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Orthodontic referrals via TeleDent Southwest

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Background

Telemedicine, the delivery of health care and the exchange of health care information across distances [1], is currently an accepted part of modern health care provision [2]. Recent publications indicate that primary care dentists in the United Kingdom [3,4] would welcome the availability of diagnostic support by such means.

Almost all children who receive orthodontic care in the United Kingdom do so within provisions of the United Kingdom National Health Service (NHS). More than half of these cases are treated by a fully trained specialist with use of multibracketed fixed appliance techniques [5]. The United Kingdom still has significantly fewer orthodontic specialists than other European countries (currently 920 for a United Kingdom population of 56 million), and their uneven distribution means that there is still a severe shortage of orthodontic specialists in many parts of the United Kingdom [6]. As a result, just less than half of all NHS general dentists in England and Wales undertake some orthodontic treatment [7]. Although many of these dentists have participated in continuing education programs in orthodontics, others are only familiar with maxillary removable appliance techniques. Even when they have received further training, general dentists often lack sufficient diagnostic knowledge to enable them to distinguish cases that are straightforward and can be treated successfully by them from cases that require specialist care [8,9].

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In theory, ever since the inception of the NHS, United Kingdom general dental practitioners have been able to obtain specialist orthodontic advice without charge by referring their patients to a local hospital to be seen by an NHS consultant orthodontist. A major disincentive, however, is the long waiting list for such appointments at all hospitals—often a year or more [10]. Only 10% of orthodontic cases treated by general dental practitioners seem to have received such advice [11]. As a result, their treatment plans are often far from ideal [9], and the outcome of a significant percentage of NHS orthodontic treatment remains unsatisfactory [11].

At the other extreme, just more than half of all United Kingdom general dental practitioners undertake no orthodontic treatment of any kind [12]. The evidence suggests that for these dentists their lack of orthodontic knowledge leads to either underreferral or unselective referral of cases for specialist advice. Studies have reported that between 19% and 50% of referrals to NHS orthodontic consultants are inappropriate [13–15], which contributes to long hospital waiting lists [10] and discouraging the referral of cases in which advice is needed. Various attempts have been made to improve matters, but neither general practitioner training nor the availability of published orthodontic referral guidelines has been found to be effective in reducing this problem [16,17]. It is against this background that this study was undertaken.

It was believed that the time had come to see if orthodontic advice could be provided electronically to United Kingdom general dental practitioners. The project was based at the University of Bristol Dental School in Southwest England and was known as "TeleDent Southwest" (TeleDent SW) to distinguish it from another study that was taking place in the United Kingdom at the time.

For many years, some NHS consultants—and persons such as one of the coauthors (C.S.), who holds an honorary NHS consultant contract—have been happy to meet with their referring dentists outside normal office hours to provide advice based on the records of the cases that those dentists bring with them. Even when the consultant is not prepared to provide a treatment plan without seeing the patient, such a system ensures that cases that must be seen urgently can be distinguished from cases in which referral is either unnecessary or should be delayed. The TeleDent SW project was envisioned as merely an extension of this practice, but the clinical records that were used would be two dimensional rather than three dimensional.

Before proceeding with the project, some reassurance was needed that orthodontic advice provided in this way did not differ, either systematically or in its degree of uncertainty, from advice provided conventionally when viewing clinical records directly. A study was undertaken in which eight specialists viewed the case records (study casts and radiographs) of 20 cases directly and on a computer screen [18]. In the latter case they were presented as a standardized set of captured digital images [19]. Each case was examined twice by each method, and each set of observations was separated by

at least 6 months from the next. On each occasion the treatment advised was noted. The results of these duplicated decisions by each method of examination were analyzed in terms of:

1. The decision to treat or not.
2. The decision to extract or not.
3. The choice of teeth for extraction.
4. The appliances required.

The analysis of these results showed that there were similar diagnostic inconsistencies in the two methods and no systematic differences between them [18].

The author's professional indemnity insurers were approached, and they expressed the view that advice provided remotely through electronic means was only an extension of an NHS consultant's normal clinical work and would be covered by them against any claim for malpractice. They confirmed that the same underlying dentolegal principles applied to advice provided by teledentistry [20]. These principles stated that

- Consent for referral should be obtained from the patient by the referring dentist.
- Where advice is obtained, the duty of care is shared jointly between the referring dentist and the dentist who provides the advice.
- The referring dentist must ensure that all relevant information is made available to colleagues.
- The dentist who accepts the referral should not offer advice unless he or she is sure of having all the necessary information with which to do so.

Method

Because full details of the protocol are to be published elsewhere [21], they are only summarized in this article. Six participating general dental practitioners were recruited by interview after an initial advertisement placed in the United Kingdom dental press. A further general dental practitioner joined the trial on an informal basis, and his data are also included in this article, although he did not provide a complete set of pretrial data. (He is referred to as Dentist G.) The closest practice was 6 miles away; three of the practices were more than 150 miles from the consultant's base at the Bristol University Dental School. Because of this proximity, the local orthodontic consultant to each participating dentist was contacted. All consultants confirmed that (1) they were happy for advice to be provided to the dentist in this way and (2) in the event of the dentist requiring specialist help to complete a case started as a result of advice received during the study, they would be prepared to provide this. (This is one of the normal responsibilities of NHS orthodontic consultants for cases in which they have provided the general dental practitioner with a treatment plan [10].)

Each of the dentists was provided with a Pentium PC and associated video conferencing software and hardware. The Picturetel Liveshare (Picturetel, Slough, UK) plus system (version 1.5) was chosen because of the intuitive screen layout of the software, the flexibility of the whiteboard, and the robustness of the program. Unlike more recent "desktop" systems, Liveshare has its own card that must be installed within one of the PCs expansion slots. The card was installed for the dentists before they collected their PC. The software to support the Picturetel card is loaded in the normal way and runs like any other MS-Windows application. The small video camera and the speaker/microphone unit plugs directly into the card, as does the connection to the integrated services digital networking (ISDN) lines. Note that in Fig. 3 a later Picturetel product is featured that uses the computer's existing soundcard and the more familiar multimedia loudspeakers and microphone.

Two British Telecom digital lines (ISDN 2: 128 Kb/second) were installed in each surgery, and the dentists were set up with the same service provider and an e-mail address. Two half-day training sessions were provided for the participants. During the first of these training sessions, the dentists received their systems and spent time unpacking and setting them up to ensure that they could do so successfully when they returned to their offices.

Capturing the clinical data

Clinical examination

To ensure that the consultant had all the necessary information with which to assess a referred case, the dentists were provided with a further piece of in-house produced software: Jeremiah 2000. This rule-based expert system incorporated fuzzy logic, which was developed from an earlier program [12,22,23]. This highly interactive program guides the dentist through a full orthodontic examination (Fig. 1). The consultant did not accept cases unless the clinical information had been gathered by this method.

Images of models and radiographs

Standardized views of the record models were required for all referred cases, including labial, left and right buccal views with the casts in occlusion, and occlusal views of the upper and lower models. Any relevant additional views could be included at the dentist's discretion or added later at the consultants' request. These views could be obtained using the Picturetel Liveshare camera. Radiographs (either a tomogram or equivalent) were captured against a light box or window using the same camera. To simplify matters, the dentists were provided with a special stand to hold the video camera, which ensured that views of the models and radiographs were standardized and appeared on a 15-inch computer screen at life size. One of the dentists preferred to use his own digital camera.

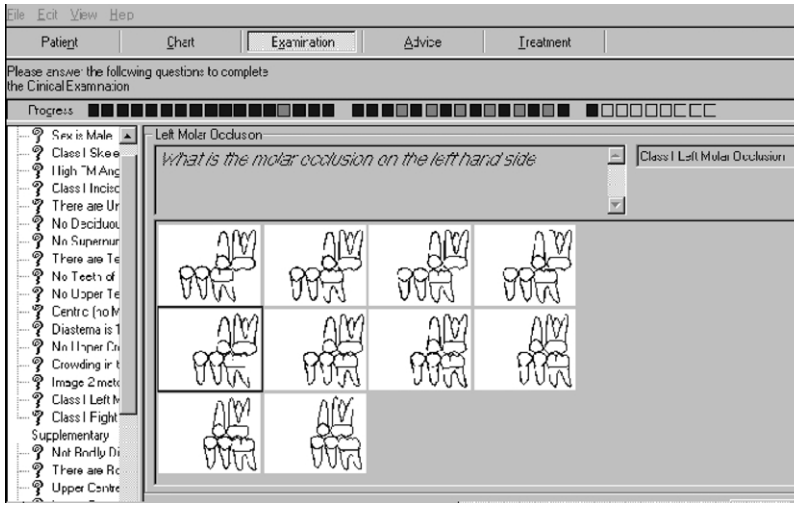

Fig. 1. The expert system showing the data entry for left molar occlusion.

Obtaining advice

During the trial, a dentist who believed that he or she had a case in need of orthodontic advice or treatment could access this advice at three levels (Fig. 2).

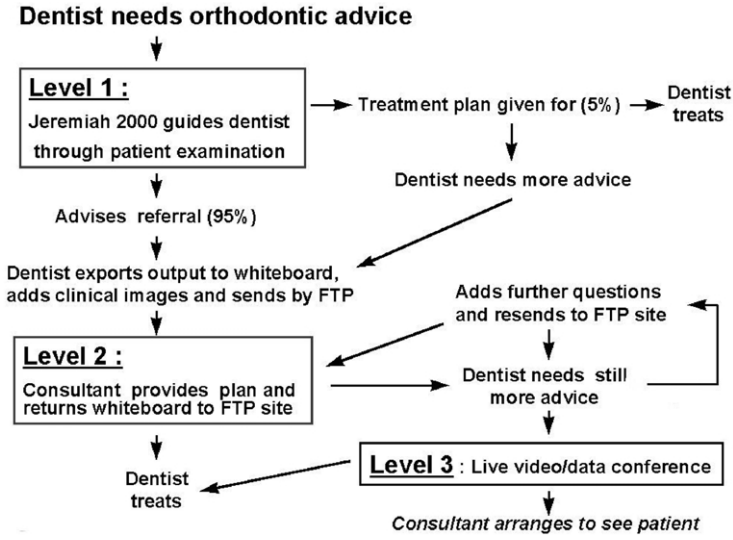

Fig. 2. The three levels of advice available and how they were accessed.

TeleDent level 1: the expert system

Although the expert system's primary function was to guide the dentist through the clinical examination, it also provided treatment plans for a small group of cases in which space maintenance or simple active plate maxillary removable appliances would produce an acceptable result. For most cases, however, the program advised that referral should be made to a specialist and gave the reasons for this being necessary.

Although the earlier versions of Jeremiah were tested extensively [22,23], dentists were advised to check all advice provided by Jeremiah 2000 before they acted on it. This recommendation was made because expert systems depend on accurate data being entered, and at the start of the study the investigators had no way of knowing how accurately the participating dentist would input the clinical data requested during the prompted orthodontic examination. For this reason, even cases in which advice at level 1 included a treatment plan, this was forwarded as if for level 2 advice (see later discussion) for checking by the consultant (coauthor, C.S.).

TeleDent level 2: file transfer protocol "store and forward"

For cases in which Jeremiah 2000 recommended referral, the general dental practitioner could export the information the program had collected into a Picturetel whiteboard file. To this file were added the digital images of the case and any comments or specific questions the dentist or the patient might have. The whiteboard was then forwarded as an encoded file to a secure Internet site accessed by a unique user password. The files were transferred in this way using the Internet file transfer protocol. Finally the dentist sent an e-mail to the consultant at Bristol to inform him of a case ready for consideration. When time allowed, the consultant retrieved the file, opened the whiteboard, examined its contents, and added his advice as typed text and line drawings. The whiteboard, with these additional pages, then was sent back to the file transfer protocol server, and an e-mail notified the dentist that the case was ready for retrieval. Sometimes a further cycle of this "store and forward" procedure was necessary (eg, when the consultant required additional radiographs).

TeleDent level 3: video conferencing and data conferencing

If the advice provided by the consultant at level 2 was insufficient (eg, cases in which a more detailed explanation of the treatment plan was required), the dentist and consultant arranged to establish a live video conference or data conference. The same whiteboard file of the case was used as the basis for this further discussion in real time (Fig. 3). The live interaction possible with this technology facilitates in-depth discussion between the consultant and general dental practitioner, just as if they were in the operatory with the case records in front of them. During such a conference, additional

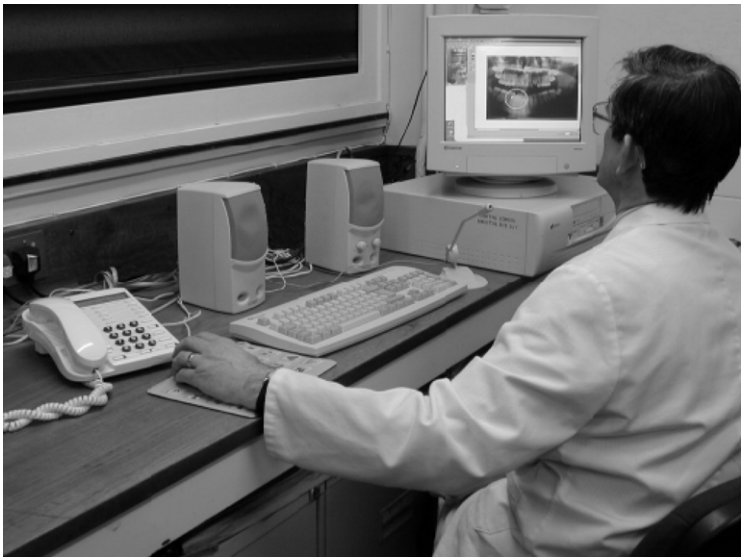

Fig. 3. A video conference in progress.

notes would be added to the whiteboard so that each party could store this updated file at the end of the conference.

Results and discussion

Technical support

Although dentists with claimed basic information technology (IT) skills were selected for the study, and despite the fact that two half-day sessions of training were provided, all but one of the dentists required significant additional support in the early weeks of the project. Mainly this support related to simple file handling and unfamiliarity with the Internet. Most of this support was provided during scheduled video conferencing sessions, for example, when undertaking the pretrial tests of orthodontic knowledge. The video conference proved to be a highly effective way of guiding a dentist through a particular procedure because screen images captured at the consultant's end of the link could be transmitted to the dentist to show exactly what keystrokes were required. These early sessions did have the unforeseen advantages of allowing the dentist to feel at ease with the consultant, who became aware of the dentists' various levels of orthodontic skill. In retrospect, it would have been better to assess the participants' IT skills formally rather than rely on the results of a self-assessment questionnaire.

By the time the case referral phase of the study started, all the dentists were familiar with the video conferencing and data conferencing system and

had all the necessary Internet and IT skills needed to collect data and send and retrieve whiteboard files.

Use of equipment and the process of referral

All but two of the dentists located their computer in their own operatory, which suited them although it was sometimes a bit cramped. The advantages were that it enabled them to prepare or continue cases between patient appointments and demonstrate the benefits of the system to patients. Two of the dentists used an adjacent unoccupied room. Two of the dentists said that they would have preferred to have the equipment installed at home because they worked part time and lived some distance from their office and would have liked to work on teledentistry cases in the evenings or on weekends (especially because there was no need to have the patient present for much of the preparation).

All the dentists found the process of sending cases by file transfer protocol straightforward. When asked which of the procedures had been most useful in obtaining advice, the dentists agreed that a combination of file transfer protocol and e-mail worked well. Although file transfer protocol and the live video link provided a quick response to queries, the live video link was not believed to be an essential part of the process of seeking and receiving advice. They could get adequate advice and information from the whiteboards sent by file transfer protocol and through e-mail correspondence with consultants. One dentist said, however, that the video link was useful from an educational point of view in that it allowed the general dental practitioner to have a dialogue with the consultant, which enabled him or her to understand the advice better. Such a dialogue also enabled alternative solutions suggested by the dentist to be discussed.

Capturing clinical data

The time it took general dental practitioners to collect clinical data using Jeremiah 2000 was similar: approximately 10 minutes per case. The time taken to capture the images was much more variable and took from 5 to 25 minutes. The dentist with his own digital camera took the least time. On a test case of the duplicated records that were sent by surface mail to all the practitioners, the overall time to complete a referral, including transfer of the whiteboard by file transfer protocol, ranged from 27 to 42 minutes. Again, the shortest time was recorded by the dentist with his own digital camera.

Cases referred

During the trial the referral system worked well, no cases were lost, and none was misdirected. The highest number of cases referred in any one week

was 13, with an average of 5 cases per week. A total of 163 cases, made up of class I, 50%; class II division 1, 29%; class II division 2, 10%; and class III, 11%, was seen during the trial. This is similar to the distribution found in studies of malocclusion in the United Kingdom population, except that the level of class III was raised to reflect a number of cases referred in the mixed dentition with incisors in linguo occlusion.

It was expected that during the trial a participating dentist would process all his or her potential orthodontic cases through the TeleDent SW system, but only one dentist chose to do so. The remainder said they referred cases through TeleDent SW for three main reasons:

- They were unsure whether it was a suitable case for them to treat or if it was too complex and should be referred.
- They were sure they wanted to treat the case but needed advice about how to proceed. In some cases they required an opinion on a particular aspect of the treatment and in others instances they required a complete plan.
- They were unsure whether the patient was ready for or in need of treatment and should be referred or left for the time being.

The cases that were not referred through TeleDent SW were those in which the dentist was certain that specialist treatment was essential, for example, a gross skeletal problem that required orthognathic surgery. For these cases, a request for Teledent advice seemed unnecessary because it would take longer to prepare the case for electronic referral than to write a referral letter. There also were patients whose parents were so demanding that the general practitioner was unwilling to become involved in the treatment, although the case was not beyond what he or she normally would attempt in the practice.

Was the advice from TeleDent what was needed?

Although only one clinician (C.S.) was used to provide advice in the trial, an earlier prospective peer review study of orthodontic treatment plans had shown that this author enjoyed a high level of peer approval from his consultant and specialist colleagues [24].

The dentists were happy with the advice that they had received, and there was general agreement that TeleDent SW was a good way of obtaining this. Advice was always returned to the dentist within 7 days, and 50% of referrals received advice within 2 days. As one general dental practitioner commented, however, it is usually not crucial for the dentist to get orthodontic advice quickly, as it might be with other dental specialties. One dentist remarked that TeleDent SW was better than a conventional referral because one can go back for advice again and again, whereas with conventional practice one cannot send the patient back repeatedly. From the consultant's standpoint,

TeleDent requests for review were much easier to handle because the case records could be retrieved in seconds from the file transfer protocol site.

The dentists reported that TeleDent SW was universally popular among patients and their parents. When asked for their consent, parents were impressed that they were getting advice from a "top expert" at the University of Bristol Dental School, and children were enthusiastic about the "high tech" approach. One dentist said that patients liked finding out quickly what the next step in the treatment would be, and he liked it because with such a recent review he did not have to go through the case records again to refresh his memory when discussing the advice with the patient.

The effect on patient care

There were wide variations in the effects that the availability of TeleDent SW had on the participating dentists' practices. This seemed to depend on a dentist's level of orthodontic expertise, distance from an orthodontic specialist, and whether he or she was in the habit of referring cases regularly to the local orthodontic consultant. Dentist C, who received additional training in orthodontics, had been treating cases for himself and his associates for some time with conventional advice from his local consultant. As a result of TeleDent SW, he avoided referring 48 cases conventionally and ended up treating 6 cases with advice that he believed initially would need consultant treatment. Dentist E, on the other hand, received little orthodontic training even as an undergraduate and always referred all cases for treatment by the local consultant. As a result of the study, referral became more selective. This dentist completed two cases of interceptive treatment successfully and a third was still under treatment at the end of the trial.

Numbers treated by the dentist

The availability of TeleDent SW did not have a dramatic effect on numbers of orthodontic patients treated at the practices. Two of the dentists started to treat cases that they would otherwise have referred, but in all only four cases were taken on in this way out of the 163 cases referred. Only two of the seven dentists said that they were treating more orthodontic patients. The dentists gave two main reasons for this lack of change in their practice: (1) They were reluctant to take on cases because they were concerned that at the end of the trial they would be left without ongoing support. (2) Although TeleDent SW was a quick way to get advice, it actually took more of the dentists' clinical time than it did to refer a case by conventional means, which required only writing a letter of two or three lines. Apart from the time taken to collect the clinical data, the authors' trial also required the dentists to capture images and complete a questionnaire for each case referred via TeleDent SW to enable the authors to assess the effect of TeleDent advice on the treatment provided (see box).

The multiple choice questions that each participating dentist was required to answer for each case once TeleDent advice had been obtained

1. What would you have done with this case if TeleDent did not exist?

(a) Reviewed again in ''x'' months
(b) Referred to colleague/my own local consultant/specialist
(c) Started treatment myself
(d) Other (please specify)

2. What will you now do as a result of the advice from TeleDent?

(a) Review again in ''x'' months
(b) Refer to colleague/my own local consultant/specialist
(c) Treat the patient myself:
- with no major changes to my original plan
- with substantial changes
- I did not originally have a plan

(d) Seek further advice from:
- A colleague/my local consultant
- TeleDent

(e) I felt no treatment was necessary
(f) Other (please specify)

Although the dentists did not take on significantly more cases, all still expressed a desire to do so, mostly because of long waiting lists to see local orthodontic specialists. At the end of the trial all said that they felt more involved in orthodontic treatment and were thinking more about the orthodontic needs of their patients even if they had not yet begun any treatment. For example, one dentist said that he was undertaking an orthodontic assessment for all potential patients, whereas before the trial he automatically referred all cases without an assessment.

Avoidance of late or inappropriate referral

Table 1 summarizes the dentists' answers to the questions posed in the box and indicates the overall effect that they believed TeleDent SW advice had on patients' treatment. These results do not suggest that there were a large number of cases that were saved from inappropriate orthodontic treatment by the availability of online advice, but a study of results achieved with and without Teledent advice would be necessary to confirm this finding.

Of the 12 cases in which the dentist intended to provide treatment anyway, only one treatment plan was changed by TeleDent SW advice. On the

Table 1
The effect of TeleDent SW advice according to the answers provided by the dentist to the questions in the box

	Dentist							
	A	B	C	D	E	F	G	Average
No change[a]	75%	55%	9%	58%	27%	53%	9%	41%
Saved an inappropriate referral[b]	21%	18%	22%	18%	45%	32%	0%	22%
Avoided neglect/ inappropriate treatment[c]	0%	0%	2%	12%	0%	5%	9%	4%
Helped the general dental practitioner to provide treatment for the case[d]	4%	27%	67%	12%	27%	11%	82%	33%

[a] The advice from TeleDent did not result in any change to what happened to the case.

[b] The case would have been referred by the dentists, but the advice from TeleDent identified that this was not appropriate at this time.

[c] A case that was ready for immediate treatment would otherwise have been left untreated or treatment would have been started that was inappropriate.

[d] The advice provided enabled the practitioner to treat the case where otherwise it would have been referred or it enabled the practitioner to obtain more conveniently the advice needed or it confirmed the need to refer the case.

other hand, some evidence indicated that immediate access to advice avoided delay in getting treatment started. Out of 17 cases that would have been put on review by the dentist, 4 received the advice via Teledent SW that immediate orthodontic treatment should be instituted.

The greatest effect was a reduction in inappropriate referrals for specialist advice or treatment. The mean level reported of 21% (range, 0–50%) equates well with other published United Kingdom studies of inappropriate referral to hospital-based United Kingdom consultants [13–15,17]. It suggests that if TeleDent SW were available in areas of the United Kingdom where there are few orthodontic specialists, it would greatly reduce hospital waiting lists and in the long term would make significant savings.

The effect on the dentists

All dentists undertook three standardized tests of their orthodontic knowledge, appliance design skill, and accuracy of case assessment before the start of the trial. These tests were repeated a year later. On both occasions, the tests were performed online and without prior warning. Only the scores of the case assessment skills tests showed a significant improvement (mean pretest score, 37.6; mean posttest score, 48; $t = 2.97$; $P < 0.02$).

At the end of the trial the author agreed to continue to provide advice free of charge to dentists in the study who wished to receive it. Three out of the seven dentists said they wished to do so, but only two of these have continued to take advantage of this service.

Summary

The information presented in this article must be interpreted with caution. Ideally the trial should have lasted longer because five of the seven participating dentists said they felt constrained from taking in more cases because access to TeleDent advice would cease before completion of all but the shortest of treatments.

Second, the number of practitioners recruited into the trial was small, and the dentists chosen were highly selected. Third, almost all the data are based on the opinions of the participating dentists, and for three of the dentists the number of cases on which those opinions were based was small. Finally, it must be remembered that all United Kingdom NHS dentists are busy and work on a highly structured "time of service" payment system. Although the costs of hardware, software, line rental, and training were borne by the TeleDent project, there was no financial compensation for the time spent by dentists capturing images of their patient records and putting together the whiteboard and transmitting the information. There was a significant financial disincentive for using the system.

Ideally, a long-term prospective randomized study of the effect of teledentistry advice on outcome of orthodontic treatment provided by general dental practitioners should be undertaken. The data collected in the current study supported the dentists' opinions that TeleDent SW enabled them to offer a better service for their patients and use specialist services more appropriately.

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