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RESEARCH ARTICLE

Remote Clinical Consultations in Restorative Dentistry - A Pilot Clinical Study

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ABSTRACT

Specialist consultations are routine in medical and oral healthcare provision. These take place as an 'in-person' event in the secondary care centres. The primary outcome of the specialist consultation is to provide the dentist and the patient with a specialist assessment, diagnosis, prognosis and a proposed care plan.

This in-person procedure remains the gold-standard as it is a considered safe and effective. It presents a number of shortcomings: (1) The referring clinician is not actively involved in the decision-making process. (2) The patient must travel to the secondary care centre for the consultation, creating inequalities of care provision. (3) The patient travel has a carbon footprint. (4) The setting of the referral centre can be unfamiliar and intimidating to the patient. (5) The outbreak of COVID-19 highlighted the need for alternative system to address this need.

This clinical study assessed the feasibility and effectiveness of undertaking remote clinical consultations in restorative dentistry between a patient and dentist co-located in a clinical primary care dental practice and a specialist consultant in a remote secondary care centre.

Method: A remote clinical consultation in restorative dentistry was conducted that enabled full engagement between the remote consultant and the patient/General Dental Practitioner (GDP) in the dental surgery. A comprehensive bespoke high-speed secure internet connected hardware and software platform was used.

Each participant completed a semi-structured interview and a validated questionnaire covering four domains: Patient safety, communication between different parties, formulation of a treatment plan, and effectiveness of the technology.

Results: Effective and safe clinical consultations were carried out in all the cases, regardless of gender, age and presenting complaint. Neither the process nor the outcomes were inferior to an in-person consultation.

Conclusion: This pilot in-practice clinical effectiveness study identified that Remote Clinical Consultations (RCCs), as conducted in this study, are effective for the delivery of specialist consultations in restorative dentistry. They are not inferior to an in-person consultation. Secondary outcomes: Three-way discussion was very positive; high levels of acceptability from the patients and the referring GDPs; an alternative to patient travel, reducing travel inconvenience, cost and the environmental burden from the associated carbon dioxide emissions.

Introduction

Teledentistry in its various formats is gaining increased acceptance and use for the provision of non-operative care.[1-4] This is driven by the continuous improvement in fast, secure and high-resolution digital technologies; the convenience of not having to attend an in-person consultation; the need for equality in access to healthcare services; and the desire to reduce our carbon footprint associated with patient commute.

The American Teledentistry Association (ATA) defines *teledentistry* as "the use of communication technology, including audio and video interaction, to remotely provide dental care services such as consultation, diagnosis, and patient education".[5,6] They report that teledentistry is a medium to reduce health disparities in society. Their position statement emphasised that the standard of care for the professional practice of dentistry should apply, whether the service is delivered in-person or via teledentistry.

According to the United Nations' International Telecommunication Union, approximately 97% of people worldwide live within reach of a mobile cellular signal (2019).[7] The application of telemedicine to enhance access and aid delivery of healthcare to patients has been discussed since the 1990s and have been widely adopted in different formats (e.g., telephone-only consultations and video consultations) with mixed results and a clear indication that video-supported consultations result in more correct treatment decisions.[8-12] A more recent and relevant study to restorative dentistry by Gleeson and Kalsi (2022) reports that the use of phone and the NHS England secure remote consultation platform 'Attend Anywhere- (AA)' for the provision of video interaction between clinician and patient provided high levels of patient satisfaction for both modalities.[13]

The ability for the clinician to reach a conclusive diagnosis and treatment strategy depends on two aspects: The sophistication of the communication technology (technical capability and ease of use) and its ability to reproduce with total fidelity and infallibility the information obtained from an equivalent synchronous in-person consultation.[14,7,9] Teledentistry can operate by using a platform of secure internet-based, high-resolution, multi-channel audio-visual streaming that enables simultaneous and synchronous sharing of information and active, engaged discussion between primary and secondary care providers. This provides integrated management of patient care between the three parties (patient, dentist and consultant) at the point of specialist treatment planning.[10] The relative merits of teledentistry modalities in restorative dentistry have been explored with the potential to overcome the recognised difficulties that are associated with in-person consultations.[7,8,10]

To understand the significance of these requirements, it is necessary to consider the conventional in-person consultation that takes place in secondary care specialist referral centres (e.g., district or teaching hospitals). The patient is required to travel to the specialist centre for the said assessment and

consultation. The recommended care plan is discussed verbally with the patient during the appointment and subsequently relayed to the referring clinician, the patient, and any other involved stakeholders in written format. The current method that enables direct visual and in-person engagement remains the gold standard for safe and effective clinical consultations. Notwithstanding, this in-person process presents with significant shortcomings: [1] The referring clinician (GDP, with ultimate responsibility for the patient's care pathway) is not actively involved in the decision-making process. This referring clinician is excluded from the actual consultation process and is not able to contribute to the information-gathering and decision-making process at any stage. [2] The patient must travel to the secondary care centre for the consultation, which may be in a remote geographical location. This creates inequalities of care provision, as the journey to the specialist centre may be long, complex, expensive and time-consuming. The Organisation for Economic Co-operation and Development (OECD) highlights in its 2019 report that the challenge of access to the secondary care setting for patients who live in remote geographical locations may also cause inequality in access to healthcare.[15] This is further exacerbated with a reported strong negative correlation between geographical barriers, transportation barriers and access to health care services.[16] [3] The patient travel and associated CO_2 emissions are identified by NHS England (UK) as contributing to approximately 33% of the of total greenhouse gas emissions by NHS dentistry in the UK.[17] There is a realisation that patient travel is considered undesirable if it can be avoided and a reduction of this is part of the UK 'NHS Long Term Plan' and the 'Net Zero NHS 2040' plan with a commitment to reduce face-to-face outpatient appointments by 30% over the next five years.[18,19] This is further emphasized by the UK National Elective Care Transformation Programme highlighting that the drivers for this plan are to save patients time and money and reduce pollution from road travel. [20] [4] The setting of the referral centre can be unfamiliar and potentially intimidating which may be counterproductive to a relaxed dialogue between the consultant and the patient. This situation may lead to the misinterpretation of information with undesired outcomes. [5] The outbreak of COVID-19 pandemic had a major impact on the ability to provide in-person consultations appointments, highlighting the need for alternative system to address this patient care need. [21,22] The pandemic accelerated the uptake of teledentistry as a potential solution to access dental care.[23, 24]

Against this backdrop, it is unquestionable that there is a growing interest and desire to engage with teledentistry for the provision of diagnostic and consultation services. In the UK, 380,000 specialist dental consultations take place every year.[25] Teledentistry is reported to reduce the long waiting times; especially for some procedures, such as endodontics, as the patients may be in pain and the prognosis may worsen with time. A number of further unintended benefits to both parties were noted in the form of, cost savings, increased convenience, and the ability to provide care to people with mobility

limitations, or those in rural areas who don't have access to a local doctor or clinic.[26] There is no doubt that teledentistry and remote clinical consultations may reduce the high prevalence of healthcare inequalities by ensuring that health and care services are designed around people's needs. [27] Notwithstanding, the implementation of remote and digital care services has to be considered with caution. The exclusive reliance on these services could prevent some people from accessing the required care and support because they did not have access to or feel comfortable using digital technology.

The previous clinical service evaluation of RCCs in restorative dentistry identified some some interesting and unexpected consequences.[14] When the referring general dental practitioner is involved as an active participant, there is an opportunity to engage in valuable two-way learning and teaching.[10,28] RCCs shift the decision-making-process from a one-to-one scenario (GDP-patient, consultant-patient or consultant-GDP) to group decision-making with all three stakeholders as active synchronous participants in the discussion. A collaborative system using telecommunication through the use of telemedicine, dental image tools, sharing electronic patient records and video-conference, helps to establish a cooperative diagnosis, treatment planning and professional mentoring.

As previously highlighted, the effectiveness and reliability of teledentistry in its various formats is dependent on two factors:

- The sophistication (technical capability and ease of use) of the audio-visual communication technology.
- The ability to replicate the information obtained and outcomes from a live in-person consultation.

The range of synchronous modalities for clinical patient assessments can be considered as a spectrum ranging from an *audio telephone conversation* as the most basic to *in-person three-way consultation* between the GDP, the consultant and the patient as the most sophisticated and desirable (Table 1). Across the range of medical conditions and requirements, each of these may adequate for the intended purpose and as such it would be inappropriate to state that one was better than the other. The more basic forms are more technologically accessible and easy to implement by the users (patient and clinician). These basic modalities may work very well as a screening tool to determine the need for more detailed consultations or to assess simple and visually accessible conditions.

Modalities for the conduct of Synchronous Dental Consultations			
Basic format	Moderate sophistication	Gold standard	Proposed
Patient-Consultant			Patient-GDP-Consultant
Two-way remote teledentistry	Two-way remote teledentistry	Two-way In-person consultation	Three-way remote consultation
• Single device • Patient-dentist • Live audio only • Any telephone	• Single device • Patient-dentist • Live audio and vision • Smart phone or tablet	• Direct patient-consultant in-person assessment • Direct vision and examination • Limited or no direct access to GDP records, appointment systems and other electronic records	• Multiple input devices • Patient-dentist-consultant • Live audio and vision • Multiple bi-directional inputs: Cameras, microphones, intra-oral camera, practice IT medical records, digital radiography and 3D models, CAD planning, etc.

Table 1: Modalities of synchronous dental consultations and their relative merits.

The majority of studies that employed teledentistry, focused on patient screening, prevention, review and preliminary examinations.[29,30] By contrast, the most sophisticated consultations need to fulfil all the requirements of the gold-standard in-person consultation as a baseline and ideally use the technology to provide the further benefits outlined above.

It is important to note that the established convention of an in-person consultation between a patient and the specialist consultant, is considered the 'gold standard' within the profession. It enables the specialist consultant to undertake a clinical assessment first-hand and in person, with full and unimpeded access to all the required clinical information through a direct patient discussion and intra-oral clinical examination. In this way, the consultant is able to establish an accurate diagnosis based on all the available information and an in-person clinical examination. This requirement overrides all other considerations and potential benefits of alternative modalities, including teledentistry.

This gold-standard requirement therefore poses both a challenge and an opportunity for the concept of remote clinical consultations. It is essential that RCCs enable an effective, high fidelity clinical assessment that leads to establishing a diagnosis with all the information that an equivalent in-person consultation would provide.[31] Thus, a RCC must be safe, effective and not-inferior to an in-person consultation; with all other additional benefits as secondary outcomes. This requirement extends and includes the ability to visually observe, with magnification, if possible, the full intra-oral status of the soft tissues, periodontal supporting structures, the dentition and any associated prostheses. It is also important that the more subtle cues and nuances of patient behaviour and interaction with the clinical team during the consultation are captured and observed from eye-cameras strategically placed in the dental surgery. The need for a comprehensive clinical examination, has been identified in the recent literature in order to establish diagnoses in RCCs.[32,23] Thus, the 'baseline standard' required to ensure that a RCC is practical, efficient and safe (not-inferior to the standard in-person consultation) has the following characteristics:[24]

- Allow for a full and unimpeded dialogue between the patient (or representative) and the specialist consultant.
- Enables the conduct of a full and appropriate clinical assessment, to include a comprehensive history, clinical examination and required special investigations.
- Enables the establishment of appropriate and accurate diagnoses (including differential) and a prognosis for every diagnosis reached.
- Enables the establishment of patient-centred and pragmatic treatment options and/or a treatment strategy for the management of the referred condition and any additional diagnoses.
- Enables the preparation and submission of a report to be returned to the patient and the referring dentist following the consultation, that includes the findings of the consultation and the outcomes as above.

The use of adjunctive technologies for intra-oral visualisation is reported with the application of an intra-oral scanner to obtain an accurate diagnosis in teledentistry.[33] The use of high-resolution communication media can aid the clinical examination resulting in an outcome for tele-dentistry that was not inferior an in-person consultation.[10,25]

The aim of this clinical study is to assess the feasibility and effectiveness of undertaking remote clinical consultations in restorative dentistry between a patient and dentist co-located in a clinical primary care dental practice and a specialist consultant in a remote secondary care centre. This study builds on the previous proof of concept service evaluation undertaken by this research group, that sought to assess the technical feasibility and acceptability of all stakeholders for conducting remote clinical consultations in a simulated manner.[10] In that study, the rationale and the effectiveness of a RCC was identified as a non-inferior process to an in-person consultation for the ability to establish

diagnoses, prognoses and planned treatment strategy; with a high level of patient acceptability that can be delivered in a practical and simple manner. The specific objectives of this study are: (i) Assure that the actual clinical examination undertaken as a RCC is as thorough and not inferior to that carried out during an in-person assessment; (ii) establish a robust and practical 'plug-and-play' technology platform with associated communication infrastructure and connectivity; (iii) identify the drivers for GDPs in primary care to engage with this process.

The feasibility of undertaking specialist clinical consultations in a remote manner is considered through an analysis of the technical and practical factors as well as participant acceptance and willingness to engage to enable the successful delivery of the required outcomes.

The hypothesis is that a RCC between co-located patient-dentist in the dental practice and specialist consultant in a remote location meets the primary outcome requirement and in addition confers additional benefits that are not attainable through the current in-person model.

Outcome measures

Primary outcome – That the RCC is a safe, effective and enables a full and comprehensive patient-centred clinical examination and assessment that is not inferior to an equivalent in-person consultation.

Secondary outcomes: Active involvement of the referring GDP clinician leading to a more consensual outcome; a reduction in inconvenience and associated cost from the patient; a reduction in CO_2 emissions from additional travel requirements. Full patient engagement in a relaxed mode enabling collaborative and group-decision making.

Method

Ethical approval for the conduct of this study was obtained from the HRA and Health and Care Research Wales (HCRW). IRAS project ID: 279582. The sponsor was Sheffield Teaching Hospitals NHS Foundation Trust REC reference 20/YH/0112.

The methodology for this study is centred around the following three objectives:

1. Design, development and testing of a 'clinical assessment and examination protocol' that GDPs can use in a predictable manner during a RCC. The protocol was devised by the clinical team investigators and tested multiple times prior to validation with iterative corrections and improvements to enable full and predictable audio-visual clinical (including intra-oral) data exchange. This was tested in a pre-intervention pilot study.

2. Design, development and testing of a bespoke communications platform and associated connectivity to be used for the study intervention. The Advanced Manufacturing and Research Centre (AMRC, Sheffield, UK) engineering team provided this and problem-solved in a pre-intervention pilot.

3. Upon completion of the intervention, obtain the views and opinions from all parties (Patient, GDP, dental nurse and Consultant) on the safety, effectiveness and ability to achieve the primary and any secondary outcomes. Semi-structured interviews and validated questionnaires were used. The questionnaire's face validity and content validity were assessed by a mixed group of trained and calibrated clinicians considered representative of the study participant. The comments made in response to the open-ended questions were analysed thematically based on the study undertaken by Braun and Clarke. [34]

The setting for the clinical study was between a primary care dental practice (Dinnington Dental Practice, South Yorkshire, UK) and consultants in a remote dental hospital location (Charles Clifford Dental Hospital, STH NHS Trust, Sheffield, UK).

A total of 21 routine patients (10 female & 11 male) in need of specialist consultation were included in this study that fulfilled the inclusion criteria (Table 2).

Inclusion criteria
• The patients are under the care of the GDPs in the primary care dental practice. • The patients and dentist would benefit from a specialist opinion in restorative dentistry, including the sub-specialities of endodontics, periodontics or prosthodontics. • An even distribution of gender, demographic status, and even representation from the three subspecialties of restorative dentistry. • Patients of either sex and at least 18 years old at the start of the study. • Patients who are able to attend the clinic for consultation and do not require multidisciplinary input from other dental specialities.
Exclusion criteria
• Patients who were unable to give informed consent for participation in the study (Classed as lacking capacity or belonging to a vulnerable population, as defined in ISO 141455) were not enrolled.

Table 2: Inclusion and exclusion criteria for the RCC clinical study

The recruitment process was as follows and was in line with the ethics approval.

1. An invitation letter with a study outline and a patient information sheet was sent to each patient who met the requirements and inclusion/exclusion criteria.

2. Patients that responded positively to the invitation letter were invited to attend the consenting session and possible recruitment thereafter.
3. The intervention took place in January 2022 over the course of ten half-day sessions.
4. Each intervention was conducted by two separate teams:

- At the specialist care centre (Charles Clifford Dental Hospital, Sheffield, UK): Two specialist consultants in restorative dentistry providing a near equal number of consultations each.
- At the primary care dental practice (Dinnington Dental Practice): A GDP, a dental nurse, an independent specialty-grade observer and an IT support investigator.
- A detailed procedural sequence of events was planned for the RCC (Table 3).

Clinical Assessment – Procedural sequence of events and interactions		
GDP	**Patient**	**Consultant**
The GDP meets and greets the patient in the dental surgery GDP and nurse in personal attendance.		Remote consultant on a live stream via a tablet on a stand at the patient's eye-level when sitting down in the dental chair. Direct vision and communication between the three parties via this tablet.
GDP invites patient to take a seat in the dental chair and explains the technical set up. Puts patient at ease	Patient takes a seat in the dental chair Patient remains upright	
Patient in chair, in conversation with GDP GDP explains nature of proceedings		
GDP introduces the patient to the remote consultant	Patient and consultant greet each other. The consultant provides a further explanation of proceedings as appropriate	
GDP listens and provides further input as required	Patient in conversation with consultant via tablet	Undertakes history aspect of clinical examination Hands control back to the GDP
GDP reclines patient		
GDP undertakes the clinical examination in conversation and guidance with the remote consultant:	Patient reclined in the chair during the clinical examination	Consultant interacts verbally with GDP and agree on the clinical observations made.

Clinical Assessment – Procedural sequence of events and interactions		
GDP	Patient	Consultant
- Overhead camera (Light) allows visualisation of extra-oral and anterior dentition. - Intra-oral camera allows visualisation of whole mouth - Procedural protocols are meticulously followed to ensure that everything is observed.		Further observations are made as required using the intra-oral camera operated by the GDP The dental nurse provides support by operating the camera if the dentist is required to use other instruments (e.g., probe/mirror).
GDP uprights the patient's chair	Patient sits upright and able to see/speak with the consultant via tablet	Consultant is visible and audible via tablet on stand next to the patient.
GDP talks with consultant and shares further findings from special investigations, including radiographs, diagnostic study casts, periodontal charts etc	Patient remains seated in the chair and listens to the discussion	Consultant in discussion with GDP regarding further investigations and findings.
GDP listens and provides further input as required	Patient in conversation with consultant via tablet	Consultant in conversation with patient. Explains and discusses findings and shares a diagnosis, prognosis and treatment strategy.
GDP, patient and consultant further discuss the proposed treatment strategy, the practicalities and any queries from either party.		
Good bye and sign out from patient and GDP to consultant		Good bye and sign out of consultant
GDP and patient address any in-practice care logistics Conclusion of RCC – Consultant written electronic report to follow		

Table 3: The procedural sequence of events and interactions that take place during the remote clinical consultation in restorative dentistry.

Connectivity

Analysis of system requirements identified that a RCC process must seek to replicate or improve the quality and thoroughness of the visual and auditory sensory information captured during an in-person consultation. Current technology using super-fast and secure broadband connectivity and advanced multimedia communication technology

enables the RCC process. The features of the system used are:

- A secure communication platform with clear regulatory boundaries to comply with clinical governance policies.
- A suite of camera/speaker/microphone systems that enable effective two-way communication.
- A suite of tablets/laptops with web-based enabled audio-visual conference facilities.
- Additional speakers as required to enable hands-free unimpeded hearing throughout.

This system primarily used the secure network infrastructure of The University of Sheffield (UoS). A server PC was connected to the UoS network, which acted as an intermediary between the consultant and the GDP-patient sites. All of the network communication was encrypted using Hypertext Transfer Protocol Secure (HTTPS) combined with the Secure Socket Layer (SSL) and Transport Layer Security (TLS) with self-signed certificates. Secure network protocols were followed, ensuring that no information was stored at any time, live data was discarded after use and adhered to the University of Sheffield Information Security Policy and IT Code of Practice.[35,36] (Fig 1).

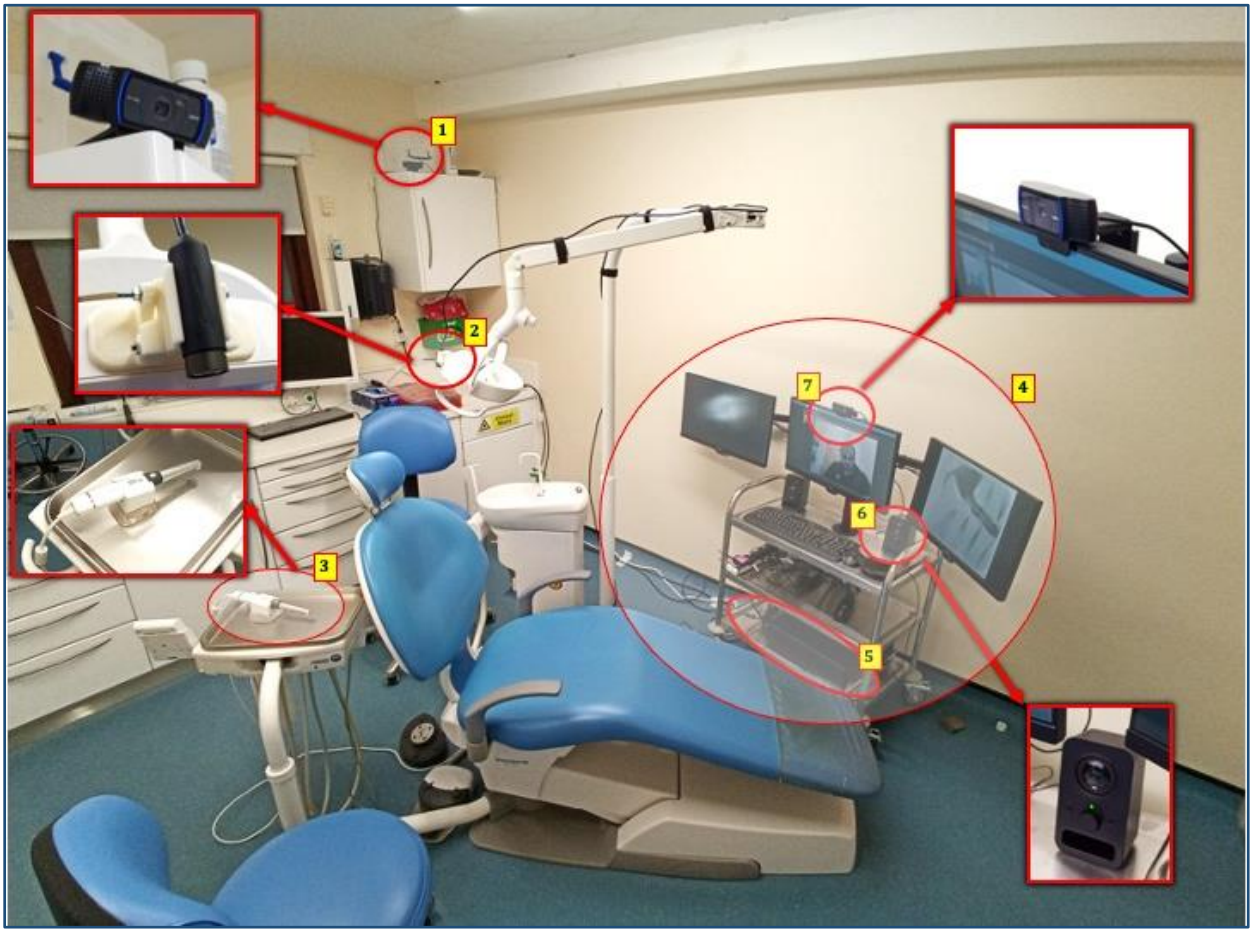

Fig 1: Hardware AV set up for RCC: (1) Room camera: This is a pc webcam, positioned at the opposite end of the door and providing a visual to the remote consultant of the patient entering and the whole of the surgery. (2) Chair light camera: High resolution, providing the same direct observation extra-oral and front of mouth view as the dentist. (3) Intra-oral camera: High resolution and magnified intra-oral visualisation. (4) RCC AV trolley: PC monitors: (left) Intra-oral camera feed, shared with the remote consultant; (centre) remote consultant; (right) patient radiographs, shared with the remote consultant. (5) Personal computer for all cameras and AV transfer. (6) Speakers for remote consultant audio. (7) Webcam: To capture audio-vision of a patient during consultation, relayed to the remote consultant.

Hardware

Clinical Surgery

- Three web-cams to provide a room view, patient face view, overhead light/close up extra and limited intra-oral view.
- An intraoral camera to provide a detailed, accurate, high resolution, magnified live view.
- Live audio streaming, audio conferencing microphone/loud speaker combination devices used for room audio capture and playback.
- Multiple monitor displays in the clinical surgery, showing full screen image feeds from the intraoral camera (to enable the clinician to drive the camera), the X-ray images, and the remote consultant camera.
- Clinical surgery PC running camera capture software and web streaming application.

Remote consultant

- Remote consultant PC running a single screen interface, showing camera feeds from the surgery.
- Single face capture camera feed.
- Live audio streaming, audio conferencing microphone / loudspeaker combination devices used for room audio capture and playback.
- External camera feed control hardware to remotely control the live video feeds from the clinical surgery.

Dynamic live AV configuration

Stream from clinical surgery to consultation room

- Full surgery view from room camera (Logitech C920 USB Webcam, or similar) to allow the remote consultant to observe the whole of the clinical set up and pick up on subtle patient queues (mobility, mood, disposition, anxiety…etc) and interaction with GDP
- Patient face camera (Logitech C920 USB Webcam, or similar) for conversational discussion feed
- Close up patient face camera (Logitech C920 USB Webcam, or similar), attached to surgical overhead light
- Video feed from intraoral camera (Carestream CS1500), with local full screen display for clinician use
- Displayed X-ray images, with local full screen display for clinician use.
- Audio capture using audio conference microphone/speaker
- All audio/video to be live composited into a single video stream to be sent out to the remote consultant. The live compositing can be controlled remotely by the remote consultant

Stream from the consultation room to clinical surgery

- Camera capturing remote consultant face for conversational discussion feed
- Audio capture using audio conference microphone/speaker

- Remote camera compositing control system to allow remote consultant to adjust the composite video feed from the clinical surgery

Software Platform

The software platform developed for the RCC was entirely web-hosted using WebRTC (Web Real-Time Communication) (Fig.2). This platform allowed for low latency peer-to-peer teleconferencing at the Clinical Surgery and the Remote Consultant. A key challenge associated with the system design was to ensure a suitable level of system response and usability within the constraints of the available network bandwidth. Providing this minimal system performance was crucial to ensure a practical user experience. To reduce the required bandwidth for the system, an intermediate software was used on the system at the Clinical Surgery that combined the various camera feeds into a single composite video feed that included a simple user interface.

A secondary webpage was also hosted, providing a video feed remote control, allowing the remote consultant to select which camera feed occupied the most significant screen segment in the remote consultant user interface. This webpage consisted of five buttons to select each clinical surgery video feed. It could also be accessed on a secondary device such as a tablet allowing for more convenient placement of the controls without the need for the remote clinician to use a secondary screen and switch away from the teleconference call.

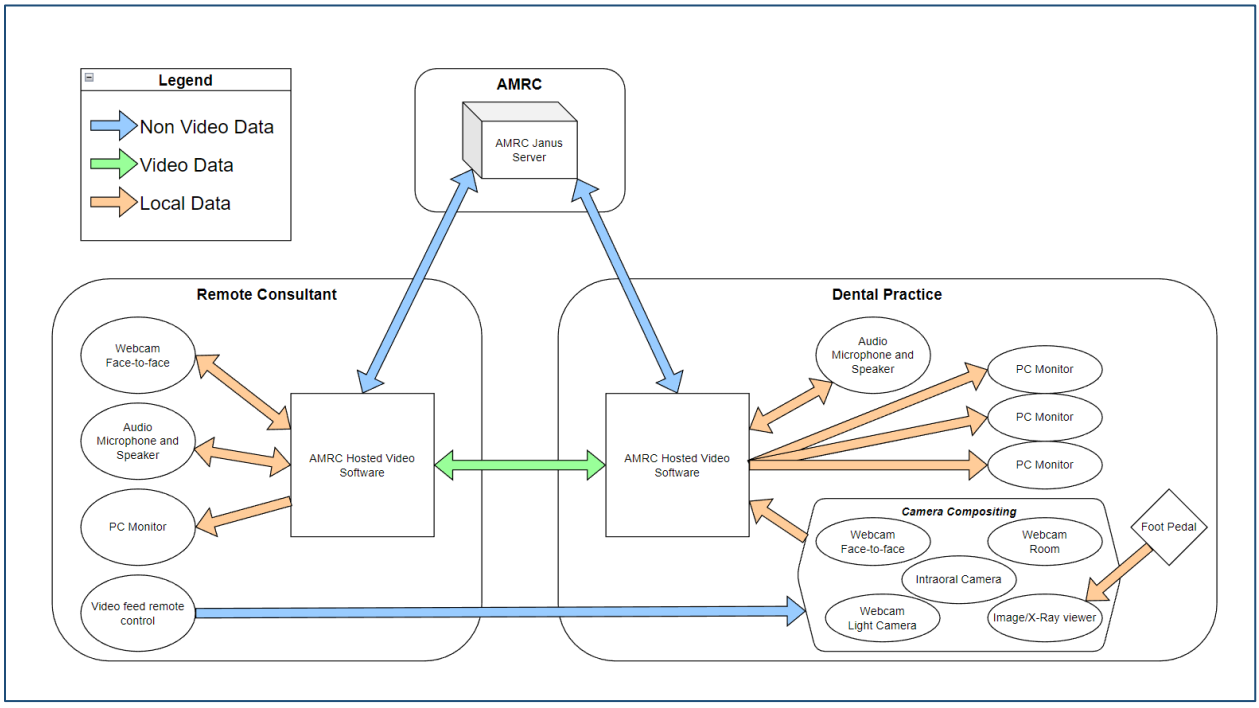

Fig 2: Software platform developed by the Advanced Manufacturing Research Centre (AMRC) for the RCC web-hosted using WebRTC (Web Real-Time Communication)

Results

A total of 24 patients were enrolled in the study. One patient cancelled his appointment on the day, and two patients did not attend their appointment. The study analysis was undertaken based on data for 21 patients, with the primary focus of the consultation being in the field of endodontics (6), periodontics (7) and prosthodontics (8). 100% of the questionnaires from all the participants were completed and returned. In 100% of cases, the GDP was able to convey all the essential information to the consultant via the use of an intra-oral camera and special investigations. In 100% of cases, irrespective of the subspeciality, the consultant confirmed that she/he was able to conduct an effective clinical consultation through the RCC process and convey all the appropriate consultation outcomes, including the correct diagnoses, prognoses, treatment options and future care pathways to the GDP, and the patient effectively.

85% of patients (18/21) felt that the RCC project worked well. Three patients would have preferred to see the consultant in person, but only if it could have been offered at the same location without the need to travel to the remote consultant centre. These patients preferred the RCC if this avoided the appointment in the remote location of the specialist consultant.

An effective RCC software platform was validated as being secure, providing high fidelity of audio and visual communication of all the required aspects for the conduct of the consultation. This included full visualisation of the whole of the dental surgery, comprehensive two-way communication between all parties and a full clinical assessment visualisation.

The majority of the barriers to the study were related to the audio quality – 9% (2/21) – and visual quality – 4% (1/21). The mean time required to undertake an RCC from start to finish was 35 minutes.

100% of GDPs agreed that there was scope for having a professional educational experience and continuing professional development (CPD) during the process.

All participants, including patients and GDPs, felt that they were included in the process and valued the ability to engage in a live three-way discussion whilst based in a familiar and non-threatening environment.

Discussion

This clinical investigation sought to confirm the findings of a previous service evaluation for the conduct of specialist remote clinical consultations between a patient and a primary care dentist collocated in the dental practice, and a specialist in a remote secondary care site. The aim of this study; to assess the true feasibility and effectiveness of undertaking restorative dentistry remote clinical consultations between a patient and GDP (co-located in their primary care dental practice) and a specialist consultant in a remote secondary care setting has been met. The hypothesis for a remote clinical consultation of this type has been confirmed. The findings from this pilot study also confirms the

technical and practical feasibility and participant (All stakeholders: Patient, dentist and consultant) acceptance and willingness to engage in the process. It is important to underline that this finding is based on the required use of the audio-visual set up as conducted for this investigation; thus ensuring that the minimal data set for remote clinical consultations in restorative dentistry has been achieved.[24] This hardware and software platform includes an intra-oral camera operated by the primary care dentist and all clinicians following specific pre-established clinical protocols for the conduct of the examination and sharing of all data. The RCC hardware/software platform delivered all the required features of an in-person consultation. Patient concerns with AV quality/volume are simple technical problems that are easy to resolve. The addition of data recording capability would further enhance the ability to review the process and outcomes for the purposes of further decision making, report writing or medico-legal disputes.

The consultant's requirement to establish an accurate diagnosis based on a comprehensive assessment of all the required data has been achieved. The consultant accepted the direct responsibility for making a diagnosis and establishing a treatment strategy based on the information obtained and assessed.

This study has confirmed in a true clinical setting the earlier findings for the conduct of RCCs in restorative dentistry between a dentist-patient and a remote consultant.[13,14] This study has further emphasised the critical importance of a clinician-to-clinician comprehensive communication channel to establish the validity of the process. The RCC provided a patient-centred discussion between all three parties that established an understanding of the findings and diagnosis, and also the options and practicalities for the provision of the required treatment in the different settings. RCCs shift the decision-making-process from a one-to-one scenario (GDP-patient, consultant-patient, consultant-GDP) to group decision-making with all three stakeholders present in the dialogue in a contemporaneous manner. The result of this study demonstrated the high satisfaction of the patients and other stakeholders which is in agreement with the previous studies.[10,25]

Thus, the primary outcome for this study was met as was the ability for all parties to actively engage in the consultation with a more consensual outcome; a reduction in inconvenience and associated cost from the patient; an associated reduction in CO_2 emissions from additional travel requirements. In this context, RCCs provide a further tool to reduce the environmental impact associated with the delivery of oral healthcare and it is a good fit with The National Elective Care Transformation Programme, that highlights the drivers for this plan "to save patients time and money and reduce pollution from road travel".[37] It is encouraging that patients acknowledge this and support the adoption of teledentistry to reduce the environmental impact from travelling.[38]

The findings from this study provide the required evidence base to pursue ways to

make better use of digital technology to address the limitations of current modes of consultation practice in the management of patient care pathways. This should involve a new clinical service operating model for the workforce centred around a more patient-centred specialist advice service with full input and ownership of all stakeholders: Patient, GDP, Consultant and commissioning services. The cultural change, technology application and service transformation required to achieve this goal is dependent on an incremental programme of research that addresses planned objectives and emerging challenges. The implementation of this remote clinical consultation modality will require collaborative engagement between care commissioners, patient safeguarding organisations and clinical delivery teams. This will enable the provision of trully patient-centred, sustainable and effective consultation modality.

Conclusions

The RCC process advocated in this study confirms the ability to provide a service that is not inferior to an in-person procedure and presents with additional benefits:

- Active patient-centred decision making.
- Greater patient acceptance with potential for reduced inconvenience, cost and care inequalities.
- A potential for reduced CO_2e emissions associated with reduced patient transport.

The main features of the RCC service provision advocated in this report are:

- A synchronous communication platform that enables a true three-way communication and clinical assessment between the three parties: Patient, dentist and consultant; the first two co-collocated in the dental practice and the consultant is in a remote location.
- The use of a comprehensive high-speed, robust and secure AV communication internet platform. The use of a range of cameras (including an intra-oral camera) and audio displays, that are low cost and readily available as plug-and-play commercial devices.
- The need to follow specific and pre-agreed examination protocols that ensure that the clinical assessment is not-inferior to an in-person examination and will provide high fidelity data in a predictable and infallible manner.
- The ability to have direct verbal contact between referring clinician, patient and consultant which minimises scope for error, misunderstandings or miscommunications and allows for bidirectional dialogue.

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References / Bibliography:

1 Estai M, Kanagasingam Y, Tennant M, Bunt S. *A systematic review of the research evidence for the benefits of teledentistry.* J Telemed Telecare. 2018 Apr;24(3):147-156. doi: 10.1177/1357633X16689433. Epub 2017 Jan 24. PMID: 28118778.

2 Irving M, Stewart R, Spallek H, Blinkhorn A. *Using teledentistry in clinical practice as an enabler to improve access to clinical care: A qualitative systematic review.* J Telemed Telecare. 2018 Apr;24(3):129-146. doi: 10.1177/1357633X16686776. Epub 2017 Jan 16. PMID: 28092220.

3 Sharma H, Suprabha BS, Rao A. *Teledentistry and its applications in paediatric dentistry: A literature review.* Pediatr Dent J. 2021 Dec; 31(3):203-215. doi: 10.1016/j.pdj.2021.08.003. Epub 2021 Sep 1. PMID: 34848924; PMCID: PMC8613071.

4 Park JH, Kim JH, Rogowski L, Al Shami S, Howell SEI. *Implementation of teledentistry for orthodontic practices.* J World Fed Orthod. 2021 Mar;10(1):9-13. doi: 10.1016/j.ejwf.2021.01.002. Epub 2021 Feb 25. PMID: 33642260.

5 American Telemedicine Association. https://www.americantelemed.org/ (Accessed 17 August 2022).

6 American Teledentistry Association. https://www.americanteledentistry.org/ (Accessed 17 August 2022).

7 International Telecommunication Union (ITU) https://www.itu.int/hub/publication/d-ind-ict_mdd-2019/ (Accessed 17 August 2022).

8 Capampangan DJ, Wellik KE, Bobrow BJ, Aguilar MI, Ingall TJ, Kiernan TE, Wingerchuk DM, Demaerschalk BM. *Telemedicine versus telephone for remote emergency stroke consultations: a critically appraised topic.* Neurologist. 2009 May;15(3):163-6. doi: 10.1097/NRL.0b013e3181a4b79c. PMID: 19430275.

9 Ball CJ, McLaren PM, Summerfield AB, Lipsedge MS, Watson JP. *A comparison of communication modes in adult psychiatry.* J Telemed Telecare. 1995; 1(1):22-6. doi: 10.1177/1357633X9500100105. PMID: 9375115.

10 Randhawa RS, Chandan JS, Thomas T, Singh S. *An exploration of the attitudes and views of general practitioners on the use of video consultations in a primary healthcare setting: a qualitative pilot study.* Prim Health Care Res Dev. 2019 Jan; 20:e5. doi: 10.1017/S1463423618000361. Epub 2018 Jun 18. PMID: 29909798; PMCID: PMC6476389.

11 Alabdullah JH, Daniel SJ. *A Systematic Review on the Validity of Teledentistry.* Telemed J E Health. 2018 Aug; 24(8):639-648. doi: 10.1089/tmj.2017.0132. Epub 2018 Jan 5. PMID: 29303678.

12 Fernández CE, Maturana CA, Coloma SI, Carrasco-Labra A, Giacaman RA. *Teledentistry and mHealth for Promotion and Prevention of Oral Health: A Systematic Review and Meta-analysis*. J Dent Res. 2021 Aug;100(9):914-927. doi: 10.1177/00220345211003828. Epub 2021 Mar 26. PMID: 33769123.

13 Gleeson HB, Kalsi AS. *Remote clinical consultations in restorative dentistry-A survey*. J Dent. 2022 Feb;117:103914. doi: 10.1016/j.jdent.2021.103914. Epub 2021 Dec 3. PMID: 34871634.

14 Martin N, Shahrbaf S, Towers A, Stokes C, Storey C. *Remote clinical consultations in restorative dentistry: a clinical service evaluation study*. Br Dent J. 2020 Mar; 228(6):441-447. doi: 10.1038/s41415-020-1328-x. PMID: 32221448.

15 OECD (2019*), Health for Everyone?: Social Inequalities in Health and Health Systems*, OECD Health Policy Studies, OECD Publishing, Paris, https://doi.org/10.1787/3c8385d0-en.

16 Jordan H, Roderick P, Martin D. *The Index of Multiple Deprivation 2000 and accessibility effects on health*. J Epidemiol Community Health. 2004 Mar; 58(3):250-7. doi: 10.1136/jech.2003.013011. PMID: 14966241; PMCID: PMC1732697.

17 Duane B, Steinbach I, Ramasubbu D, Stancliffe R, Croasdale K, Harford S, Lomax R. *Environmental sustainability and travel within the dental practice*. Br Dent J. 2019 Apr; 226(7):525-530. doi: 10.1038/s41415-019-0115-z. PMID: 30980009.

18 NHS Long Term Plan. www.longtermplan.nhs.uk. (Accessed 17 August 2022)

19 NHS England - *Delivering a net zero NHS*. https://www.england.nhs.uk/greenernhs/a-net-zero-nhs/ (Accessed 17 August 2022)

20 NHS England - *Elective Care Transformation Programme*

https://www.england.nhs.uk/elective-care-transformation/ (Accessed 17 August 2022)

21 Coulthard P, Thomson P, Dave M, Coulthard FP, Seoudi N, Hill M. *The COVID-19 pandemic and dentistry: the clinical, legal and economic consequences - part 1: clinical*. Br Dent J. 2020 Dec; 229(11):743-747. doi: 10.1038/s41415-020-2404-y. Epub 2020 Dec 11. PMID: 33311687; PMCID: PMC7729702.

22 Coulthard P, Thomson P, Dave M, Coulthard FP, Seoudi N, Hill M. *The COVID-19 pandemic and dentistry: the clinical, legal and economic consequences - part 2: consequences of withholding dental care*. Br Dent J. 2020 Dec; 229(12):801-805. doi: 10.1038/s41415-020-2406-9. Epub 2020 Dec 18. PMID: 33339931; PMCID: PMC7747003.

23 Singhal S, Mohapatra S, Quiñonez C. *Reviewing Teledentistry Usage in Canada during COVID-19 to Determine Possible Future Opportunities*. Int J Environ Res Public Health. 2021 Dec 21; 19(1):31. doi: 10.3390/ijerph19010031. PMID: 35010285; PMCID: PMC8751218.

24 Hung M, Lipsky M, Phuatrakoon T, Nguyen M, Licari F, Unni E. *Teledentistry implementation during the COVID-19 pandemic: Scoping Review*. Interact J Med Res 2022;11(2):e39955. URL: https://www.i-jmr.org/2022/2/e39955. DOI: 10.2196/39955

25 Cope AL, Chestnutt IG, Wood F, Francis NA. *Dental consultations in UK general practice and antibiotic prescribing rates: a retrospective cohort study*. Br J Gen Pract. 2016 May; 66(646):e329-36. doi: 10.3399/bjgp16X684757. Epub 2016 Mar 29. PMID: 27025554; PMCID: PMC4838445.

26 Ibraheim A, Sanalla A, Eyeson J. *The role of teledentistry in oral surgery during the COVID-19 pandemic,* Advances in Oral and Maxillofacial Surgery, 2021; 1:100005. doi.org/10.1016/j.adoms.2020.100005.

27 Health inequalities further exposed. Care Quality Commission, England. Page last updated: 12 May 2022. https://www.cqc.org.uk/publications/major-reports/soc202021_01b_inequalities-exposed (Accessed 01 September 2022)

28 Bavaresco CS, Hauser L, Haddad AE, Harzheim E. *Impact of teleconsultations on the conduct of oral health teams in the Telehealth* Brazil Networks Programme. Brazilian Oral Research 2020; 34:e011. doi.org/10.1590/1807-3107bor-2020.vol34.0011.

29 Aboalshamat KT, Althagafi TK, Alsaeedi SA, Alhumaidi SN, Alemam AA. *Accuracy and perceptions of teledentistry in KSA during the COVID-19 pandemic: A single-centre randomised controlled trial.* Journal of Taibah University Medical Sciences, 2022; 17:506-515. doi.org/10.1016/j.jtumed.2021.11.015.

30 León S, Giacaman RA. *Proposal for a Conceptual Framework for the Development of Geriatric Dentistry.* J Dent Res. 2022 Mar;101(3):247-252. doi: 10.1177/00220345211042268. Epub 2021 Sep 28. PMID: 34581227.

31 Romano DM, Longson TD, Martin N. *Minimal Data Set for Remote Clinical Consultations in Restorative Dentistry - An Exploratory Case Study*. Eur J Prosthodont Restor Dent. 2020 Aug 31;28(3):142-150. doi: 10.1922/EJPRD_1972Romano09. PMID: 32347670.

32 Aboalshamat KT, Althagafi TK, Alsaeedi SA, Alhumaidi SN, Alemam AA. *Accuracy and perceptions of teledentistry in KSA during the COVID-19 pandemic: A single-centre randomised controlled trial.* J Taibah Univ Med Sci. 2022 Jun; 17(3): 506-515. doi: 10.1016/j.jtumed.2021.11.015. Epub 2022 Jan 21. PMID: 35079243; PMCID: PMC8778484.

33 Steinmeier S, Wiedemeier D, Hämmerle CHF, Mühlemann S. *Accuracy of remote diagnoses using intraoral scans captured in approximate true color: a pilot and validation study in teledentistry.* BMC Oral Health. 2020 Sep 25; 20(1):266. doi: 10.1186/s12903-020-01255-8. PMID: 32977794; PMCID: PMC7517740.

34 Braun V, Clarke V. *What can "thematic analysis" offer health and wellbeing*

researchers? Int J Qual Stud Health Well-being. 2014 Oct 16;9:26152. doi: 10.3402/qhw.v9.26152. PMID: 25326092; PMCID: PMC4201665.

35 Governance and Management, Information Security Policy: Confidentiality and Integrity. University of Sheffield. https://www.sheffield.ac.uk/govern. (Accessed August 2022).

36 IT Code of Practice regulations. University of Sheffield. https://www.sheffield.ac.uk/it-services/code-practice/regulations. (Accessed August 2022).

37 Charles-Ozuzu. *Long Term Plan will be a game changer.* National Elective Care Transformation Programme. NHS England 03 May 2019. (https://www.england.nhs.uk/blog/long-term-plan-will-be-a-game-changer/) (Accessed August 2022).

38 Rahman N, Nathwani S, Kandiah T. *Teledentistry from a patient perspective during the coronavirus pandemic.* Br Dent J. 2020 Aug 14:1–4. doi: 10.1038/s41415-020-1919-6. Epub ahead of print. PMID: 32801323; PMCID: PMC7427495.