Journal of Clinical Orthopaedics and Trauma 11 (2020) 713–717

Contents lists available at ScienceDirect

Journal of Clinical Orthopaedics and Trauma

journal homepage: www.elsevier.com/locate/jcot

Internet of Medical Things (IoMT) for orthopaedic in COVID-19 pandemic: Roles, challenges, and applications

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ARTICLE INFO

Article history:
Received 9 May 2020
Accepted 12 May 2020
Available online 15 May 2020

Keywords:
Orthopaedic
Internet of medical things
IoMT applications
Coronavirus
COVID-19
Pandemic

ABSTRACT

Internet of Medical Things (IoMT) is an innovative mean of amalgamating medical devices and their applications to connect with the healthcare information technology systems by using networking technologies. We have explored the possibilities of confronting the ongoing COVID-19 pandemic by implementing the IoMT approach while offering treatment to orthopaedic patients. The data sharing, report monitoring, patients tracking, information gathering and analysis, hygiene medical care, etc. are the various cloud and connected network-based services of IoMT. It can completely change the working layout of the healthcare facilities while treating orthopaedic patients with a superior level of care and more satisfaction, especially during this pandemic COVID-19 lockdown. Remote-location healthcare has also become feasible with the proposed IoMT approach.

1. Introduction

Internet of Medical Things (IoMT) can be defined as the application of the fundamentals, principles, tools, techniques and concepts of the well-recognized with Internet approach particularly for the medical and healthcare sectors and domains. It needed all the efforts to make the feasible network of services so that the available healthcare resources and the various medical services can be interconnected through the ultimate applications of internet-based devices. The crucial roles of proposed IoMT concepts come into picture when the medical services need to deliver in some remote areas. The use of IoMT concepts and tools has completely changed the healthcare, medical operations and services.[1,2]

The IoMT offers all the possible treatments to the orthopaedic patients in various ways and means whether it is related to the bones, tendons, ligaments, joints, muscles, etc. The orthopaedic patients are facing several crucial and severe issues in such tough COVID-19 time.[3,4] The proposed IoMT concept offers the solutions and the treatments to these issues related to orthopaedic patients by utilizing the advanced technology, and intelligent machine learning-based approaches which merged to provide the fruitful proposals to the orthopaedic patient's treatment, especially in today's COVID-19 pandemic background.

2. Background of IoMT and services

The very first internet assisted solicitation came into existence in 1982 with the purpose to sell-out the cold drinks, and the term *Internet of Things (IoT)* was coined in 1999 by Procter & Gamble organization. The IoT is the structure of interrelated devices and operations complied with all the network elements such as; software, hardware, connectivity of the network, and any other required electronic and computer means that ultimately makes them responsive by supporting in data exchange and compilation.[5–7] There are several areas of applications in which IoT concept is well established and productive, namely; consumer-related, industrial, infrastructure, and commercial applications.

In commercial solicitations, serving the medical and healthcare sectors, transportation facilities, etc. are the major ones. Moreover, the well-proven *IoT strategy* has now become more exploring in serving the healthcare and medical sectors, where it is mainly known as – Internet of Medical Things (IoMT). Fig. 1 explains the various employable tools and tactics of IoMT to serve the

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https://doi.org/10.1016/j.jcot.2020.05.011
0976-5662/

Fig. 1. Proposed IoMT services for orthopaedic patients during COVID-19.

orthopaedic patients, during COVID-19 period significantly. IoMT further allows medical and healthcare professionals to provide medical care for orthopaedic patients by offering them the solutions in critical areas and even in remote locations.[8,9] This solution also reduces the overall stress level as well as improves the effectiveness of the physicians, staff, nurses, etc. It reduces unnecessary hospital visits and an overall burden on health care systems, by directly connecting the patients to their physicians and thus allowing the transfer of medical data through a secure network.

3. Research objectives

The present challenging situation of COVID-19 pandemic is compelling for the medical personnel, staffs, healthcare workers, etc. to offer services and treatments to their patients in a more impactful, productive and effective manner. This comprehensive review proposes the possible means of offering medical care to the orthopaedic patients through IoMT approach, during COVID-19 pandemic. The orthopaedic patients are commonly facing many problems in this pandemic such as; visiting the medical facilities, medicine purchase, testing and report monitoring etc.[10–12] These issues can be resolved more conveniently and effectively through IoMT approach. It also helps to serve the orthopaedic patients residing or stuck in some remote location where the medical facilities cannot be otherwise provided timely and promisingly. Fig. 2 reflects the possible advantages offered by IoMT approaches in serving and treating orthopaedic patients in COVID-19 crisis.

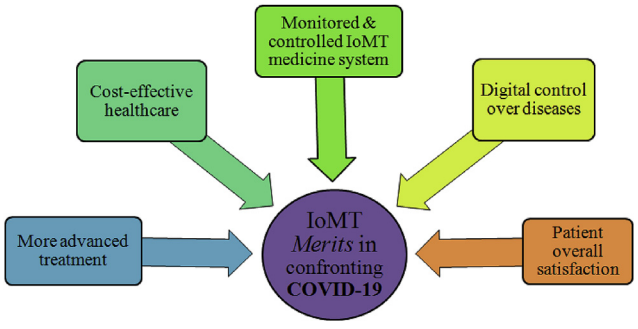

Fig. 2. Typical merits offered by implementing IoMT −19 services in COVID.

4. Major challenges in the orthopaedic speciality during COVID-19

The lockdown period during this COVID-19 pandemic has tensed the patients whose treatment and prescriptions are currently in progress and is getting affected by the present circumstances. All the patients needed to be in touch with their physicians for routine and regular follow-ups. The patients with orthopaedic problems face unique challenges, as their mobility is restricted due to their ailment or due to past surgery of fractures, joint replacement, arthroscopic and spinal surgery etc. The face-to-face interaction with their doctors may not be possible to avoid the chances of contamination and infection by the Coronavirus.[13–15] The pain in these orthopaedic patients is sometimes intolerable; therefore, there is a need to come with some advanced cloud-based services, which can at least support and heal-out the orthopaedic patients during this pandemic COVID-19 framework.

5. Working process of IoMT for orthopaedic during COVID-19

The present research study targets the implementation of proposed IoMT methodology for the treatment of orthopaedic patients in this ongoing COVID-19. The workflow process of IoMT approach includes the integration of healthcare appliances, medical treatment system, internet network, software solicitations and services. IoMT system enables the data collection, report monitoring, patient database, testing images and analysis, etc. facilities for the orthopaedic patients in a more effectual manner. The workflow process makes the connections between the essential major IoMT elements, medical appliances, and advanced technology-based devices which ultimately serve the intended functions intending to improve the patient care especially in remote areas.[16–20] The proposed workflow process of IoMT concept for serving orthopaedic patients in COVID-19 period is exemplified in Fig. 3.

The proposed flow chart of IoMT processes can offer typical and much-needed service facilities during the time of COVID-19 when it comes to treat-out the orthopaedic patients with the latest and advanced methodologies. The better treatment and care, along with the superior workflow process, is also attainable with the offered philosophy of IoMT.

6. Digital connectivity of hospital during COVID-19 pandemic using IoMT

IoMT methodology allows the Healthcare and medical personnel to utilize its well-connected network of services and facilities while offering treatment to the patients. These interconnected services include the well-systemized channel of clinical advances, a digital monitoring system for patients, smart medicocare, data analysis tools, cloud-based computing, smart bed facilities, scanning appliances, etc. and these all facilities are further tuned-up with the much-needed internet-based schemes namely; wireless fidelity, Bluetooth, modem, etc.[21–24] Fig. 4 discusses the connected network of features and facilities of IoMT.

7. Key-roles of IoMT in orthopaedic field during COVID-19 pandemic

IoMT approach has been well proven and established in serving the healthcare sector most effectually. Its roles and services are further needed to be employed in treating orthopaedic patients

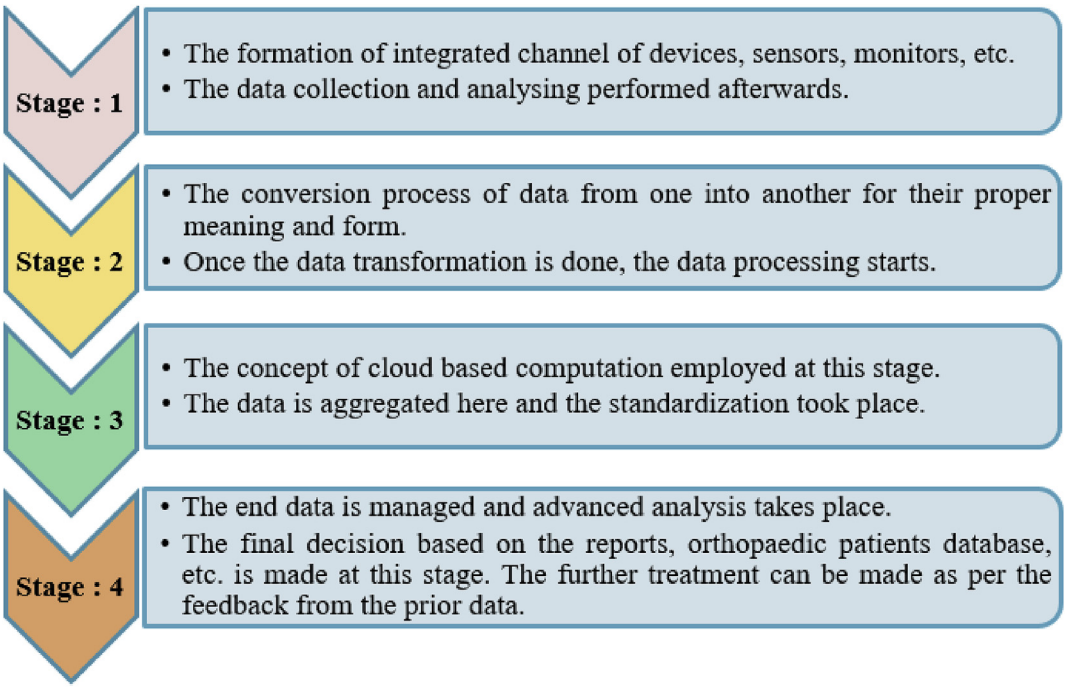

Fig. 3. Process workflow chart for applying IoMT methodology for orthopaedic patients.

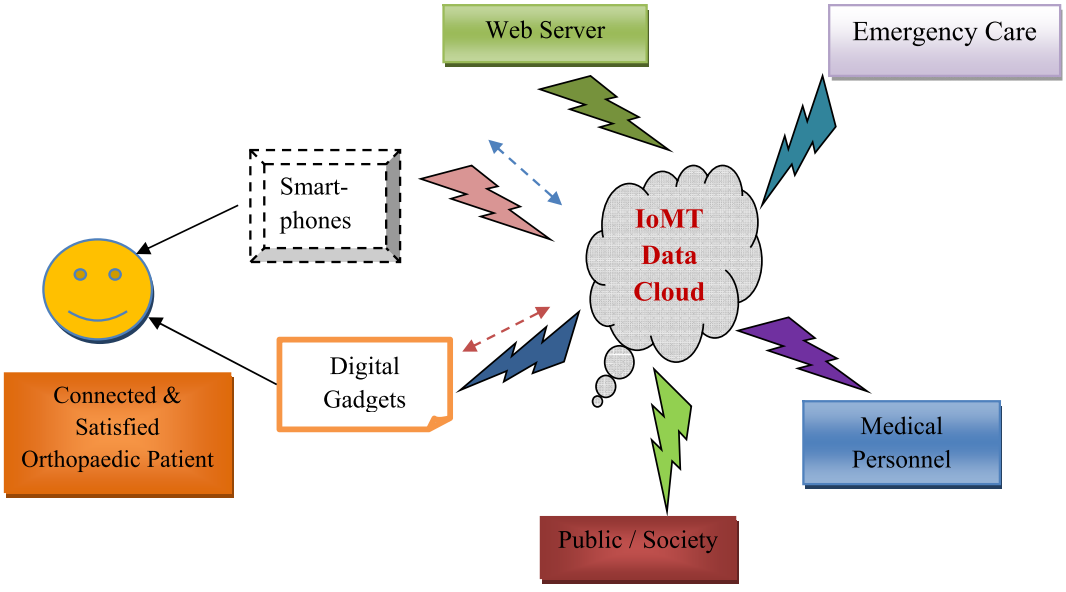

Fig. 4. The connected medical facilities under the proposed IoMT concept.

during the ongoing pandemic COVID-19 period.[25–30] Table 1 is reflecting and explaining the major roles of IoMT concept in providing the proposed services in the field of orthopaedic during COVID-19.

The IoMT can help orthopaedic surgeons to manage their work in the clinic and the hospitals, by offering the administrative and clinical functions. Remote telemedicine consultations are possible through its use. IoMT can be a handy tool in hospital management, by way of:

a) Tracking and monitoring the assets like high capital value instruments and implants;
b) managing the inventory;
c) improving the management of patient's flow in the hospital and identifying the problems;
d) measuring the staff productivity and efficiency etc.

8. Expected applications of IoMT in future

The IoMT provides several vital applications to overcome the crucial impacts ofepidemics and pandemics. The facility of providing medical services in a remote location, online and onscreen checkups, report analysis, database sharing, information computing, overall

Table 1
Major roles and services of IoMT in the field of orthopaedic during COVID-19.

S.No.	Role of IoMT	Description
1	Proactive orthopaedic treatment	• It opens the door for an interrupted health supervising and offering proactive orthopaedic care.
2	Cost Reduction	• It is cost-effective; as the cost incurred by the patients in the frequent visits to doctors, testing, etc. can be avoided.
3	Emergency Care	• IoMT creates an advanced culture in the treatment process by using the analytics and modern digital devices so that anypossible emergency can be predicted and analyzed from a distance away.
4	Remote orthopaedic care	• The orthopaedic patients in a remote location can be treated through cloud-based services, telemedicine, etc.
5	Health monitoring and tracking	• IoMT offers advanced digital wearable devices for the proper monitoring of the patients. The pulse, Blood pressure, etc. can be checked and monitored. • The health tracking of orthopaedic patients can be made by using cloud-based data analyzing and report testing.
6	For Physicians	• IoMT enables physicians with the smart monitoring of the patients. In the present COVID-19 situation, when the pandemic is not allowing face to face regular interactions, IoMT offers a super class facility. • The offered analysis results help the doctors to decide on further necessary treatment protocols.
7	For orthopaedic Hospitals	• Smart orthopaedic hospitals can be developed by using this technology. The well-connected devices make the proper hygiene monitoring system within the hospital so that any possible infections can be avoided. • Enables the medical staffs to serve the patients instantly whenever needed. Real-time monitoring culture makes smarter care of patients effectively.
8	Offers fast disease detection	• The real-time database supports in diagnosing the disease at a very initial level as the data well monitored on cloud base.
9	For Health Insurance Companies	• The insured person can be monitored to avoid any possible fraud. It makes the claims, facilities, etc. more transparent.
10	For Drug Management	• As IoMT deals with the connected channel of devices throughout, the medicine storage and consumption can be computed out.

tracking and monitoring of patients are some of the major applications of IoMT. The remembering feature devices for the aged persons to keep them reminding about various acts like medication, medicine timings, sleeping level monitoring, etc. are some of the specially developed features from IoMT services for the older patients.[31–34] Some more typical proposed applications for confronting such pandemic like COVID-19, Internet of Medical Things (IoMT) offers front tackling tools, devices, applications as summarised in Fig. 5.

9. Challenging aspects and future scope of the study

Apart from all the success and advantageous perspective of the proposed IoMT technology in solving orthopaedic issues, there exist some challenging aspects too, while implementing this concept in treating the survivors of this pandemic. The challenging issues include the security concerns as the main background to develop this approach is based upon the effective cloud-connected database. The interoperability is another concern in addition to the data security during IoMT functioning. There is always a need to create a dynamic, connected scheme to merge these advanced digital facilities following the medical facilities and services. In providing more impactful training to the medical personnel, the future investigations should be targeted to create additional sessions for creating further clinical reasoning, more targets to be set for poor and remote locations during COVID-19 period, the differential diagnosis for symptom localization, joint & soft tissue

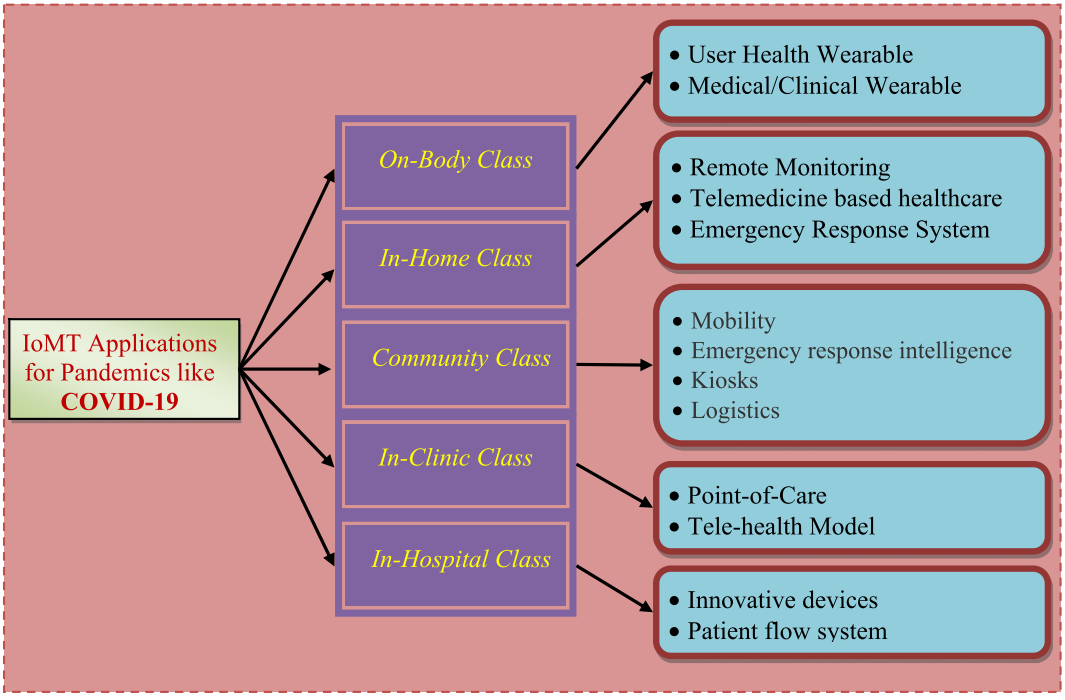

Fig. 5. Class-wise applications of IoMT to serve in COVID-19 pandemics.

assessment studies, etc. Moreover, further research should be attempted to create a more digital resolution for the muscle stretching techniques, thoracic manipulation, locking tactics for spines, cloud data based prescription for spine exercise, etc.

10. Conclusion

In the time of ongoing pandemic COVID-19, IoMT offers several advanced cloud-based services and facilities to serve orthopaedic patients more effectually. The remote healthcare system is much meaning in such a critical time of lockdown. The effective interconnected system of devices, applications, internet, database, etc. helps the consumers to avail the services smartly. IoMT also promotes its services by developing the quality culture of smart-healthcare or mobile-clinic. It is a 'game-changer technology' which may completely change the practices in the field of orthopaedic globally. Even its quality services in this tough time making this approach more fruitful and worthwhile. The IoMT help in monitoring and tracking of older individuals, patients in remote locations for their healthcare requirements. We believe that the traditional health care is likely to witness a significant paradigm shift in the near future, as the digital transformation would put advanced technology and its connected products in the hands of the patients and provide both the patients and the physicians in the remote locations better access to the quality health care facilities.

Author statement

On the behalf of all the authors in paper, I corresponding author hereby accept that this paper contains works that have not previously published or not under consideration for publication in other journals.

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