AKTUELNA I POTENCIJALNA PRIMENA MODERNIH TEHNOLOGIJA U MEDICINI I STOMATOLOGIJI KAO POSLEDICA INDUSTRIJE 4.0

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SAŽETAK

Industrija 4.0, odnosno četvrta industrijska revolucija, je doprinela ogromnom napretku znanja i nauke u mnogim različitim oblastima života. Cilj ovog rada je da prikaže trenutne i potencijalne primene modernih tehnologija kao dirktna posledica Industrije 4.0 u medicini i stomatologiji i stvaranje koncepta Medicina 4.0 i Stomatologija 4.0. Industrija 4.0 ima veliki uticaj na sve oblasti savremene nauke, ali i na medicinu i stomatologiju. Očigledno je da se celokupno zdravstvo transformisalo u potpuno novi, moderan i drugačiji oblik - Zdravstvo 4.0 sa velikim benefitima od Industrije 4.0. To znači bolju i sigurniju budućnost u smislu optimiziranih medicinskih usluga i lečenja, mnogo veći procenat izlečenih pacijenata, virtuelnih medicinskih i stomatoloških klinika za konsultacije uz pomoć telemedicine i još mnogo toga. Takođe, industrija 4.0 je omogućila brzu i kvalitetnu poizvodnju različitih vrsta medicinskih i dentalnih implantata, što doprinosi značajnom smanjenju troškova. Upotreba novih digitalnih tehnologija, novih koncepata u radu omogućava potpuno novi pristup i mnogo bolje rezultate u medicini i stomatologiji.

Ključne reči: tehnologija, Industrija 4.0, Medicina, Stomatologija, Zdravstvo

Uvod

Razvoj Industrije 4.0, odnosno četvrte industrijske revolucije, predstavlja veliki korak u ljudskoj istoriji u smislu razvoja nauke i tehnologije. Upotreba novih tehnologija dovela je čovečanstvo do nezamislivih dostignuća. Tehnologija i njene primene su toliko napredovale da su unapredile skoro sve sfere života i rada ljudi. Ove promene i inovacije su izazvale mnoge promene i inovacije u medicini i stomatologiji, tako da je postignut novi nivo i novi koncept ovih oblasti – Medicina 4.0 i Stomatologija 4.0. Medicina i stomatologija sada imaju svoj „oblak" (eng. cloud) i virtuelne modele, kao i virtuelne pacijente (1,2). Pod „oblak" se podrazumeva veliki broj računara sa svim mogućim resursima koji se tretiraju kao jedan virtuelan računar. Klinike, laboratorije, menadžment, osoblje, proizvodnja, lečenje, informacije i usluge su povezani i umreženi preko Interneta. Pacijenti imaju poboljšan pristup medicinskim i stomatološkim službama i klinikama. Troškovi su značajno smanjeni. Dijagnoze se postavljaju ranije, što implicira bolje lečenje, kao i bolje efekte i ishode lečenja. Za intervencije je potrebno kraće vreme. Komunikacija i zaštita podataka su na veoma visokom nivou.

Ranije, doktori nisu bili upoznati sa korišćenjem kompjutera, ali danas upotreba više kompjutera, uređaja, robota predstavlja realnost i trend. Jedna od važnih stvari je precizna i efikasna edukacija, pomoć i sugestije medicinskom i stomatološkom osoblju "na daljinu" u realnom vremenu. Takođe, značajno treba povećati produktivnost u medicinskim i stomatološkim uslugama, jer su osnova za efikasno pružanje kvalitetnih usluga (1,2). Naravno, to će zahtevati značajna finansijska sredstva, ali kada se uporede efekti i investicije, efekti jesu i biće gotovo neverovatni.

Cilj ovog rada je da prikaže trenutne i potencijalne primene modernih tehnologija kao direktna posledica Industrije 4.0 u medicini i stomatologiji i stvaranje koncepta Medicina 4.0 i Stomatologija 4.0.

PROFESSIONAL ARTICLE

CURRENT AND POTENTIAL APPLICATIONS OF MODERN TECHNOLOGIES IN MEDICINE AND DENTISTRY AS A CONSEQUENCE OF INDUSTRY 4.0

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SUMMARY

Industry 4.0, i.e. the fourth industrial revolution, has contributed to enormous progress of knowledge and science in many different areas of life and brought lots of benefits. The aim of this paper is to present the current and potential applications of modern technologies as direct consequence of Industry 4.0 in medicine and dentistry and designing the Medicine 4.0 and Dentistry 4.0 concept. Industry 4.0 has a great influence on every field of modern science, and also on medicine and dentistry. It is obvious that complete healthcare transforms in the totally new, modern and different form - Healthcare 4.0 with a huge benefit from Industry 4.0. This means a better and safer future in the form of optimized medical services and treatment, much bigger percentage of cured patients, virtual medical and dental clinics with telemedicine consultations and lot of other things. Also, industry 4.0 enabled the fast and high-quality production of various types of medical and dental implants, which contributes to a significant reduction in costs. The use of new digital technologies and new concepts enable a completely new approach and better results in medicine and dentistry.

Key words: technology, digitalisation, Industry 4.0, Medicine, Dentistry, Healthcare

Introduction

The development of Industry 4.0, i.e. the fourth industrial revolution, presents a great step in human history in the sense of the development of science and technology. The use of new technologies has brought humanity to unimaginable achievements. Technology and its applications have advanced so much that they have improved almost all sphere of human work and life. These changes and innovations caused many changes and innovations in medicine and dentistry and therefore, a new level and new concept of these spheres - Medicine 4.0 and Dentistry 4.0 were achieved (1,2). Medicine and dentistry now have their own "cloud" and virtual models, as well as virtual patients. The cloud means a large number of computers with all possible resources that are treated as one virtual computer. Clinics, laboratories, management, personnel, production, treatment, information and services are connected via the Internet. Patients have an improved access to medical and dental services and clinics. Expenses are significantly reduced. Diagnoses are established much earlier, which implies better treatment, as well as better treatment effects and outcomes. Interventions demand shorter time. Communication and data protection are at a very high level.

Before, doctors were not familiar with computers, but today, manipulation with more computers, devices, robots present reality and trend. One of the important things is the precise and effective education, help and suggestions given to medical and dental personnel at a distant place in real time. Also, productivity in medical and dental services should be significantly increased, because they are the basis for efficient provision of quality services (1,2). Of course, it will demand significant financial resources but, when effects and investment are compared, effects are and will be almost unbelievable.
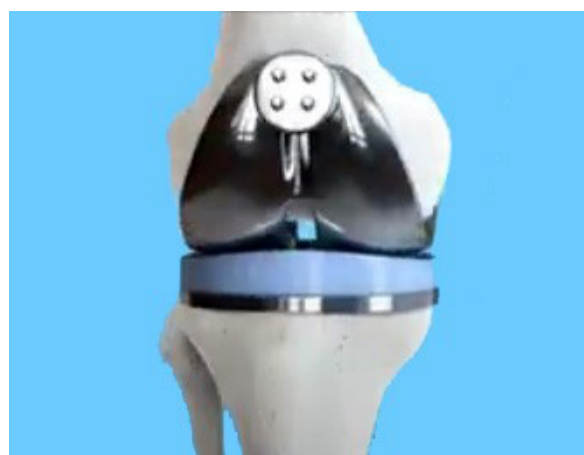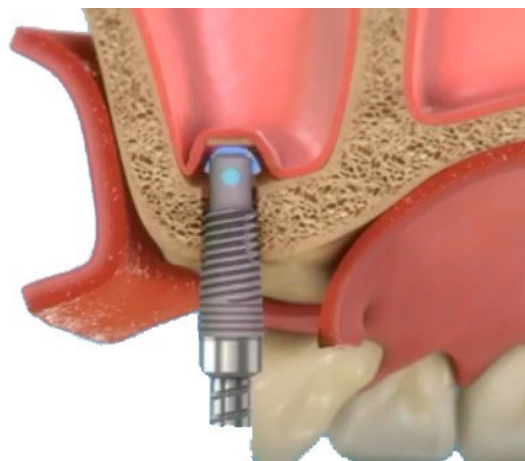
Primena tehnologija Industrije 4.0 u medicini i stomatologiji

Jedna od veoma interesantnih primena Industrije 4.0 su personalizovani medicinski i dentalni implantati. Zahvaljujući velikoj količini podataka, uspostavljaju se lake i brze veze između različitih pretraživača podataka. Industrija 4.0 je omogućila brzu i kvalitetnu poizvodnju različitih vrsta medicinskih i dentalnih implantata, zbog obilja različitih informacija. Takođe, kompletni troškovi su značajno smanjeni (1,2). Pravu revoluciju kada su u pitanju implantati donela je upotreba 3D štampe. Primer dentalnog i medicinskog implantata dat je na slici 1.

Pametni implantati su veliko dostignuće modernih tehnologija. Savremeni implantati koji se koriste u medicini i stomatologiji mogu se proizvoditi veoma precizno i mogu se pratiti na daljinu u realnom vremenu. Uz upotrebu pametnih materijala, implantati mogu biti složenog i različitog oblika i

Slika 2. Primer pametnog implantata u medicini i stomatologiji
Izvor: https://benhvienranghammatsg.vn/cay-ghep-rang-implant-co-tot-khong/; https://www.biomag-medical.com/joint-arthroses/

mogu reagovati na određene parametre (npr. na pritisak ili temperaturu). Ovakvi implantati, koji se koriste u medicini i stomatologiji su se pokazali kao mnogo prikladniji za pacijente (1,2). Oni moraju biti napravljeni tako da budu neko vreme ili ceo život u telu čoveka. Primer pametnog implantata u stomatologiji i medicini je prikazan na slici 2.

Digitalna klinika i digitalna stomatološka ordinacija predstavljaju nove i moderne termine. Tehnologije Industrije 4.0 omogućile su najbolji način upravljanja i distribucije informacija u medicini i stomatologiji putem Interneta. Upravljanje laboratorijom, vođenje evidencije i mnoge druge prednosti su veoma važne u funkcionisanju digitalne klinike i digitalne stomatološke ordinacije. Industrija 4.0 takođe omogućava laku dijagnostiku u medicini i stomatologiji. Sistem koji predstavlja digitalnu bolnicu ili kliniku 4.0 na osnovu „cloud" kompjuterskog modela dat je na slici 3 (1,2).

Slika 1. Primer dentalnog i medicinskog implantata
Izvor: https://www.1888implant.com/dental-implants-procedures.html/; https://www.youtube.com/watch?v=hOMKaaCnxEc&ab_channel=UCDavisHealth

The aim of this paper is to present the current and potential applications of modern technologies as direct consequence of Industry 4.0 in medicine and dentistry and designing the Medicine 4.0 and Dentistry 4.0 concept.
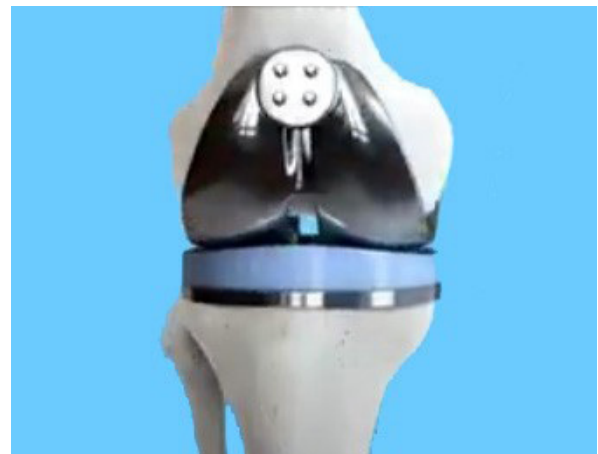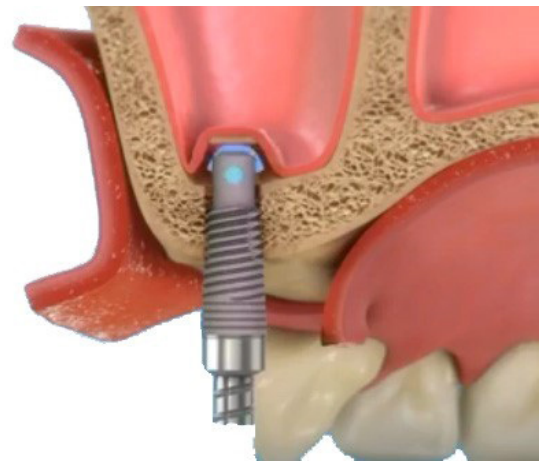
Applications of technologies of Industry 4.0 in medicine and dentistry

One of the very interesting applications of Industry 4.0 is personalized medical and dental implants. Thanks to the large amount of data, easy and fast connections between different data browsers. Industry 4.0 has enabled the fast and high-quality production of various types of medical and dental implants, due to the abundance of different information. Also, complete costs are significantly reduced (1,2). The real revolution related for dental and medical implants has been started with the use of 3D printers). An example of dental

Figure 1. An example of dental and medical implant
Source: https://www.1888implant.com/dental-implants-procedures.html/; https://www.youtube.com/watch?v=hOMKaaCnxEc&ab_channel=UCDavisHealth

Figure 2. An example for smart implant in dentistry and medicine
Source: https://benhvienranghammatsg.vn/cay-ghep-rang-implant-co-tot-khong ; https://www.biomag-medical.com/joint-arthroses/

and medical implant is presented in Figure 1.

Smart implants are the great achievement of modern technologies. Modern implants used in medicine and dentistry can be produced very precisely and they can be monitored at the distant place in real time. With the use of smart materials, implants can be made to have a different and complex shape and they can react on some particular parameters (pressure or temperature, for example). Those implants, used in medicine were shown as more appropriate for patients (1,2). They must be made to be on the specific place in the human body for some time or for whole life of the patient. An example of smart implant in dentistry and medicine is presented in Figure 2.

Digital clinic and digital dental office present new and modern terms. Technologies of Industry 4.0 provided the best way of information managing and distribution in medicine and dentistry
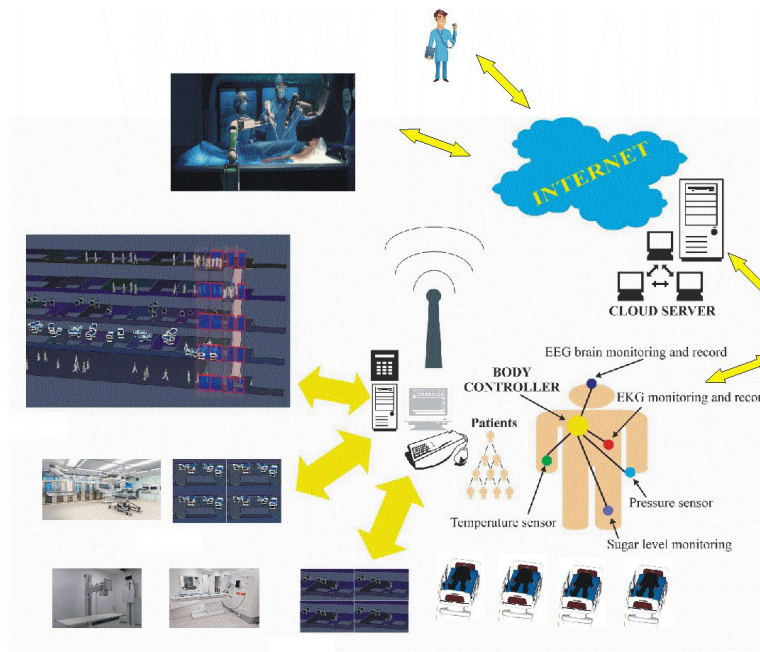
Slika 3. Digitalna klinika 4.0 na osnovu „cloud" kompjuterskog modela

Slika 4. Primer precizne hirurgije

Slika 5. Značaj komunikacije u medicini i stomatologiji

Figure 3. Digital clinic 4.0 related to the cloud computing model

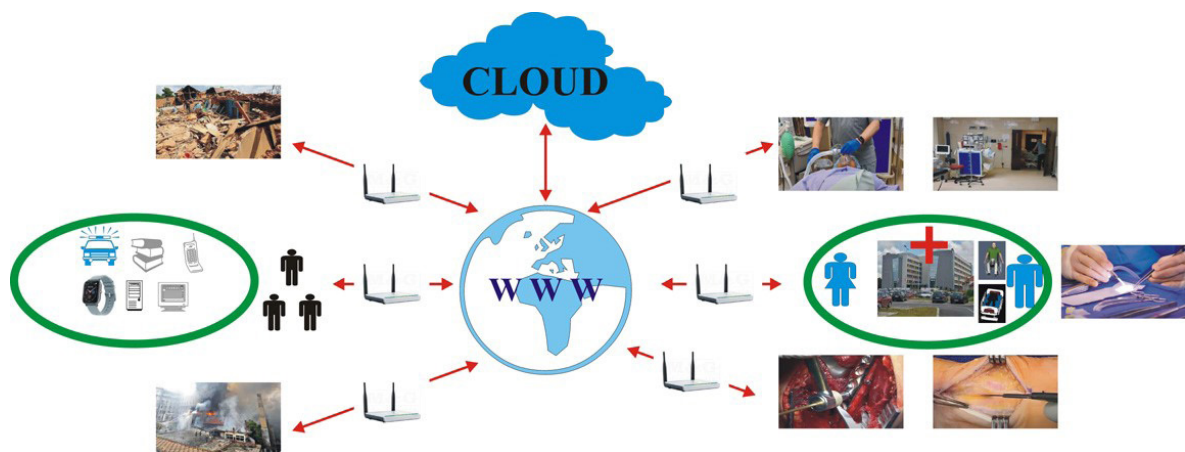

Figure 4. An example for precise surgery

Figure 5. The significance of the communication in medicine and dentistry

Industrija 4.0 je obezbedila dizajn i proizvodnju hirurških alata i aparata neslućenih mogućnosti, dimenzija i efikasnosti. Ovi alati i aparati su proizvedeni upotrebom aditivne proizvodnje (stvaranje trodimenzionalnih objekata iz digitalnog modela). Njihov kvalitet, izdržljivost i završna obrada su na mnogo višem nivou nego ranije (1,2).

Jedna od interesantnih posledica Industrije 4.0 vezanih za medicinu i stomatologiju je menadžment prve pomoći. Na primer, u kritičnim situacijama, kada je potrebna brza i precizna akcija, ova tehnologija veoma lako otkriva i prepoznaje prethodnu istoriju bolesti sa svim neophodnim informacijama, poput osnovnih podataka (ime, prezime, adresa, ustanova) i važnih medicinskih informacija (krvna grupa, prosečna težina, prosečna vrednost krvnog pritiska, komorbiditeti itd.). Na ovaj način, štedi se važno i, u mnogim slučajevima, kritično vreme; određuje se i dijagnostikuje trenutna situacija. Korišćenje različitih modernih instrumenata i uređaja povećava preciznu detekciju i dijagnostiku, poput tehnika 3D snimanja (1,2).

Ekonomija i menadžment u medicini i stomatologiji imaju potpuno novi pristup. Moguća je optimizacija troškova u proizvodnji aparata, medicinskih i stomatoloških sredstava, implantata itd. Upravljanje na svakoj klinici je digitalno, što značajno povećava i ubrzava usluge koje se pružaju pacijentima. Proizvodnja se pažljivo i precizno planira i prilagođena je pacijentu. Sve se prilagođava pacijentu, i time se smanjuje rizik i povećava efikasnost (1,2).

Precizna hirurgija je postigla veliki uspeh u složenim operacijama u medicini i stomatologiji i značajno unapredila dosadašnju hirurgiju. Industrija 4.0 i pametna proizvodnja proizvele su robote i precizne mehanizme i instrumente sposobne da realizuju složene, precizne i teške operacije u medicini i stomatologiji. Na primer, jedan hirurg, koliko god da je dobar, ne može da operiše dvadeset i više sati bez pauze i bez povećane mogućnosti da napravi grešku. Roboti ne mogu da se umore; njihova preciznost i efikasnost su kontinuirani, bez uticaja bilo kakvog fizičkog ili psihičkog faktora; roboti mogu da obavljaju nekoliko zadataka u isto vreme, što je hirurgu gotovo nemoguće. Veoma složene operacije u medicini i stomatologiji su sada lake i brze (različite laparoskopske operacije, vađenje zuba itd.). Primer precizne hirurgije prikazan je na slici 4.

Komunikacija lekara ili stomatologa sa pacijentom je na znatno višem nivou. Količina informacija je znatno veća, ali je rukovanje ovim informacijama znatno lakše i brže. Kada su u pitanju dostignuća u komunikacijama, medicina i stomatologija će praćenjem moći da predvide ishode lečenja, i ako je potrebno, realizuju odgovarajuće promene vezane za ishod lečenja. Očigledno je da će ogromna količina informacija biti dostupna veoma brzo i lako zahvaljujući novim komunikacionim tehnologijama. Na primer, lekari su u mogućnosti da u realnom vremenu vrše operaciju, koju istovremeno mogu da posmatraju studenti i specijalizanti, kao i da pri tome vrše komplikovana praćenja, kao i konsultacije sa kolegama. Takođe, prilikom nesreće, moguće je da se vrši komunikacija tokom transporta pacijenta, da se prati stanje pacijenta i da se organizuje najbolji mogući njegov prihvat (1,2). Značaj komunikacije u medicini i stomatologiji na različitim nivoima prikazan je na slici 5.

Jedna od najvećih prednosti Industrije 4.0 je smanjenje rizika po zdravlje i život pacijenta. Razvoj različitih senzora omogućava bolju efikasnost tokom operacija ili tretmana, jer se problemi mogu lako i brzo detektovati i rešiti. Primena novih tehnologija, naročito simulacija i virtuelne stvarnosti omogućava prethodnu probu i proveru tako da su zahvati koji se izvode na pacijentu potpuno bezbedni i unapred isplanirani. Matematički gledano, sve potencijalne „varijable" (pretnje) se mogu predvideti i mogu se u potpunosti kontrolisati i pratiti.

Nove tehnologije se sve intenzivnije koriste. Jedan veoma dobar i upečatljiv primer je holografija. Ova tehnologija može se koristiti za predstavljanje stanja pacijenta uz pomoć 3D tomografskog prikaza. Generalno, holografija podrazumeva kreiranje 3D slika pomoću svetlosti. Holografija je jedna od prednosti Industrije 4.0 i predstavlja veoma važan medicinski i stomatološki alat sa mnogo primena u patologiji, urologiji, kardiologiji, ortopediji, stomatologiji i protetici (1-5). Primer holograma zuba i srca prikazani su na slici 6.

Simulacija i virtuelna stvarnost predstavljaju standard u različitim naučnim oblastima, tako da je bilo samo pitanje vremena kada će se ova tehnologija koristiti u medicini i stomatologiji. Prednosti simulacija i virtuelne realnosti su ogromne. Na primer, u protivpožarnoj zaštiti, simulacija se može koristiti za predviđanje širenja vatre, dima, plamena, što može spasiti mnoge živote. Takođe,

via the Internet. Laboratory management, record management and many other benefits are very important in the functioning of digital clinic and digital dental office. Industry 4.0 also enables easy diagnostic in medicine and dentistry. System that presents digital hospital or clinic 4.0 related to the cloud computing model is shown in Figure 3 (1,2).

Industry 4.0 enabled design and production of surgery tools and apparatus with unimaginable possibilities, dimensions and efficiency. Noted tools and apparatus were manufactured using additive manufacturing (creation of three-dimensional objects from a digital model).). Their quality, endurance and sand are at a much higher level than before (1,2).

One of the interesting consequences of Industry 4.0 related to medicine and dentistry is first-aid management. For example, in critical situations, when fast and precise action is needed, this technology very easily detects and recognizes previous illness history with all necessary information, such as basic information (name, surname, address, affiliation etc.) and important medical information (blood group, average weight, average blood pressure, comorbidities etc.). In this way, important and in many cases critical amount of time is saved; determination and diagnosis of the current situation is made. The use of different modern tools and devices significantly increases the precise detection and diagnostics, such as 3D imaging techniques (1,2).

Economy and management in medicine and dentistry have a totally new approach. It is possible to realize the cost optimization in the production of devices, medicine and dentistry resources, implants etc. Management at every clinic is digital, which significantly increases and accelerates services provided to patients. Manufacturing was carefully and precisely planned and adapted to patients' needs. Everything is adapted to the patient, which reduces risks and increases efficiency (1,2).

Precise surgery has achieved great success in complex operations in medicine and dentistry and significantly improved the previous surgery. Industry 4.0 and smart manufacturing produced robots and precise mechanisms capable to realize complex, precise and hard operations in medicine and dentistry. For example, one surgeon, no matter how good he is, simply cannot operate twenty or more hours without pause and without increased potential for mistake. Robots cannot be tired; their precision and efficiency are continual, without in-
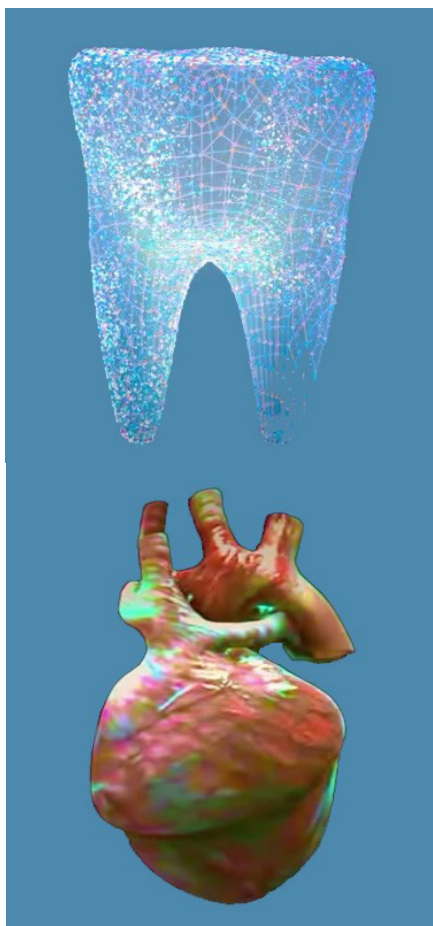
fluence of any physical or psychic factor; robots are capable of doing several tasks at the same time what is for a human surgeon almost impossible. Very complex operations in medicine and dentistry are now easy and fast (different laparoscope operations, tooth extraction etc.). An example for precise surgery is presented in Figure 4.

Communication between a doctor or a dentist with a patient are at a significantly higher level. The quantity of information is significantly greater but handling with this information is significantly easier and faster. Considering communication achievements, medicine and dentistry will be able to predict epilogues of treatment with monitoring and, if it is necessary, realize appropriate changes related to healing epilogue. When it comes to achievements in communications, medicine and dentistry will be able to predict treatment outcomes through monitoring, and if necessary, implement appropriate changes related to treatment outcomes.It is obvious that huge amount of information will be available very fast and easily thanks to new communication technologies. For example, doctors are able to realize operation in real time, where in the same time students and specialists can observing the operation, so as to realize complex monitoring and consultations with colleges. Also, in the event of an accident, it is possible to communicate during the transport of the patient, monitor his condition and organize the best possible reception (1,2). The significance of communication in medicine and dentistry at different levels is presented in figure 5.

One of the biggest benefits from Industry 4.0 is the risk reduction, related to the patients' health and life. Development of different sensors provides better efficiency during operations and treatments, because potential problems can be detected and solved fast and easily. The application of new technologies, especially simulation and virtual reality, enables preliminary testing and checking so that procedures performed on the patient are completely safe and planned in advance. From the mathematical point of view, all potentials „variables "can be predicted and can be fully controlled and monitoring.

New technologies are more and more intensively used. One very good and striking example is holography. This technology can be used for the presentation of medical states of patients with 3D tomography view. Generally, holography pur-
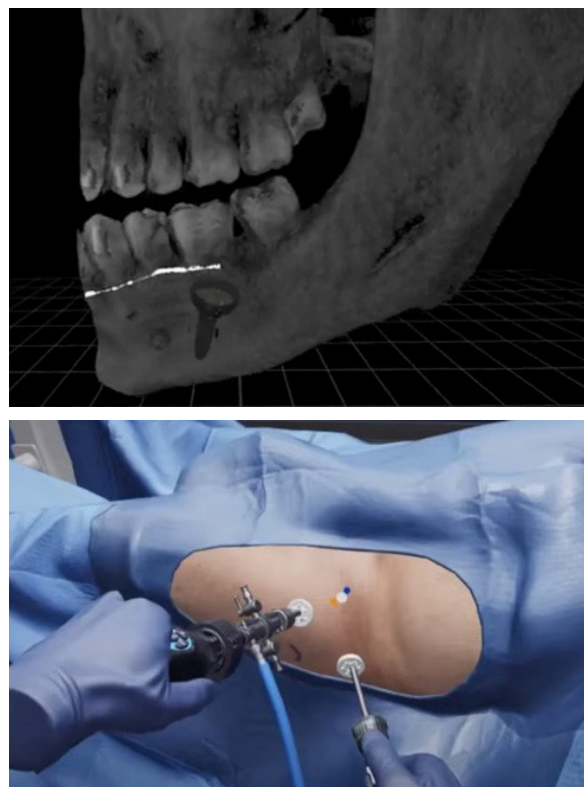
Slika 6. Primer holograma zuba i srca
Izvor: https://depositphotos.com/video/holo-gram-screen-of-molar-tooth-299092082.html;
https://free3d.com/3d-model/heart-pro-animat-ed-textured-4653.html

Slika 7. Simulacija i virtuelna stvarnost u stomatologiji i hirurgiji
Izvor: https://www.youtube.com/watch?v=3t-pnRFshvsA&ab_channel=MedtronicDigitalSurgery

kada je u pitanju protivpožarna zaštita, strategije evakuacije i scenariji evakuacije sa preciznim proračunima vremena potrebnog za evakuaciju se mogu realizovati korišćenjem simulacija i softvera za simulaciju (6,7). Naravno, postoje i mnogi drugi primeri u drugim naučnim oblastima.

Simulacije i virtuelna stvarnost imaju sjajnu ulogu u medicini i stomatologiji. Virtuelna starnost može pružiti važne informacije o pacijentima doktorima i stomatolozima. Planiranje kompleksnih aktivnosti i operacija u medicini i stomatologiji uz pomoć 3D snimaka obezbeđuje kvalitet i značajno umanjuje vreme potrebno za planiranje i realizaciju neke aktivnosti ili operacije. Ove tehnologije značajno unapređuju hirurške i manuelne veštine hirurga i stomatologa zbog mnogo boljeg prikaza i šanse da se vežba pre operacije (1,2,6,7). Upotreba simulacije i virtuelne stvarnosti prikazana je na slici 7.
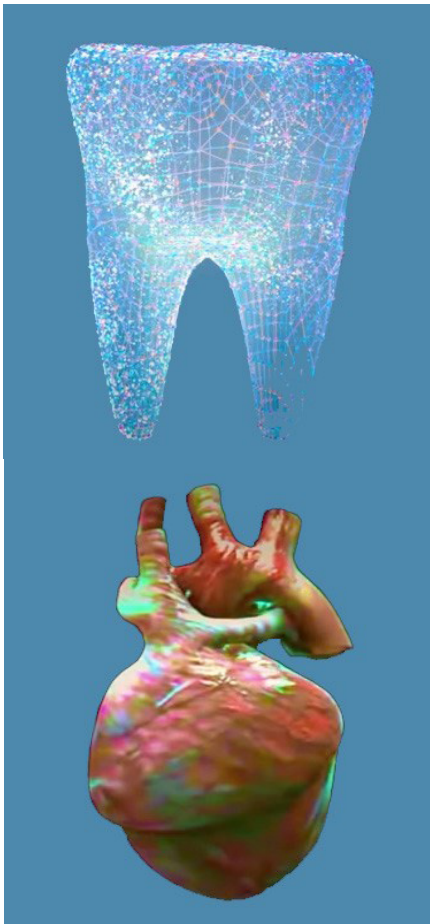
Posmatranje i praćenje u medicini i stomatologiji ima veliki značaj. Korišćenjem tehnologija Industrije 4.0, posmatanje i praćenje celokupnog procesa lečenja je veoma lak i efikasan. Sve važne informacije su pripremljene i dostupne. Na primer, mnogi kardiološki pacijenti mogu biti praćeni uz kompletne informacije o njihovim tegobama, bolesti, terapiji uz mogućnost da se odmah reaguje u slučaju hitnih stanja. Korišćenjem ovih tehnologija, moguće je sprovesti posmatranje i praćenje kompletne javno-zdravstvene situacije, što je od ključne važnosti za optimizaciju zdravlja, predviđanje potencijalnih kriznih situacija (pandemija, na primer), optimizaciju kvaliteta lečenja u medicini i stomatologiji, optimizaciju troškova, recikliranje medicinskog i stomatološkog otpada itd. (1,2,5,10).

Optimizirana proizvodnja različitih implantata bilo kog oblika u medicini i stomatologiji predstavlja standard. Više nije potrebno povećavati rezerve jer se implanti proizvode prema ličnim zahtevima. Primetno je i veoma veliko smanjenje papirologije. Korišćenjem digitalnih tehnologija, informacije o
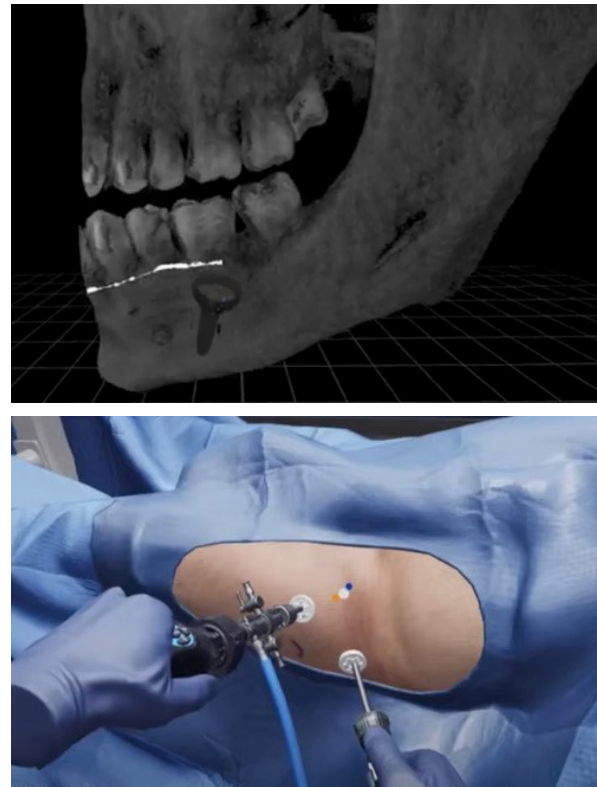
Figure 6. An example for hologram of tooth and heart.
Source: https://depositphotos.com/video/hologram-screen-of-molar-tooth-299092082.html; https://free3d.com/3d-model/heart-pro-animated-textured-4653.html

Figure 7. Simulation and virtual reality in dentistry and surgery
Source: https://www.youtube.com/watch?v=3t-pnRFshvsA&ab_channel=MedtronicDigitalSurgery

ports design of the 3D pictures by light. Holography presents the consequence of Industry 4.0 and presents a very important medical and dentistry tool with plenty of applications in pathology, urology, cardiology, orthopaedic, dentistry, prosthetics etc. (1-5). An example of a tooth and hart hologram is shown in Figure 6.

Simulation and virtual reality represent a standard in different fields of science, so it was just a question of time when this technology would be used in medicine and dentistry. The benefits of simulations and virtual reality are enormous. For example, in fire safety, simulation can be used to predict the spreading of fire, smoke, flame which can save many lives. Also, in relation to fire protection, evacuation strategies and evacuation scenarios with precise calculation of needed evacuation times can be realized using simulations and sim-

ulation software (6,7). Of course, there are many other examples in other fields of science.

Simulations and virtual reality have a great role in medicine and dentistry. Virtual reality can provide important information to doctors and dentists about patients. Planning of complex actions and operations in medicine and dentistry with providing of 3D presentation of the patient enables quality and significantly reduced time needed for preparation and realization of action or operation. These technologies significantly increase operation and manual skills of surgeons and dentists because they have much better view and chance to practice before operations (1,2,6,7). The use of simulation and virtual reality in dentistry and surgery is presented in Figure 7.

Monitoring and tracking in medicine and dentistry have very important roles. With the use of Industry 4.0 technologies, monitoring and tracking of complete treatment process is very easy and effective. All important information is prepared and available. For example, many of cardiac patients can be monitored and tracked with complete in-

pacijentima se čuvaju u digitalnom obliku i mogu se lako odštampati (10).

Postoje brojni drugi primeri primene tehnologija Industrije 4.0 u medicini i stomatologiji. Očigledno je da se promene izazvane digitalnim tehnologijama pojavljuju i nepovratno menjaju mnoge sfere života i rada ljudi, pa je tako i u medicini i stomatologiji (8,10).

Budući trendovi razvoja

Očigledno je da Industrija 4.0 ima sve više mogućnosti u smislu primene, istraživanja i inovacija. Primenjuje se korišćenjem pametne proizvodnje, integrisanog dizajna, pametnih usluga i menadžmenta i pametnog istraživanja. Pametni medicinski i stomatološki uređaji i aparati se već proizvode, a u bliskoj budućnosti će se proizvoditi mnogo bolji. To će zahtevati edukaciju medicinskog i stomatološkog kadra, ali će korist od njih biti neverovatna (1,2).

Uticaji Industrije 4.0 i njene tehnologije će takođe značiti i ogromnu pomoć i prednosti za studente medicine i stomatologije u smislu postavljanja precizne dijagnoze, lečenja, usavršavanja njihovih veština itd.

Tehnologije Industrije 4.0 će se suočiti sa enormnim količinama informacija, njihovim upravljanjem i čuvanjem. Sve potrebne informacije o pacijentu će biti pružene i dostupne u svakom trenutku.

Jedna od veoma bitnih stavki kada su u pitanju Zdravstvo 4.0, odnosno Medicina 4.0 i Stomatologija 4.0, su neograničene mogućnosti za istrživanje. Primena novih procedura, instrumenata, implanata, robota, lekova daju neslućene mogućnosti za uspostavljanje znatno efikasnijeg zdravstva u celini. Procena je da će mnoge bolesti u budućnosti biti potpuno iskorenjene ili da će preći u hronične, sa mnogo povoljnijim ishodima po pacijente.

Bolesti će se potpuno pratiti, u svim potencijalnim pravcima i sa uvek najboljim solucijama. Pretpostavlja se i da će veliki broj retkih bolesti biti potpuno eliminisan zahvaljujući neslućenim mogućnostima predikcije koje donose nove tehnologije. Mnoge operacije za koje su bili potrebni posebni uslovi (anestezija, razni neophodni instrumenti i pomagala itd.) će biti potpuno automatizovane sa unapred predviđenim pozitivnim ishodom.

Angažovanje velikog broja doktora, sestara, specijalista će drastično biti smanjeno. Naravno, to će podrazumevati efikasna rešavanja mnogih problema i izazova koji se odnose na standarde, bezbednost, privatnost, raznovrsnost podataka, mogućnosti prilagođavanja i prihvatanja, snabdevanje različitim resursima itd. Bez obzira na postojeće i potencijalne probleme, poređenje, generalno, zdravstva 4.0 sa prethodnim (zdravstvo 1.0, zdravstvo 2.0 i zdravstvo 3.0) dokazuje da je upotreba novih tehnologija nužnost, potreba i budućnost i to ne samo za istraživanje i razvoj, nego i za druge oblasti zdravstva (medicina, stomatologija) (1,2,11,12).

Zbog svega navedenog, očigledno je da će industrija 4.0 u medicini i stomatologiji povećati svoje mogućnosti, ali i potrebe. Prilagođavanje na digitalne tehnologije biće na najvišem nivou sa jasnim ciljem kreiranja pametnog, jedinstvenog zdravstvenog sistema (1, 2,7, 8, 10).

Inovativne tehnologije Industrije 4.0 će stvoriti bolju i sigurniju budućnost u smislu optimiziranih medicinskih usluga i lečenja, mnogo većeg procenta izlečenih pacijenata, virtuelnih medicinskih i stomatoloških klinika sa konsultacijama uz pomoć telemedicine i terapija i još mnogo toga (8-12).

Zaključak

Medicina i stomatologija predstavljaju oblasti u kojima se primenjuju različiti pametni proizvodi i rešenja koja su kreirana na osnovu tehnologija Industrije 4.0. Napravljeni su mnogi složeni i efikasni medicinski i stomatološki uređaji i aparati sa mogućnostima koje se do pre nekoliko godina nisu mogle ni zamisliti. Performanse i kvalitet zdravstvenih tretmana i usluga su na veoma visokom nivou i taj nivo će biti još veći u budućnosti.

Iako je Industrija 4.0 donela mnoge prednosti, to nije kraj istraživanja i razvoja. Osnovane su veoma važne baze, pripremaju se novi trendovi istraživanja i razvoja. Istraživanja se bave novim uređajima, aparatima i implantatima koji će doprineti daljem napretku u medicini i stomatologiji i omogućiti potpunu realizaciju koncepta Medicina 4.0 i Stomatologija 4.0.

Konflikt interesa

Autor je izjavio da nema konflikta interesa.

formation about their problems, illness, therapy and possibility to react instantly in case of emergency. Using these technologies, it is possible to realize the monitoring and tracking of complete public health situation, which has crucial importance in optimization of health, prediction of potential crisis situations (pandemics for example), optimization of quality of medical and dental treatments, optimization of costs, recycling of medical and dental waste etc (1,2,5,10).

The optimized production of different implants of any shape present a standard in medicine and dentistry. It is not necessary to increase reserves anymore because implants are produced by individual requirement. A very large reduction of paper documentation is also notable. Using digital technologies, information about patients is stored in digital form and can be easily printed (10).

There are numerous other examples of applications of Industry 4.0 technologies in medicine and dentistry. It is obvious that changes caused by digital technologies appear and irrevocably change many spheres of human work and living, including medicine and dentistry (8,10).

Future trends of development

It is obvious that Industry 4.0 has more and more possibilities of applications, research and innovations. It is applied using smart manufacturing, integrated design, intelligent services and management and smart researching. Smart medical and dental devices and apparatus have already been produced, and in the near future, much better will be produced. It will demand the education of medical and dental staff, but the benefits of them will be unbelievable (1,2).

The influences of Industry 4.0 and its technology will also provide great help and benefits to students of medicine and dentistry in the sense of precise diagnostics, treatment solutions, improving of their skills etc.

Technologies of Industry 4.0 will face enormous quantities of information, their management and storing. Necessary information about patients will be provided and available at the moment.

One of the very important items when it comes to Health 4.0, i.e. Medicine 4.0 and Dentistry 4.0, are unlimited opportunities for research. The application of new procedures, instruments, implants, robots, and drugs provide unprecedent-

ed opportunities for the establishment of significantly more efficient health care as a whole. It is estimated that many diseases will be completely eradicated in the future or that they will become chronic, with much more favorable epilogues for patients.

Diseases will be fully monitored, in all potential directions and always with the best solutions. It is estimated that many diseases will be completely eradicated in the future or that they will become chronic, with much more favorable epilogues for patients. It is also assumed that a large number of rare diseases will be completely eliminated thanks to the unprecedented possibilities of prediction brought by new technologies. Many operations that required special conditions (anesthesia, various necessary instruments and aids, etc.) will be fully automated with a predetermined positive outcome.

The hiring of a large number of doctors, nurses, and specialists will be drastically reduced. Of course, this will involve effective solutions to many problems and challenges related to standards, security, privacy, diversity of data, possibilities of adaptation and acceptance, supply of different resources, etc. Regardless of the existing and potential problems, the comparison, in general, of healthcare 4.0 with the previous ones (health 1.0, healthcare 2.0 and healthcare 3.0) proves that the use of new technologies is a necessity, a need and the future, not only for research and development, but also for other fields of medicine (medicine, dentistry) (1,2,11,12).

Based on the above mentioned, it is obvious that industry in medicine and dentistry will increase their possibilities and needs. The adaption to digital technologies will be at the highest level with the clear aim of designing a smart unique healthcare system (1, 2, 7, 8, 10).

Innovative Industry 4.0 technologies will design a better and safer future in the form of optimized medical services and treatment, much bigger percentage of cured patients, virtual medical and dental clinics with telemedicine consultations, optimal use of medicaments and therapies and lot of other things (8-12).

Conclusion

Medicine and dentistry present spheres where many different intelligent products and solutions

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designed by technologies of Industry 4.0. Many complex and efficient medical and dental devices and appliances have been created with possibilities that could not even be imagined until a few years ago. Performances and qualities of complete healthcare treatments and services are at a very high level and this level will be even higher in the future.

Although Industry 4.0 has brought many benefits, this is not the end of research and development. Research deals with new devices, appliances and implants that will contribute to further progress in medicine and dentistry and enable the full realization of the concept of Medicine 4.0 and Dentistry 4.0.

Competing interests

The author declared no competing interests.

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