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Patients' preferences when comparing analogue implant impressions using a polyether impression material versus digital impressions (Intraoral Scan) of dental implants

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Abstract

Objectives: The primary objective of this clinical study was to assess the patients' perception of the difference between an analogue impression approach on the one hand and an intra-oral scan (IO scan) on the other when restoring implants in the non-aesthetic zone. A second objective was to analyse the difference in time needed to perform these two procedures.

Materials and methods: Thirty consecutive patients who had received 41 implants (Straumann tissue level) in the non-aesthetic zone in an implant-based referral practice setting in the Netherlands. As they were to receive crown and or bridge work on the implants, in one session, the final impressions were taken with both an analogue technique and with an intraoral scan. Patients were also asked if, directly after the treatment was carried out, they would be prepared to fill out a questionnaire on their perception of both techniques. The time involved following these two procedures was also recorded.

Results: The preparatory activities of the treatment, the taste of the impression material and the overall preference of the patients were significantly in favour of the IO scan. The bite registration, the scan head and gag reflex positively tended to the IO scan, but none of these effects were significant. The overall time involved with the IO scan was more negatively perceived than the analogue impression. Overall less time was involved when following the analogue impression technique than with the IO scan.

Conclusions: The overall preference of the patients in our sample is significantly in favour of the approach using the IO scan. This preference relates mainly to the differences between the compared approaches with respect to taste effects and their preparatory activities. The patients did perceive the duration of IO scan more negatively than the analogue impression approach.

Although the first intraoral scanners came on the market two decades ago, it is only recently that the popularity of these systems in the dental practice has started to grow. Within the past years, new brands of intraoral digitizers were developed and successfully introduced in the dental market Logozzo et al. 2011. The increase in accuracy and efficiency seemed to be the explanation for the increase in use of these tools in the dental practice. Recently published studies on the accuracy of intraoral scanners (IO scanners) show a comparable or even better general accuracy of the digital scans compared with the conventional impression methods Ender & Mehl 2011.

van der Meer et al. (2012) analysed the accuracy of the LavaCOS, CerecAC and iTero by determining the distance and angulation errors *in vitro*. The absolute distance errors ranged from 2.2 μm (Lava COS) to 287.5 μm (CEREC AC). In an *in vitro* study from Ender & Mehl (2011), it was concluded that the accuracy of a digital impression with the Cerec AC and the LavaCOS was similar to a conventional impression.

During the last decades, implant dentistry has become fully integrated into prosthetic patient treatment and dental reconstructions. The dental implant industry has started to develop tools that facilitate the use of intraoral scanners to make digital impressions of

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dental implants. At this point in time, the golden standard for the impression taking of dental implants is a conventional impression with either an open or closed tray technique Gallucci et al. 2011. Despite the deformation of impression materials Johnson & Craig 1985 and the cast (Millstein 1992; Faria et al. 2008; Konstantinos et al. 2009) the workflow of conventional impression taking of implants has proven itself in clinical practice (Imbery et al. 2010). The introduction of scan bodies, however, now enables the use of IO scanners as an alternative to analogue impression taking. Del Corso et al. (2009) showed in an *in vitro* study that IO scans could be a valid alternative to analogue impression taking. A recent clinical study by Karl et al. (2012) showed that the intraoral digitalization of dental implants appears to be at least as precise as conventional impression taking and master cast fabrication using prefabricated transfer components and laboratory analogues. To the knowledge of the authors up till now, no research has been published on the patient's perception of the intraoral scanning procedure.

Therefore, we have set up this study. In an implant-based referral practice setting in the Netherlands, 30 consecutive patients who had received implants in the non-aesthetic zone and were to receive crown and or bridge work on the implants had the impressions taken with an analogue technique (polyether impression material, e.g. Impregum F^R 3M Espe) and with an intraoral scan (Itero^R). The amount of time needed for both techniques was registered. The patients were asked to fill out a questionnaire on their perceptions of both types of impression-taking techniques that were followed. The goal of this study was to determine whether patients considered the IO scanning technique as more acceptable than the analogue impression-taking procedure and secondly if there were any differences in time involved between the two.

Material and methods

The sample under consideration consists of thirty consecutive patients who had received implants in the non-aesthetic zone in an implant-based referral crown and or bridge work on the implants. They were asked to participate in one session in which the final impressions were taken with both an analogue technique (polyether impression material) and with an intraoral scan (Itero). They were also asked if, directly after the

treatment was carried out, they would be prepared to fill out a questionnaire in which they were asked to reflect on both techniques. All patients were informed that the total treatment time would take longer (with a maximum of 40 min) than if only an analogue impression was taken. The research protocol that was followed was in accordance with the Helsinki Declaration of 1975, as revised in 2000 and again in 2008, and patients provided an informed consent to participate in the study.

The implants in this study were all Straumann tissue level implants. For all the implants, an osseointegration period of 6 weeks had been respected. Patients included in this study had either implants in the maxilla or in the mandible but not in both jaws. They could have two implants provided that these were in the same quadrant. In total, the 30 patients had 41 implants.

The prosthetic protocol included three visits to the practice. During the first visit, if indicated, the soft tissue around the implants was surgically corrected. The cover screw was removed, and a cover screw of choice that covered the implant neck and that extended above the soft tissue level was screwed into the implant. The time necessary for this phase of the treatment was written on a time sheet. The cover screw was again removed, and the implant carrier that was saved after implant insertion was screwed into the implant. An alginate impression (Cavex CA37^R) was taken. The insertion section was removed, and the cover screw of choice was screwed into the implant. The implant carrier was then placed into the impression (Fig. 1a–c). The impression was placed in an impression decontamination bath for 3 min. The recipe for the dental laboratory was filled out. The impression was sent to the dental laboratory where an individual impression tray was fabricated (Fig. 2a,b). The time necessary for this treatment phase was recorded using a stopwatch, and the time was written on a time sheet. After at least 1 week, the patient was asked to return to the practice to take the final impression. In this phase, the patients were randomized as to which impression technique was first to be carried out. If the intraoral scan was first procedure to be carried out, the cover screws were removed and the appropriate scan body (Straumann 2 part scan body) was screwed into place (Fig. 3a). Patient-specific information was typed into the computer connected to scanning device, as well as the recipe for the dental laboratory.

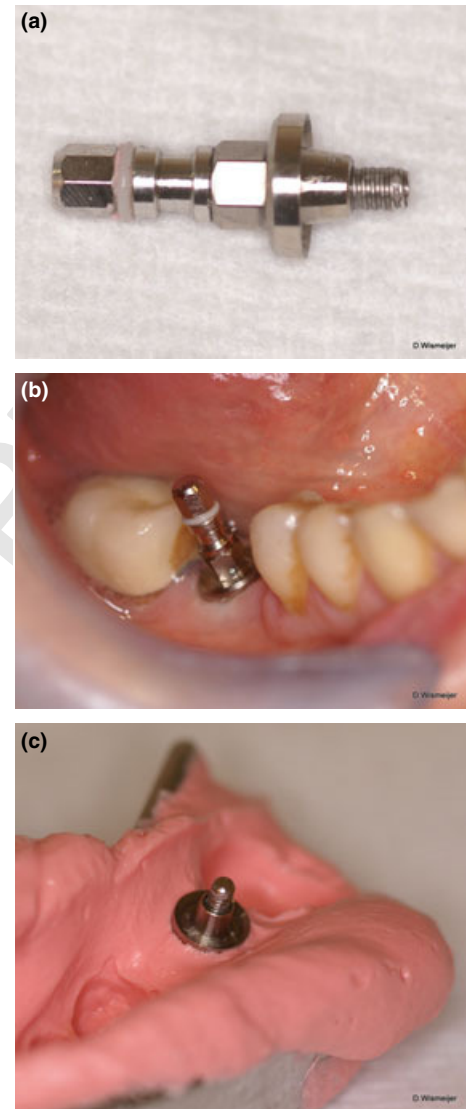


Fig. 1. xxxxx.

Quadrant scans were taken according to the protocol described by the manufacturer. After the scans were taken, the scan bodies were removed and the cover screws were screwed back into the implants. The time involved with this stage of the treatment was written on the time sheet. Fig. 3(b) shows the result of an intraoral scan. All the IO scans were made using the Cadent Itero (Carlstadt, NJ, USA) digital impression system.

For the analogue impressions, the cover screws were again removed and the appropriate screw retained analogue impression coping was inserted. The impression tray was then checked for fit (Fig. 4a). If necessary, the tray was trimmed to adjust the fit. The tray was filled with a polyether impression material (Impregum; 3M Espe, St Paul, MI, USA), and an impression syringe was also filled. The impression copings were covered with impression material using the

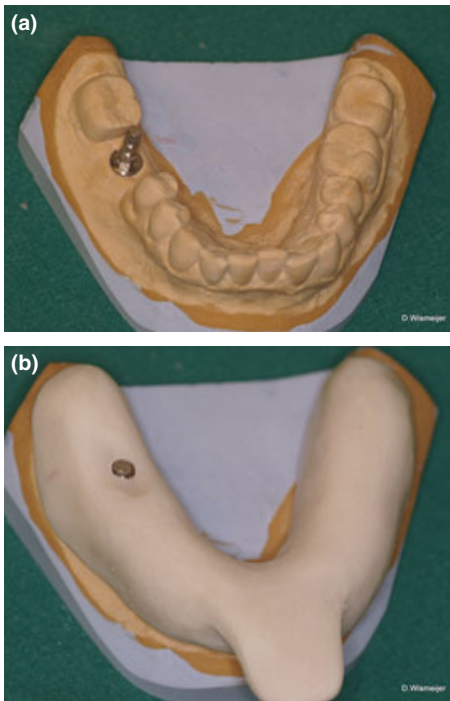


Fig. 2. xxxxx.

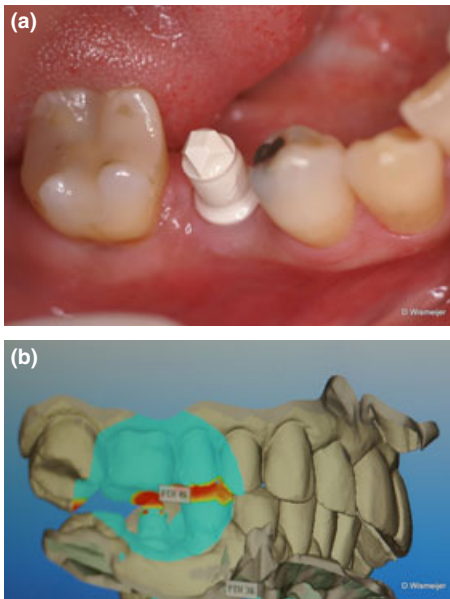


Fig. 3. xxxxx.

impression syringe, and the tray was inserted making sure that the screw approach of the impression coping through the top of the tray was accessible (Fig. 4b). The setting time prescribed by the manufacturer was respected, after which the impression copings were screwed loose and the impression was removed. The implant analogues were then screwed on to the impression copings (Fig. 4c), and the impression was placed into the impression decon-

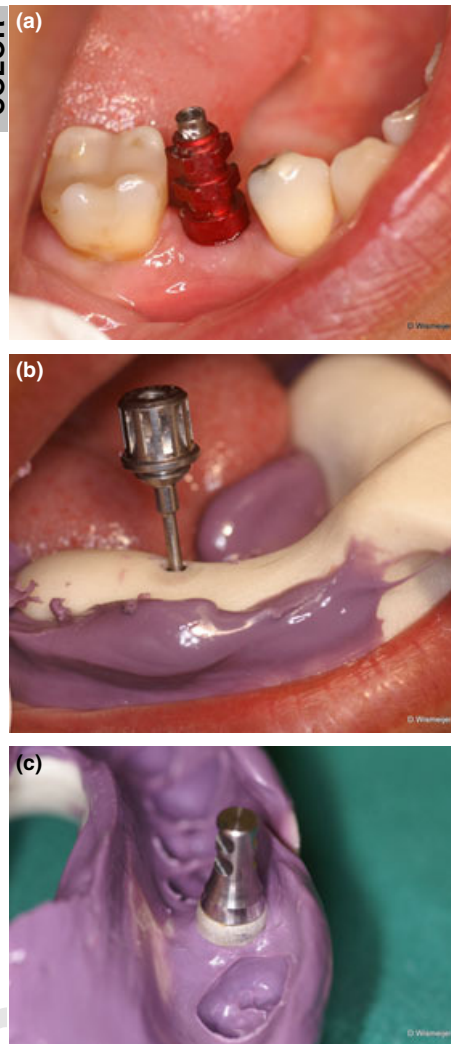


Fig. 4. xxxxx.

tamination bath for 3 min. A wax bite was taken to register the intraoral relationship between the mandible and maxilla. An alginate impression (Cavex, Haarlem, Netherlands) was taken from the antagonistic jaw. The laboratory recipe was filled out. The time necessary for this part of the treatment was written on the time sheet. Next, the colour of the dental prosthesis was determined and typed into the computer for the IO scan; this was noted on the laboratory recipe for the analogue impression. This time was also recorded on the time sheet.

The questionnaires were given to the patients, and they were asked to fill these out in the waiting room. On completion, they were asked to deliver them to the receptionist at the front desk.

As we were not aware of comparable research, we used a self-developed 7-item questionnaire. The questionnaires were based on a 10-point scale where 1 was seen as nega-

tive and 10 as positive. The following questions were posed as follows:

Analogue impression

1. **General opinion**
Overall what is your opinion on the analogue impression procedure?
2. **Preparing for the impression**
What is your opinion on the preparations necessary to be able to take the analogue impression (insertion of the impression copings, checking the fit of the tray and if necessary adjusting the fit of the tray)?
3. **The time involved**
What is your opinion of the time involved with this procedure?
4. **Taste**
What is your opinion of the taste of the impression material that was used?
5. **Registration of the intraoral relationship**
What is your opinion on the wax bite that was made?
6. **Size of the impression tray**
What is your opinion on the size of the impression tray?
7. **Gag reflex**
Did you feel any tend to gag during the impression-taking procedure? (yes or no). If so how would you appreciate this on a scale from 1 to 10?

Digital impression:

8. **General opinion**
Overall what is your opinion on the digital impression procedure?
9. **Preparing for the impression**
What is your opinion on the preparations necessary to be able to take the digital impression (insertion of the impression copings, checking the fit of the tray and if necessary adjusting the fit of the tray)?
10. **The time involved**
What is your opinion of the time involved with this procedure?
11. **Taste**
What is your opinion of the taste in your mouth during the digital impression taking?
12. **Registration of the intraoral relationship**
What is your opinion on the registration of the relationship (teeth in contact with each other and the scanning from buccal to register this)?
13. **Size of the impression tray**
What is your opinion on the size of the intraoral scanner (part used in your mouth)?
14. **Gag reflex**
Did you feel any tend to gag during the impression-taking procedure? (yes or no). If so how would you appreciate this on a scale from 1 to 10?

15. All in all, which impression technique do you prefer more: the digital or the analogue approach

- Analogue
- Digital
- It does not make any difference to me.

Results

Our study involved thirty consecutive patients who had received 41 dental implants (Straumann AG, CH) of the tissue level type (RN/WN) in a referral practice for oral implantology in the Netherlands. For all of these patients, the referring dentist had asked if the prosthetic follow-up could also be carried out and had their impressions taken following both an analogue and digital approach. The time involved with the impression taking was evaluated, as well as the patients' perception of the treatment. Thirteen patients had implants in the maxilla and seventeen in the mandible (see Table 1). The implants were either in the molar or the premolar area, and aesthetics-driven soft tissue emergence profile shaping of the soft tissues was not indicated. The patients were not fitted with temporary crowns.

All patients had three appointments. The first and the third appointments were the same for all patients. During the second appointment, both a digital and an analogue impression were taken. The selection of the type of impression taken first was chosen at random. The time involved with both the digital and the analogue approach during this visit was registered on a time sheet. The patients' perception of the treatment was recorded in a questionnaire which they filled out in the waiting area before leaving the practice.

Patients were asked about their opinion on the preparation of the analogue and the digital impression, the time involved, the taste of the impression material, the bite registration, their perception of the size of the impression tray/scan head, if they had experienced a gag reflex and on their overall preference for either the IO scan or the analogue impression. The results are given in Table 2.

Table 1. Number of implants per patient in the maxilla/mandible

Number of implants per patient	1	2
Maxilla	17	9
Mandible	24	10
Total	41	

Table 2. Patients' preference of treatment

N = 30	Patient preference	P-values (signed rank test)
Preparation	Digital	0.021
Time involved	Analogue	0.021
Taste	Digital	0.000
Bite registration	Digital	0.247
Impression tray/scan head	Digital	0.593
Gag reflex	Digital	0.773
Overall preference	Digital	0.026

Table 3. Descriptive statistics on the differences in opinion between the analogue and digital impression

N = 30	Mean difference	Standard deviation difference	Median difference
Preparation	-0.633	1.377	0
Time involved	0.867	1.191	0.5
Taste	-2.289	2.242	-2.0

The mean, standard deviation, and median of the difference between an analogue and a digital impression. It should be noted that a negative value for the mean or median in this table points at a preference for the digital impression.

Table 3 shows the values for the mean and standard deviation of the difference and the mean difference in patients on the type of impression taken. Preparation and taste are once again in favour of the digital impression.

Table 4 shows the time comparison between the analogue impression and the intraoral scan procedure as followed for each individual patient. In total, the time involved was registered for 27 patients. Three patients were seen as dropouts as the scan data were not satisfactorily processed by the scanning company. Two of these patients had one implant in the maxilla and one had one implant in the mandible.

Table 5 shows the statistical analysis of the comparison of the different impression-taking procedures. These have been com-

pared for the maxilla and the mandible as well as the number of implants. We also looked at the procedures for upper and lower jaw separately as well as the procedures independent of which jaw they were used. The results show that there was no statistical difference between these procedures when taking an impression of 1 implant in the mandible and 2 implants in the maxilla.

Statistical analysis

The statistical analysis for both the patient's perception of the type of impression procedure as well as the analysis of the time involved with impression taking following both procedures was analysed with the Wilcoxon signed-rank test. All assumptions for this test were met, that is, all data are paired, each pair is sampled independently and at random, and the data are measured on at least an ordinal scale. Note that we applied this nonparametric analysis considering that the data were not normally distributed for all items under consideration.

Discussion

The IO scan technique for crown and bridge work has proven its possibilities as an alternative for the analogue impression-taking technique. The use of IO scanners recently became an alternative for the analogue impression-taking technique for dental implants. Several implant companies have developed scanning abutments for their implant system. The question then arises if patients perceive the analogue impression-taking technique as more cumbersome than the digital technique or not.

We have seen the development in the dental laboratories going towards digitalization of their production techniques, in which analogue impressions are being digitalized. The digitalized files are then used in a CAD CAM environment to design the crown and bridgework on natural abutment teeth.

Table 4. Time comparison (minutes) between the Analogue impression and the Intra Oral Scan at patient level

P	AU1	IOSU1	P	AU2	IOSU2	P	AL1	IOSL1	P	AL2	IOSL2
1	12	12	10	12	25	13	12	25	22	12	24
2	14	25	11	15	40	14	14	20	23	12	35
3	10	15	12	12	20	15	12	15	24	15	40
4	10	40				16	15	25	25	12	35
5	14	25				17	15	20	26	10	40
6	12	18				18	18	10	27	12	18
7	12	20				19	12	18			
8	10	20				20	12	17			
9	10	15				21	10	16			

P, patient number; A, Analogue impression; IOS, Intra Oral Scan; U, Maxilla; L, Mandible; 1/2, number of implants.

Table 5. The statistical analysis. Hypothesis there is no difference between the analogue impression and the IOS

Analogue impression	IOS	P value
AU1	IOSU1	0.012
AU2	IOSU2	0.109*
AL1	IOSL1	0.092
AL2	IOSL2	0.027
AU	IOSU	0.03
AL	IOSL	0.03
A	IOS	0.00

Recently, implant companies have provided the dental laboratory with scanning abutments so that the models with implant analogues can also be scanned and digitalized. This has made the CAD CAM approach for the production of implant abutments and crown and bridgework on implants an option for the dental laboratory as well. This development has paved the way for IO scanners to be introduced into the dental practice for registration of implant borne reconstructions. Especially for the dental laboratories, this approach will make their work easier: it becomes an option to skip the model scanning, as the digital scan will be coming directly from the dental practice. Possibly, the IO scanning in the dental practice will also introduce the reduction in inaccuracies, as less separate steps have to be taken to get the digital model the laboratory needs to go ahead with the CAD planning. The question then arises if the IO scanning procedures are as precise as the analogue impression taking and if dentists are prepared to invest into these digital techniques. Our research into the digital workflow in dental laboratories has shown a significant reduction in design and production time of individual dental elements Mans et al. 2012. Other research from our group looking at the precision of IO scanners has shown that there is a difference in the precision of different IO scanners but that they are within the range of analogue impressions Ender & Mehl 2011.

When analysing the time involved when following analogue impression taking compared with the IOS, we see that in nearly all situations the analogue impression took significantly less time than the IOS. The results do show that when taking an impression of the implants in the maxilla, there was no statistical difference in the time involved. However, as this group only consisted of three patients, we expect the power here to be insufficient to draw any conclusions. In this study, the results when taking impressions in the lower jaw with one implant showed no statistical difference in the time involved. All other

combinations showed that the less time involved was statistically in preference of the analogue impression. Possibly, the IOS technique is more easy to carry out in the mandible due to direct view of the procedure in the patient's mouth when compared to the maxilla. Secondly, when more implants were involved, we experienced that the IOS had problems when stitching the various shots as the scanning abutments have the same shape and the system could not always differentiate which abutment was situated where in the jaw. Another problem we encountered was that it was not always easy to scan the approximal areas of the neighbouring teeth due to the fact that the scanning abutment was too close making it difficult to aim the IOS in such a way that the area could be scanned satisfactorily. We would advocate here that a change in the algorithm of the IOS making it possible to scan the approximal neighbouring surfaces first. Then, the scanning abutments could be screwed onto the implants and scanned separately after which the images are stitched together. This would make the IOS procedure easier and quicker to carry out being beneficial to both the restorative dentist and the patient.

A recent paper by Lee & Gallucci (2013) discussed the operator's preference on digital versus analogue impression-taking techniques. In this *in vitro* study, a customized model was used instead of live patients. The students were totally inexperienced in taking impressions. The overall perception of the inexperienced student operators was that they preferred the digital procedure. In the present study, however, we have an implant dentist in a referral practice with 25 years of experience in analogue impression-taking procedures with which a standardized nearly foolproof procedure as shown in the illustrations has been developed. It is understandable that, when provided by an experienced team, this can rapidly be carried out. Therefore, the results of these two studies are not really comparable. The operator's opinion was not analysed in the present study due to the fact that all patients were treated by the same dentist.

This current research project on the patients' perception of IO scanning techniques of dental implants shows that patients do not perceive the IO scanning as more negative to undergo than analogue impressions. On the contrary, they have an overall significant preference for the IO scan ($P = 0.026$). It should be noted that "preparation," "time involved" and "overall preference" the results are significant yet small.

We had expected a more positive response for the IO scanner when looking at the gag reflex.

However, the patient's preference for the IO scan was not significant ($P = 0.593$). Apparently, in the relatively small patient group, we considered gagging caused by intraoral impression taking was not an issue. This corresponds with the general opinion on the size of the impression trays and the scan head and the bite registration using a wax bite. These three parts of the impression-taking process showed a tendency towards the digital approach, but were not perceived as statistically significant different. The questions concerning preparation of the treatment and the taste of the impression material both showed a statistically significant preference for the digital approach. Particularly, the taste of the impression material was perceived by the patients as more negative ($P = 0.0$). Clearly, as there is no discernible taste component to the IO scanning procedure, this is understandable. The preparation procedure (putting the impression copings on the implants and the fitting and adjusting the impression tray) was perceived by the patients as less favourable than the insertion of the digital scanning abutments ($P = 0.021$). Perhaps the extra pressure on the soft tissues involved with the fit and insertion of the impression tray were debit to this. As we did not interview the patients on why they considered this as negative, this argument is speculative.

The responses of the patients through the questionnaires pointed only to the time duration involved with the IO scan as relatively negative; in that aspect, they had a statistically significant preference ($P = 0.021$) to undergo the analogue impression.

It must be stated that this comparative study does not analyse the difference in precision between the two impression-taking procedures. The authors state that this is, however, an important aspect and that further research in this area is necessary.

Conclusion

In this research, based on a relatively small cohort of patients, the overall conclusion is that the preference of patients for the IO scan is statistically significant. This is mainly because of the perception of the taste effect of the analogue impression and the preparatory activities involved. However, patients did perceive the duration of the IO scan more negatively than the analogue procedure.

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