.79	409	98.79	409	98.79	411	99.28	32	7.73	32	7.73	411	99.28	incorrect	2	0.48	3	0.72	6	1.45	4	0.97	6	1.45	5	1.21	5	1.21	5	1.21	3	0.72	2	0.48	2	0.48	3	0.72	Total	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00
sublingual	11	2.66	11	2.66	10	2.43	12	2.90	10	2.42	13	3.14	9	2.17	12	2.90	11	2.66	11	2.66	11	2.66																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
submental	66	15.94	64	15.46	66	15.94	65	15.70	67	16.18	65	15.70	68	16.43	69	16.67	63	15.22	63	15.22	63	15.22	63	15.22																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
submandibular	89	21.50	90	21.74	93	22.46	93	22.46	84	20.29	87	21.01	92	22.22	89	21.50	93	22.46	93	22.46	85	20.53	85	20.53																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
<i>Angina Ludovici</i>	8	1.93	8	1.93	8	1.93	7	1.69	7	1.69	7	1.69	7	1.69	9	2.17	7	1.69	7	1.69	8	1.93	8	1.93																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
pterygomandibular	24	5.80	22	5.31	22	5.31	24	5.80	26	6.28	23	5.56	22	5.31	25	6.04	25	6.04	25	6.04	22	5.31	22	5.31																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
buccal	61	14.73	62	14.98	66	15.94	65	15.70	64	15.46	58	14.01	60	14.49	60	14.49	60	14.49	57	13.77	65	15.70	65	15.70																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
submasseteric	4	0.97	5	1.21	2	0.48	3	0.72	7	1.69	2	0.48	2	0.48	3	0.72	3	0.72	5	1.21	5	1.21	5	1.21																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
fosse canine	41	9.90	41	9.90	39	9.42	43	10.39	39	9.42	39	9.42	42	10.14	44	10.63	38	9.18	37	8.94	44	10.63	44	10.63																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
abscess of the tongue	2	0.48	2	0.48	1	0.24	2	0.48	2	0.48	2	0.48	2	0.48	2	0.48	2	0.48	2	0.48	1	0.24	2	0.48																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
palatal abscess	36	8.70	36	8.70	33	7.97	36	8.70	35	8.45	38	9.18	33	7.97	36	8.70	36	8.70	36	8.70	35	8.45	35	8.45																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
frontal upper fornx	27	6.52	27	6.52	29	7.00	24	5.80	27	6.52	26	6.28	28	6.77	29	7.00	30	7.25	30	7.25	26	6.28	26	6.28																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
absence of dentogenous infection	18	4.35	20	4.83	19	4.59	18	4.35	21	5.07	22	5.31	22	5.31	19	4.59	20	4.83	22	5.31	21	5.07	21	5.07																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
other	27	6.52	26	6.28	26	6.28	22	5.31	24	5.81	29	7.02	25	6.05	25	6.05	21	5.07	27	6.51	27	6.51	27	6.51																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
Total	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
Type of infection																						abscess	330	79.71	332	80.19	332	80.19	333	80.43	329	79.47	328	79.23	330	79.71	331	79.95	331	79.95	331	79.95	330	79.71	330	79.71	phlegmon	50	12.08	48	11.59	50	12.08	47	11.35	51	12.32	49	11.84	48	11.59	49	11.84	51	12.32	51	12.32	51	12.32	51	12.32	absence of infection	18	4.35	18	4.35	19	4.59	18	4.35	21	5.07	22	5.31	19	4.59	20	4.83	18	4.35	18	4.35	21	5.07	21	5.07	other	16	3.86	16	3.86	13	3.14	16	3.86	13	3.14	15	3.62	17	4.11	14	3.38	14	3.38	14	3.38	12	2.90	12	2.90	Total	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	Trismus presence																						yes	33	7.97	33	7.97	33	7.97	33	7.97	32	7.73	34	8.21	33	7.97	33	7.97	33	7.97	33	7.97	33	7.97	33	7.97	no	381	92.03	381	92.03	381	92.03	381	92.03	382	92.27	380	91.79	381	91.79	381	92.03	381	92.03	381	92.03	381	92.03	381	92.03	Total	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	Therapy																						required extraction	233	56.28	233	56.28	236	57.00	234	56.52	239	57.73	237	57.25	239	57.73	241	58.21	239	57.73	239	57.73	238	57.49	238	57.49	required incision	167	40.34	168	40.58	183	44.20	159	38.41	173	41.79	187	45.17	173	41.79	173	41.79	178	43.00	181	43.72	177	42.75	177	42.75	required hospitalization	44	10.63	42	10.14	42	10.14	47	11.35	45	10.87	47	11.35	44	10.63	44	10.63	46	11.11	46	11.11	43	10.39	43	10.39	required antibiotic therapy	399	96.38	401	96.86	400	96.62	398	96.14	404	97.58	402	97.10	398	96.14	406	98.07	400	96.62	401	96.62	401	96.62	401	96.62	Incision approach																						intraoral	113	27.29	114	27.53	124	29.95	109	26.33	118	28.50	126	30.43	120	29.00	124	30.19	122	29.47	122	29.47	122	29.47	122	29.47	extraoral	54	12.99	54	12.99	59	14.25	50	12.08	55	13.29	61	14.73	53	12.79	53	12.79	54	13.04	59	14.25	55	13.29	55	13.29	Total	167	40.34	168	40.58	183	44.20	159	38.41	173	41.79	187	45.17	173	41.79	173	41.79	178	43.00	181	43.72	177	42.75	177	42.75	Diagnosis																						correct	412	99.52	411	99.28	408	98.55	410	99.03	408	98.55	409	98.79	409	98.79	409	98.79	411	99.28	32	7.73	32	7.73	411	99.28	incorrect	2	0.48	3	0.72	6	1.45	4	0.97	6	1.45	5	1.21	5	1.21	5	1.21	3	0.72	2	0.48	2	0.48	3	0.72	Total	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00	414	100.00																																																																																																																																																																																																																																																																																																																																																																																
abscess	330	79.71	332	80.19	332	80.19	333	80.43	329	79.47	328	79.23	330	79.71	331	79.95	331	79.95	331	79.95	330	79.71	330	79.71																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
phlegmon	50	12.08	48	11.59	50	12.08	47	11.35	51	12.32	49	11.84	48	11.59	49	11.84	51	12.32	51	12.32	51	12.32	51	12.32																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
absence of infection	18	4.35	18	4.35	19	4.59	18	4.35	21	5.07	22	5.31	19	4.59	20	4.83	18	4.35	18	4.35	21	5.07	21	5.07																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
other	16	3.86	16	3.86	13	3.14	16	3.86	13	3.14	15	3.62	17	4.11	14	3.38	14	3.38	14	3.38	12	2.90	12	2.90																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
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open dental root canals using telemedicine, found that distant consultation of experienced dentists can be of great help to younger colleagues regarding the correct diagnosis of open root canal. Kopycka-Kedzierawski and Billings¹⁵ found that using telemedicine the prevalence of caries in children could be successfully assessed, collecting the information from children in the cohort group for 12–60 months and using simultaneously the methods of telemedicine and traditional visual/tactile examination. The results of the respective authors agree with our own results, especially regarding the reliability of used teledentistry methods, with special stress on the store and forward telemedicine method.

Since dentogenous infections represent a relatively common pathology, our study offered a significant insight into the excellent prospects of distant examination and treatment planning in the management of these patients. In contrast, inadequate management and frequent antibiotic treatments of dentogenous infections with only oral antibiotics (which is rather common in the routine dentistry practice), contribute to a rapid development and wide spread of these infections, endangering thus the general health of our patients¹⁶. In these patients, the first clinical examination is of key importance, since it requires ample clinical knowledge and experience¹⁷. Using the methods of telemedicine, other specialists or, later, even the patients themselves can seek adequate expert help from oral and maxillofacial surgeons or otorhinolaryngologists, i.e. from subspecialists in the appropriate fields, getting the requested advice regarding proper diagnosis or treatment. Timely teleconsultation can help physicians in charge of the patients to react better, supported by sufficient expertise; in many cases, the spread of infection into deeper regions of the neck can thus be prevented (the origin of such infections is dental in over 40% of cases, and lower molars are most commonly implicated in that regard)¹⁸.

As the precondition of proper telemedicine diagnosis, adequate technical-technologic equipment is required for the collection, analysis, and exchange of diagnostic data between teleconsultants. We achieved excellent results using 3.1 megapixel or stronger cameras (with built in electronic flash units). Since digital photographic equipment is becoming increasingly cheaper, with imaging resolution being on the rise too, we believe that the resolution of 3.1 megapixels constitute the minimum for teledentistry imaging and that there is no need to go below that standard. It is also necessary to adhere to the common procedure of taking intraoral or extraoral photographs, capturing by digital photographs the real situation in the mouth, as well as extraoral changes¹². The patient should be photographed en face and bilaterally, taking as good as possible images of the region of interest. With dental radiographs, the ideal situation is that the digital image is transported from the radiography center through multiple telemedicine systems in unchanged format. If an analog radiography is to be digitalized using a camera or a scanner device, the minimum requirements a 3.1 megapixel image

should be abided by Witherow et al.¹⁹ observed that a large number of patients with dentogenous infections were referred to various other specialists, such as plastic surgeons, dermatologists, emergency services, or general practitioners and general dentists, when a proper diagnosis is commonly a problem. The significance of our study lies in the practical demonstration that in such cases rapid and effective telemedicine consultation is the method of choice, eliminating the need for patient transport to other relevant specialists.

Since the results showed an almost complete agreement between teleconsultants regarding the therapy ($\kappa > \text{or} = 0.892$), there is the possibility of help to remote nonspecialists in the decision-making whether to extract the causal tooth at once, or to postpone the extraction and perform only incision. This can have a marked impact on infection subsiding and alleviation of pain, as well as on the general status of the organism²⁰. Viewed from the aspect of general intention to reduce microorganism resistance, telemedicine consultation in such patients offers an additional differentiation regarding the decision to include antibiotic therapy or to stick to tooth extraction only, providing surgical debridement, removal of the infection cause, and drainage. In this way, unnecessary increase of resistance to antibiotics can be minimized²¹. An almost complete agreement between the teleconsultants was achieved also regarding the need for hospital admission, eliminating the possibility of inadequate, nonspecialist assessment of the need for constant medical observation, i.e. that the present dentogenous infection had to be seriously considered.

The method of telemedicine used in the study can improve the quality of health care, facilitate the work of doctors, reduce treatment costs, and contribute positively to the budget of the health care system.

Conclusion

Our study showed that using the method of telemedicine it is possible to make correct clinical diagnosis of dentogenous infections equally well as in real time, assess their nature and course, and successfully consider the treatment option.

Telemedicine consultation is a vital patient management tool of key importance to any field doctors or those in geographically remote regions, but also to any other doctors who are not sufficiently specialized in the area of dentogenous infections.

In addition to its being a valuable medical tool, the method of telemedicine significantly contributes to cost-effectiveness of health care and speeds us the process of healing.

Acknowledgement

This paper is dedicated to the memory of Aleksandar Janković MD, PhD, from Niš, Serbia.

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