

# The Application of the Assembly Line to the Delivery of Oral Health Care

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## Abstract

This paper examines the delivery of oral health care and compares the delivery in 2020 with that before 1900. While equipment and materials have changed, the design of the office, and the use of personnel within the office has remained remarkably similar. The doctor is responsible for diagnosis and treatment with some support services provided by hygienists and assistants. This piece work delivery model contrasts with an assembly line model. The assembly line model is explored here in a hypothetical visit to a dental office in 2025. The paper describes the layout of practice as well as the role of the doctor and auxiliary personnel in the office.

**Keywords:** Dental care history, machine learning, robotics, teledentistry

## DELIVERY OF DENTAL CARE IN THE UNITED STATES BEFORE 1900

In the United States in the 1700s and into the early 1800s dental care was provided in the nearest medical office by medical doctors. But in rural areas in America where physicians were not available and because dental surgery was usually performed with the patient seated in a chair, dental treatment was performed in the local barber shop by the barber/surgeon.<sup>[1]</sup> As extractions were usually the only treatment provided, the only equipment that was needed was an instrument to grab the crown of the tooth like pliers and sufficient strength and leverage to separate the tooth from the bone and enough whiskey to deaden the pain.

In 1840 the Baltimore College of Dentistry opened.<sup>[2]</sup> Graduates of the year-long educational program followed the medical model and opened practices usually in a room in their home or storefront near their home. By 1900 the office had a waiting room and business office, but the focus remained the surgery and the dental chair usually placed prominently in the middle of the room. Not surprisingly in 1900 the dental chair looked like the barber chair. In addition to the dentist, the office might have a receptionist and perhaps an assistant. In 1903 Dr. Kells added dental x-rays into his practice and in 1913, a Connecticut dentist hired the first dental hygienist.<sup>[3,4]</sup>

For the remainder of the 20<sup>th</sup> century, the dental office became larger as more operatories were added for the dentist and for a hygienist. By 2000 the digital technology revolution reached dentistry resulting in the introduction of new equipment and new procedures. Despite all these changes, almost all dental procedures remained surgical and were performed by the dentist. While a typical dental office includes hygienists, lab technicians and assistants, it was the dentist who not only made the treatment plan but carried out the treatment.

## THE DELIVERY OF DENTAL CARE IN THE 20TH AND EARLY 21ST CENTURY

It is of interest that the dental office for general dentistry of 2020 has a floor plan that looks surprisingly like it did in 1899. There is a waiting room, a business office, one or more operatories and areas for sterilization and radiographs. In

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2020 there are more colors, better furniture, and more comfortable waiting room chairs. The fact that the floor plan has not changed suggest either that this plan is ideal, or that no one has considered an alternative.

In the operatory, the basic equipment remains: a chair and dental cutting instruments – a drill. In 1900 dentists had a drill driven by a foot pedal.<sup>[5]</sup> In 2020, dentist's drill at much higher speeds and the drills are driven by air or electricity. The dental chair, too, has evolved: in most practices, patients are now treated in a reclined position and the porcelain basin has been replaced by the saliva ejector.<sup>[6]</sup> Also, in 2020 the office equipment includes cone beam x-ray units and sterilization equipment.

Dental office personnel have expanded as well. Many offices now include hygienists. Most dentists practice with one or more assistants and sometimes specialists like prosthodontists might have lab technicians.

It is also of interest that the process of delivering dental care in 2020 remains similar to that in 1900. Dental care is delivered primarily by the dentist. While some type of care can be delivered by dental therapists, hygienists and even assistants, it is the doctor who decides on treatment plans and who delivers the dental care needed.

In the traditional office the patient is seated, and the doctor and assistants move about the patient. Assistants move about getting materials and instruments as needed often having to leave the operatory. The doctor often moves from operatory to operatory waiting for anesthesia to take effect or for products to dry or cure.

This method of completion of a task is reminiscent of manufacturing in 1900 and is often referred to as “piece work”. For example, if the task was to manufacture a car, a worker (or workers) would gather at a workstation and slowly step by step build the car from the chassis to the finished car. If parts were needed, the worker would walk to the storeroom and acquire the part. The worker was paid when the auto – the piece – was completed. Piece work has remained the treatment model for the delivery of dental care for several centuries. Given the advances in technology and the demands for dental care, it may be time to rethink this model.

## **In 1905 HENRY FORD INTRODUCED THE ASSEMBLY LINE**

Before 1905 almost all manufacturing was working on one piece at a time and workers were paid when the fabrication of the piece, they worked on was completed. For example, to fabricate a car a worker stands at a workstation and build the car from beginning to end. For piece work, the piece – the car being built – would remain stationary and the worker would walk from a central supply room retrieving each component or part and adding the part to the auto under construction. This process would be repeated over and over again until the auto was completed. When the auto was completed the

worker was paid for completion of the piece – hence the name piece work.

In 1905 in the United States Henry Ford pioneered the assembly line for the manufacture of automobiles.<sup>[7]</sup> With the assembly line the auto under construction moved on a belt from workstation to workstation. At each workstation, a worker would add a part. Each worker was trained to perform the task in the most efficient manner. To be efficient, there would be a supply of parts readily at hand so the worker would not have to leave the workstation. The assembly line model for manufacturing was so successful that it rapidly replaced the piece work model. As the assembly line debuted in 1905, about the time dental care were becoming more formalized, it is surprising that some innovation minded dentist did not think about the application of the assembly line to the delivery of dental care.

Of course, there were many reasons why in 1905 the assembly line model would not have worked. By 2020, however, many of these reasons can be overcome. In this paper, I propose to explore what configurations the assembly line delivery model might take to make it successful.

## **A VISIT TO THE DENTAL OFFICE OF 2025: THE DIAGNOSTIC ROOM**

Imagine its 2025. What would a visit to a dentist be like? The patient, you, arrives at the building entry door. You state your name into a video camera which takes your temperature and a receptionist inside the building's business office appears on a video monitor, identifies the patient on a closed-circuit monitor, and electronically opens the exterior building door. You enter and proceed down a hallway with doors on the right – hand side – each door is numbered. Each door leads to a diagnostic room. The receptionist remotely opens door to the room assigned to you. The receptionist ensures that only one patient is in the hallway at any time. This ensures patient privacy and appropriate social distancing.

Inside the diagnostic room is a dental chair. Instructions on a monitor ask you to be seated and when sensors record you are seated instructions appear on the monitor to explain the procedure. The receptionist is available by video link to respond to any of your concerns or questions.

With you in the chair, voice prompts from a virtual assistant ask you to respond to questions to provide medical, dietary, and oral hygiene history. This information is collected with a voice-activated computer interface to eliminate the keyboard. Voice activation reduces the number of disposable items, barriers and one less item for disinfection.

The dental chair, specifically designed with sensors for this purpose, allows collection of your vital signs including, blood pressure, temperature, respiration, pulse, and sensors can record an EKG if necessary as on a smartphone.<sup>[8]</sup> All information is collected by voice prompts from the virtual assistant.

After all background history and vital signs are obtained, an assistant enters to welcome the patient and explains to you that an intraoral camera will be used to perform an intraoral exam. This is the first time a member of the dental staff has interacted with you.

The assistant positions the patient for the intraoral video camera that will complete the intraoral exam. This camera captures intraoral appearance of soft tissues using traditional photography as well as video using infrared for thermal imaging to capture “hot” areas on the gingival tissues that might be indicative of inflammation. Sensors palpate the glands in the neck and the responses recorded. External images of head and neck area are recorded. The camera also captures images of teeth. Using appropriate diagnostics scanners, intraoral soft tissues including the tongue are screened for oral cancers. Newly developed equipment will allow for automated pocket depth determination, and for obtaining samples of gingival crevicular fluid from each tooth. The microbial population of a sample of your saliva will be determined. A panel of biochemical determinations will be performed on the gingival crevicular fluid and saliva like those usually performed on blood samples.<sup>[9,10]</sup> But there will be added biochemicals of interest to dental care including inflammatory cytokines, hormones, and glucose. When all these data have been collected and stored for analysis the assessment step is complete.

You are now informed by the virtual assistant that cone beam x-rays analysis will be in another room. You prepare to stand to walk to the cone beam suite, but the virtual assistant informs you to remain seated. The door to the cone beam suite opens and the entire dental chair with you in it moves on rails into the cone-beam room. The connecting door is closed, an x-ray technician appears, adjusts the equipment, and performs the test. After the test is completed the patient remains seated and the chair, plus patient, travels back to the operatory.

All patient data (vital signs, visual, microbiological, biochemical, x-ray) will be processed by algorithms to predict susceptibility to caries, make home care recommendations, evaluate gingival disease, diabetics screening, oral cancer screening. Decayed teeth are identified as well as areas of gingival inflammation.

Treatment plans are developed electronically and forwarded to the doctor who is seated in a separate room (a control room – see below) in front of monitors, one for each operatory (and therefore one for each patient). The doctor can view the diagnostic information of several patients.

The doctor opens an audio/video link and the doctors face appears on the patient’s monitor. The doctor greets the patient and presents the diagnostic and treatment plan options including time for completion, costs, and payment options. Once a treatment plan is agreed to, the doctor says goodbye and the scheduling receptionist appears on the monitor to arrange a follow-up schedule to begin the treatments. Once

completed the receptionist bids you good day and you exit the chair and depart the diagnostic room the same way you entered.

At this point you, the patient, have only seen two people: the chairside assistant and the x ray technician. The doctor and the receptionist are only seen virtually.

When the room is empty the entire room including all surfaces is sterilized by the introduction of sterilization gas. After sterilization is complete the gas is removed by suction and the room ready for the next patient.

## A DIFFERENT ROLE FOR THE DENTIST: THE ORAL CARE CONTROL ROOM

The unique difference between the piece work model and the assembly line model is in the former there is a stationary workstation with workers moving about the project while in the latter the workstation moves with workers stationary.

When applied to dental delivery, the patient (the workstation) moves and the workers dental personnel remain stationary. This change means the dentist does not move from patient to patient but remains stationary while the patient moves.

In the assembly line model, the dentist is in a control room. With the availability of technology to perform treatment procedures, and technicians to guide the technology, it is possible to envision the doctor in an advisory role. This is accomplished by placing the doctor in a control room equipped with video monitors, one for each operatory/patient. In the control room the doctor can analyze all incoming data, develop a treatment plan, discuss the treatment plan with the patient, and guide the technician assigned to monitor the robot in providing treatment.

## RETURNING TO THE DENTAL OFFICE FOR TREATMENT

Returning to the dental office for treatment includes entry into the office as before. But in this case the patient has returned for restorative treatment. In this case the receptionist provides entry into a Preparatory Room. Once seated, a video monitor plays music preselected by the patient to produce a calm effect. Once sensors in the chair indicate the patient is relaxed, a dental auxiliary professional/assistant enters to make the preparations for the restorative procedures that the doctor has recommended, and the patient accepted, at the previous diagnostic appointment. Preparations include options include local anesthesia, sedation, nitrous oxide for example. During this preparation step, sensors in the chair monitor vital signs as well as signs of anxiety or stress. Following completion of preparations, the chair (with patient) glides through a series of doors, into another room – the Restorative Room – and post treatment instructions provided by video link as necessary. In 2025 the cavity preparation is accomplished by a robotic instrument.<sup>[11]</sup> The technician to set up the robot arrives and proceeds to calibrate the instrument for you.<sup>[11]</sup>

After completion of the procedure you glide back to the preparatory room for observation.

## THE BUSINESS OFFICE

At the completion of all procedures, the patient chair with the patient glides to the billing station where financial transactions are managed by virtual assistants communicating with patients via touch screens or voice through the virtual assistant.

## A VISIT TO A HYGIENIST

By 2025 plaque removal has become automated.<sup>[12]</sup> This innovative technology will allow hygienists to care for more patients. A visit to a hygienist begins with patient first entering the diagnostic room for a full work up. From a control room like that used by the dentists, the hygienist greets the patient virtually, and reviews the findings and suggests a treatment plan all virtually. After an agreement is reached the patient and the chair glide into the hygiene treatment room where a technician greets the patients and completes the preparations for plaque and calculus/tarter removal and complete hygiene care. The patient does not interact with the hygienist who remains in the hygienist's control room.

## CONCLUSION IMPROVING THE DELIVERY OF ORAL HEALTH CARE

There are several differences between providing dental care via an assembly line vis piece work. In the assembly line dental office, the patient glides from one station to another. In the piece work model, the patient is stationery and office personnel including the dentist move about the patient. In the assembly line model, the doctor is in a control room and manages the treatment of multiple patients while the treatment is performed by robotic technology overseen by technicians with specialty training in the robotic technology. In piece work, the dentist provides the treatment and moves from patient to patient as each stage of treatment is completed. Clearly the movement of the doctor from patient to patient is time inefficient. The introduction of unique stations, like the Diagnosis, Preparatory, X ray and Treatment stations, allows for isolation of patients from each other, sites to be designed for the use of dedicated equipment, and ease of whole room disinfection between patients. Also having a business station allows uniformity in messaging to patient at the conclusion of a visit. The patient sits in special chair lined with sensors to evaluate the patient's condition will be invaluable to all dental office personnel as they will be better able to monitor the patient's response to events during the visit. The design of the office provides controlled access to all aspects of the office including initial entry by personnel in the reception area thus eliminating the need for a reception area. The rapid acceptance of teledentistry suggests that the use of virtual assistants and video monitor for office personnel including the doctor to communicate will be accepted by patients.

While much research will be needed to overcome all the hurdles blocking implementing the change in delivery of oral health care from piece work to an assembly line model, CRET is providing dental companies and dental schools with an opportunity to collaborate with the dental schools to overcome these barriers and introduce this new model.

CRET invites the dental industry to join CRET as the science of the design of the next generation of "Smart Innovation Centers" for our dental schools begins. These Smart Centers could well become prototypes for the design of dental offices of the next half century.

## EPILOGUE

Will all these changes occur by 2025? Probably not. But at the rate technology enters the dental office, such changes will happen eventually. But will the patient like the idea of interacting with the technicians and interacting with the dentist and the hygienist only virtually. Perhaps not immediately but the acceptance of teledentistry suggests virtual interactions maybe more acceptable as the technology gets better.

What about the dentist sitting all day in a control room? Will anyone go to dental school if that is how they will spend their day? That depends on who applies to dental schools. What is expected of an applicant to dental school is changing. In the 1950s and 1960 part of the dental aptitude exam consisted of chalk carving. At that time success in dental school required some manual dexterity hence a demonstration of this skill was included. In the 1950 and later, dental students did all their own fabrication in the school's dental lab. In today's dental schools most fabrications are done in professional laboratories.

Also the dental licensing exam is changing. Until recently, students had to demonstrate dental competency on a live patient. This requirement is being replaced with students having to demonstrate a competency in treatment planning.

Perhaps by 2025 the dental school graduate will have many more diagnostic tests at their disposal and the treatment plan will be a more significant part of the dental office visit. And the surgical interventions will be performed by robots.

Whatever happens 2025 it should be interesting.

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Nil.

## CONFLICTS OF INTEREST

There are no conflicts of interest.

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