Discussion and suggestions regarding the debate over centric relation

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Deep L Web translation software, Google Translate software used

A consideration of how we must do it in order to one day be able to use cad assisted by artificial intelligence.

Please note

You may feel some discomfort with the way the following sentences are expressed, but that is because they are one step short of becoming science.

Discussion and suggestions regarding the debate over centric relation

Can a dental technologist mention things that only a dentist is supposed to be able to talk about, such as where the centric occlusion should be and things related to the centric relation?

I believe that when manipulating biologic bodies, the dentist should be in charge of any specialty issues related to them. I also think that when manipulating CAD for requirements that are not related to medical treatment or diagnosis, the dental technologist can, to a certain extent, request the dentist for the choice of settings in his/her opinion.

We can talk about this system when we use CAD to create prosthetics. From the standpoint of a dental technologist, I believe that in this way we can propose ideas and move forward in solving problems, if not solving the problems we are currently facing with regard to the fabrication of prosthetics.

The centric occlusion is the relationship between the upper and lower dental arches. The centric relation is the so-called bone-to-bone positional relationship regarding the position of the mandibular fossa on the lateral side of the maxilla and the mandibular head on the mandible. The definition of centric relation has changed historically.

Terminal hinge axis and central relation. Centric relation in the terminal hinge position of the mandible , in which the hinge axis is constant to both the mandible and maxilla.)
This is taken from "Rethinking the Central Position (Theory)," which is featured in the July 2022 issue of “Shikai Tenbo”.

“Shikai Tenbo” is a Japanese dental trade magazine.

For cases with large dental prosthetics, such as those involving the upper and lower jaws: The determination of the central occlusal position or central position is done by the dentist, since it is a diagnostic matter.

The shape of the occlusal surfaces of prosthetic molars is nowadays mostly created by dental technologists. However, I believe that if possible, it is better for the dentist to do the design. The reason for this is that the dental technologist cannot get out on his own from doing repetitively what he was first taught. The only thing they can do is to shape up their skills and shorten their fabrication time.

This is so because dental technologists do not have direct contact with patients. There is also the fact that it is for reasons of professional authority. Patients come to the office relying on the dentist and not the dental technologist. It is about authority and responsibility. Also, when reporting a case in an academic presentation, it is more interesting to the audience to say that the dentist designed the case and asked the dental technologist to produce it.

In the case of dentists, I believe that they can interactively change prosthetics by engaging with the living body, the patient. Nowadays, dentists rarely make prosthetics directly, so I think it would be better if dentists design prosthetics with CAD and dental technologists do the fabrication. So, what should be done in the dental care industry to achieve this kind of "new manufacturing"?

One of the system theories that is currently attracting attention is "autopoiesis". If this autopoiesis can actually be introduced into dental prosthetics and prosthetic manufacturing in the field of prosthodontics, we believe that "new manufacturing" can be realized. I believe that autopoiesis will be realized when dentists actively participate in the design of prosthetics with a CAD-based system.

It may be difficult for dentists to freely use CAD without financial burden. Also, until now, it has not been customary for dentists to design specific prosthetics and for dental technologists to fabricate them. In the dental field, it is essentially the dentist who is responsible for both the treatment and the fabrication of prosthetics. Therefore, there is no problem for dentists to design with CAD from the viewpoint of the Dental Practitioners Act and the Dental Technologists Act.

Is there anything preventing "new manufacturing"? If so, is it the practice for dental technologists to design specific prosthetics? As for the use of CAD by dentists, there are now various forms of CAD licenses, which I believe have reduced the financial burden.

Before the advent of CAD, it was not possible to specifically design organic three-dimensional shapes such as teeth. We had no choice but to follow the style of designing while building.

In the general industrial world, 2D drafting systems appeared in the 1960s, and 3D CAD systems were commercialized in the 1980s. The first dental CAD system is considered to have been the "CEREC System", which was developed and introduced in 1985 by a group at the University of Zurich, Switzerland, in collaboration with Siemens AG, Germany.

With some technical impetus, it would be possible to return the current situation where the dental technologist is designing the specific design of the prosthesis to its ideal form. The ideal form would be for the dentist to design the prosthesis and the dental technologist to fabricate it accordingly. Or it could be that the dental technologist creates the design when complete and the dentist checks it before fabricating it. The "optimization" operation that autopoiesis refers to would be a difficult operation for a dental technologist who has no contact with the patient.

The profession of dental technologist started when dentists became too busy with treatment, so they entrusted the fabrication of prosthetics for dental treatment to assistants who did not have sufficient knowledge of diagnosis and treatment, but only limited themselves to the scope of dental technology. Later, it became an independent profession.

However, since dental technologists do not have direct contact with patients, they are unable to evaluate the prosthetics placed in the mouth. For this reason, I would argue that dentists should be directly involved in the specific design of prosthetics.

It will be necessary to explain the rationale for the participation of the dentist in the specific design of the prosthesis. I propose the introduction of the "reduction of complexity" or the "concept of autopoiesis" for handling the oral cavity as a system. The "reduction of complexity" can be described as a procedure to make the system easier to deal with.

When human beings try to interact with nature in a new way, there must be some kind of orderly procedure, and it is not just a matter of being able to do it. Autopoiesis" is the procedure for this.

What is autopoiesis, a component of the dynamical system?

In the 1960s, the concept of autopoiesis, the basic model for a new system of autopoiesis, was introduced by two Chilean biologists and neurophysiologists, Humberto Augusto Maturana Romesín and Francisco Javier Varela Garcia. The artificial word autopoiesis, synthesized from the Greek words autos (= self) and poiein (= to make), means something like self-production. They describe this concept as an approach that appeals only to physical and chemical laws of nature, without the aid of supernatural forces or principles.

Autopoiesis was conceived as a concept to solve the mysteries of living systems, especially the immune system. How is it possible for life to utilize "non-self" and self-organize while still maintaining "self" as a system inside and outside the environment? It is thought that there is a mechanism of "self-reference to reproduce the self" and "self-recursion by the self."

It is possible that life, while "self-reference" itself, has the ability to transcend the self-contradictions (conflicts) that arise in the process of self-referencing. Maturana and Varela hypothesized that this could be called autopoiesis. Their attempt is to use the concept of autopoiesis to formulate a general organizational principle for living things, one that is valid for all living organisms. Niklas Luhmann also created the social systems theory based on autopoiesis. The systems theory discussed here is based on Niklas Luhmann's theory of social systems.

What is a complex system?

Niklas Luhmann always viewed the world and society as complex systems. He continued to seek for "meaning" as the fundamental unit that forms the world and society, and he regarded everything that processes and edits meaning as a "system."

Luhmann saw society as a complex system, and that system is constituted by the meanings that humans understand. The science of complex systems is a new approach to science that studies how parts relate to the behavior of the system as a whole, how the system relates to each other and to the environment to which it belongs.

It is useful to approach the problem from two aspects. Consider, for example, the masticatory movements of the mandibular movement. The aspect from the natural sciences deals with the shape of the occlusal plane, which is the form of the teeth of the entity, while the aspect from the social sciences deals with the changes in the interocclusal space.

The "interocclusal space" is the place of communication between the upper and lower teeth. Simulation is one of the effective techniques in the science of complex systems, which includes design by changing parameters in CAD and coupled analysis of structure and motion using the finite element method.

The function of the teeth as a system cannot be found from the shape of a single tooth alone, and the shape of the occlusal surfaces of the molars cannot be understood without considering the communication created by the act of masticatory movement. The occlusal surfaces of the maxillary and mandibular molars are not only questioned in terms of their contact relationship in the centric occlusion position, but also in terms of the change in proximity relationship mandibular movement. The change in

interocclusal space refers to the change in the gap between the upper and lower jaw teeth when the mandible is in motion to chew food. It is the same as a change in proximal relationship.

Complexity, such as in social systems, is resolved by systems theory, which brings exquisite complexity reduction or liberation from internal conflict. The more complex the subject matter, the more complex the system theory. Not only dentistry, but medicine in general is said to belong to the field of applied natural sciences. Medical care is also said to belong to the field of social science because it is organized by human beings. In other words, social systems theory distinguishes between the human world and the natural world, while at the same time integrating them to create a worldview based on the unique interpretation of human beings.

What is the relationship between autopoiesis and dental technology?

I believe that dentists should be actively involved in the specific design of prosthetics. To make this happen, we need a CAD system that can handle this and a concept for implementation. Autopoiesis is an appropriate concept for this. Rather than dental technology, we should expand the scope and introduce the concept of autopoiesis into the field of dental prosthodontics. This is beyond the scope of dental technologist, so I will limit my discussion here to the field of dental technology. I believe that the concept of autopoiesis can be introduced not only to the social systems of human society, but also to dental technology.

The field of dental prosthodontics is the study of prosthodontics. Prosthodontics, one of the specialties of dentistry, is a branch of clinical dentistry that aims to restore the dysfunction and esthetics of the oral and maxillofacial system caused by the loss of teeth and related tissues. It is also referred to simply as prosthodontics.
From Wikipedia.

When considering the shape of the occlusal surface of a prosthetic crown molar, this means that we must consider both the body of the tooth as a natural object and the occlusal surface space as a social object. In fact, it is the change in the gap/space between the upper and lower teeth that chews and bites through food, not the teeth as entities. No matter how fine the teeth are on only one side of the upper or lower jaw,

they cannot perform their original function. I believe that "changes in the space between the occlusal surfaces of the molars caused by mandibular movement should be designed emergently."

Unless the shape of the occlusal surfaces of the molars and the incisal edges of the premolars, which represent the function of the molars, are treated in a social scientific manner, it would be impossible to interpret the meaning of the shapes. The convexity and concavity of the occlusal surfaces of molars has a specific pattern depending on the site. Some molars have one root, some have two roots, and some have three roots, depending on the site of the molar. The roots of molars also have complex curvatures. I believe that the left-right joint of the mandible is also a complex system with a mixture of three-dimensional sliding and rotation, and is so complicated by various factors that it is difficult to model it into a simple system.

In order for the dentist to describe from the standpoint of the autopoiesis concept why the pattern of convexities and concavities of the occlusal surfaces of the molars that function during masticatory movements are shaped in this way, it is necessary to accurately measure the internal structure and shape. It will also be necessary to analyze the exact movement of the mandible. Furthermore, it would be necessary to accurately measure how the interocclusal space of the upper and lower dentition changes as the mandible moves.

Teeth are not created by humans. The "human jaw system as an entity" already exists. Therefore, the structure and shape of the actual jaw joints, teeth, and bones already exist as solid, rigid objects. This is analyzed in detail. Tooth enamel is a hard substance and is clearly delineated, but it gradually wears away over time.

The need to consider how the gap between the occlusal surfaces of the upper and lower jaw teeth changes is important because, although there was something unknown before occlusal wear, it cannot be treated without knowing what has changed over time. The gap between the occlusal surfaces of the teeth gradually changes over time. The treatment is to restore what has changed, and this emergent content may be a new target for treatment.

I believe that CAD design requires static and dynamic design for the same object. Static design is a blueprint in the usual sense. It includes the dimensions, position, and tilt of

the teeth. The dynamic design is necessary to explain the static design, and it does not mean that two types of blueprints are needed. It is needed to design the "why of static design. Dynamic design is a four-dimensional design. Time is built into the design.

The words contingency and double contingency are confusing words. Can you describe them in other words?

Contingency can be translated as "possibility of another kind," "functional equivalence," or "contingency," or it can be translated in various ways depending on the context. Contingency also has two semantic configurations. One is "dependent on something that is". The other is "is otherwise possible". In other words, contingency as "impossibility" and "negation of necessity. It seems that double contingency can be paraphrased as "double conditional dependence".

What is a social system anyway?

What was the problem that Parsons was trying to solve in his book the "Social System"? It is the famous "Hobbes Problem". The "Hobbes Problem" is the question of how social order is possible when people pursue their interests in a utilitarian manner. According to Parsons, Thomas Hobbes believed that this problem could be solved by a social contract between individuals. However, Parsons considered this to be an overextension of the concept of merit, which in fact has not been solved. In the "Social System", the "Hobbesian problem" is replaced by the problem of double contingency.

The "double contingency" means that the fulfillment of the needs of the self and the other depends on the actions of the other, but that the actions of the other depend on the actions of the self and the other. Thus, the problem of social order is transferred to the problem of the stability conditions of mutual action in a bilateral relationship. In other words, the social system is used to stabilize and maintain the self and the other party. This is a description of the system of human society, but I think it can also be applied to natural things in other words. In the end, it is a matter of human beings themselves. It is a matter of how human beings perceive themselves.

The "structural coupling" of autopoiesis

Let us now apply the "structural coupling" of the autopoiesis theory to the case of reconstructing the shape of the occlusal surfaces of the molars. Each maxillary or mandibular dentition remains within a closed system of its own value system, and if it is beneficial to improve the functionality of its own system, it can be shaped to establish a reciprocal relationship with the dentition of the other jaw.

Interpenetration, on the other hand, refers to the phenomenon that occurs when two different systems, i.e., the maxillary and mandibular dentition, are interrelated, thereby increasing the complexity of the meshing of their respective occlusal surfaces. According to Luhmann, the key to interpenetration is that the two systems are open to each other, allowing the complexity of each system to be transferred to the other. Through this interpenetration, the two systems have the opportunity to transform each other. The occlusal surfaces of the maxillary and mandibular dentition systems are open rather than closed, exchanging the complexity of the opposing system for the complexity of their own system. This is what we might describe as interpenetrating.

Even if humans understand how the natural world works, they cannot do the same things that the natural world does. There may be things that cannot be done without relying on the human imagination. With regard to the generation of tooth shape, it may be genetically determined in the natural world, but if a human reconstructs a part of it, it cannot be created by genetic manipulation.

The goal will be achieved by using reverse engineering thinking to reconstruct the resultant existence that would have taken place in the natural world. This method is called the autopoiesis method of reconstructing tooth shape. While the traditional method involves manual editing of tooth shape based on human imagination, the new method uses artificial intelligence to play the role of communication between the upper and lower dentition and the two systems, and CAD to create the auxiliary shapes.

Necessity and Coincidence

To change what is at work inside the object to the categories of uniqueness and diversity, rather than the categories of necessity and chance, is to trust and bifurcate the spontaneous sensibility of man. By perceiving the object from these two perspectives, it

may be defined as being "optimized". What would change by changing the way we dualize in this way?

Let us first consider necessity and contingency. I will discuss uniqueness and diversity later. The categories of necessity and contingency were also created by man. This is an important view in materialism. Where is the perspective that can be seen in the combination of these two? And what is the difference between the newly proposed categories of uniqueness and diversity? The former sees only the past and not the future, leaving the future to come from the other side. The latter believes that we must look at both the past and the future and actively engage with both.

The theory of evolution was created by analyzing what would have happened in the past based on physical evidence. The cutting edge is the present. There is no further to go. What is evolution trying to explain? It is the present, and the natural world, including us humans, as we exist in the present. It is the process by which we have come to be the way we are today. Evolutionary theory explains that our world as it exists today exists for this reason. The future cannot be analyzed because there is no concrete data. It is unknown. It is natural. If there is one, it is the hope of humans to exist in the future.

Materialism has divided the past into two parts. I said it divided the past into two parts, but actually it did not divide the past into two parts. In fact, the past cannot be divided into two parts, such as inevitability and contingency. This is possible only because the outcome is known. The present is something that has already been determined. It cannot be applied to the future. It is a human evaluation of something that has already been determined. No matter what evaluation we give to the past, the present in the material sense remains unchanged.

Inevitability is the certainty that it will happen, that it cannot be otherwise, and that we know when it will happen. Coincidence is the element or property that makes the unexpected happen. Coincidence changes the present, but we do not know how. It also means that we do not know when it will change. There are causes that cause certain things to happen and causes that cause uncertain things to happen, and the world has been established by the combination of these two.

In this category, the future is 100% coincidental, meaning that it is uncertain. Inevitability can only be found in what has been experienced in the past. The future does not yet exist and should not be spoken of lightly by humans. And the future, as such, is not subject to concrete analysis by humans. The passage of time in one direction explains what makes the present and the reason for the existence of the present, which explains man's passive position in relation to nature. There is no vision for the future.

The categories of necessity and chance revolve around the perception of opposites. Inevitability and contingency are a choice between two opposites. They are relative, such as "what we know" and "what we don't know," or "what is clear" and "what is blurred." This is the human mind, and the conflicting minds within us have come up with this division in an attempt to solve existing problems. This is a way of explaining the present in terms of these opposing relationships.

We cannot find certainty by looking into the future from the present. Certainty can only be found in the past. Everything we can see today was produced in the past. Looking only at the past is called thinking in terms of the categories of necessity and coincidence. The categories of necessity and coincidence are tools for recognizing the past. The past cannot be separated because the relationship is fixed. The cause-and-effect relationship between things is fixed, but we just cannot know everything.

I believe that the categories of necessity and chance that support evolutionary theory can be rephrased as a mixed bag. The division into two categories, necessity and chance, is merely rhetoric. In fact, it represents a state of affairs in which the two are indivisible. The category of inevitability and contingency encourages us to adopt such an attitude toward the future.

Uniqueness and Diversity

What is the only thing that matters to human beings? I believe it is the eternity of the human world. There is nothing else for human beings. Diversity refers to the ratio of choices between two things. By diversity, I mean a ratio of 10,000 to 1, or 100,000 to 1, or more. In any case, it means that the other person has only one choice, but I have an overwhelming number of choices in relation to it. I think we should take pride in the fact that we are special in the natural world.

Science, by the way, is useful, and I believe it is the field in which humans are currently focusing most of their efforts. Science is a tool for man's active involvement in the future, and was created to project the achievements of the past into the future. The future does not yet exist. Is the future something that should be left to nature through "necessity and chance," or is it something that will be created automatically? Or is it something that must be created by human beings? It seems that the materials for creating the future have been prepared from the past to the present. Is there anything in particular that humans should do about the future? I think that what is certain about the future is that it is human. As long as human beings can think about the future, there is a future. Only human beings can think about the future. To think about the future, we need two basic categories: uniqueness and diversity.

One is the eternity of the human world, and the other is the recognition that humans are in many ways diverse and overwhelming in the natural world. These are things that must be fulfilled with human responsibility. Without a sense of responsibility, it is impossible. The categories of uniqueness and diversity have a common perception of match. Without the unity of these two concepts, man cannot exist in the future. It is not harmony or unity.

How should we treat history when we consider it in the category of "uniqueness and diversity" that I have proposed here? I believe that history is a record of reality based on evidence and facts that we can refer to when we think and perceive, and that it is a description of one possibility that seems reasonable among all the possibilities that could be generated. This is a very subjective view. The subject of the choice is the human being, who selects one possibility from all possibilities and describes the best one as a fact, and that is what history is.

Therefore, future history is a description of a direction more advanced in time than the present, and therefore has not yet occurred in reality. It is human beings who create the path from the described future and present. To think in the category of "uniqueness and diversity" is to be convinced that it is man himself who will protect the future of mankind, and that it is man who sustains this world.

If we consider history in the categories of inevitability and coincidence, how should we treat it? Even if we use objective expressions, the subject is definitely a human being. This is the traditional view of history. I think evolutionary theory is included in this.

Uniqueness and diversity" and "necessity and chance" are different categories. Naturally, the two are expressed differently. Past history is what has been chosen and how it has been chosen and described by objective human judgment.

What I am trying to say here is that if we think in the category of uniqueness and diversity, we are free to create our future. Also, when it comes to the past, we cannot physically manipulate the past, but we can change our evaluation of the past. By changing the category from "inevitability and chance" to "uniqueness and diversity," we can find more things in the past that are important for the future of human beings, and we can divert them to the future.

We do not know whether monkeys gradually evolved into humans or whether smooth-skinned humans appeared out of nowhere, but humans appeared in this world before we knew it. A baby grows up and becomes a child, and before long, it has a mind that understands about the world. Just as it is difficult for human beings to recall their early childhood in their own memories, it is difficult for human beings to know the beginning of human history. Since there are no records, the only way to know this is through our imagination. Moreover, as long as we look to the future in the categories of inevitability and coincidence, we will only reproduce the past and will not move forward in the slightest.

The Importance of Social Science

When we look at the structure of the human jaw joints, the overall shape of the upper and lower teeth, and the pattern of the occlusal surfaces of the molars, we see a situation in which they function. Their function and form are consistent, and no contradiction or conflict can be found. When we look at biting and articulating food, we see a situation in which the parts of the oral cavity are matched to their purpose and each performs a specific function. We can find in this situation a system of perception and knowledge as a social scientific community that cannot be reached only from the natural sciences.

This is why we also look to the social sciences. It is because it is what humans observe and think about. Humans cannot escape the ties of being human. Even if something is not created by humans, if the observer is human, it becomes a fact through the filter of humans. No matter how you do it, you cannot remove the human filter. Even if it could

be removed, it would be something that humans could not understand. It would be a meaningless enumeration. Human beings can only be perceived as meanings and values that we can understand.

Although humans are part of the natural world and independent beings, until now humans have found and used everything from nature. The only thing humans can really create is logic (theory). As for things, we use 100% of what is found in nature. However, even this may be called a discovery rather than a creation. Ways of expressing reason (theory) include philosophy and mathematics. These are human inventions. However, we cannot add human-invented rules to the natural world. All we can do is engage the rules of nature. All that man can do is to use the forces and mechanisms of nature.

In the natural world, the only thing that humans alone have had is the "human filter." The "human filter" is the data you refer to in your head. We have seen, heard, and thought through this filter. Because we have this filter, we have been able to flourish as we do today. It is the recognition of the eternity of the human world and the fact that humans are in many ways the dominant force in the natural world, and we have thought about the future. This is why we need the social sciences as well as the natural sciences.

Can you use the terms "double contingency" and "contingency" to describe the oral system and tooth production?

Let me describe the human "jaw system as an entity" in terms of the autopoiesis concept. When the actuation switch, "mandibular movement," is turned on, a structure and system emerge. When the actuation stops, the system disappears and the “component” becomes a free-way space (interocclusal distance).

What is a free-way space (interocclusal distance)? In the rest position of the mandible, there is no occlusal contact between the upper and lower teeth. There is a vertical gap of about 2 to 3 mm between the upper and lower jaw teeth at the central incisor. This void is called the free-way space (interocclusal distance), which is a relaxed state in which the oral cavity is not performing any special function.

The mandible operates to create a structure called the "jaw system," which is distinguished from the structure and the environment. The environment then includes the dentition of the upper and lower jaws, periodontal tissues, tongue, lips, and jaw joints. The "component" is the change in space between the occlusal surfaces. The network of the production process consists of four elements: "action," "component," "structure," and "environment. The network of producing processes produces the "component." When the mandible ceases to operate, the "component" becomes a resting position void. In other words, when the mandible is activated, the "component" determines the structure.

The question is how contingency and double contingency explain the generation of teeth, but the two create a system. Double contingency is such that it "renounces and changes the status quo, is the only one that is selective, and is also symmetrical, community oriented, and maintained forever by circulation." Contingency would be such that it "has mercy, continues the status quo, is overwhelmingly selective, and is also relative, collective, and causally oriented, and therefore will eventually disappear."

Contingency is the element that moves the system forward and keeps it going. And double contingency is the element that changes the system. This is an expression of tooth generation from two standpoints, one from the social sciences and the other from the natural sciences. It is the very mechanism that generates and maintains itself. Luhmann used the double contingency as the basis for the establishment of his social systems theory. In other words, in Luhmann's system theory, the double contingency is an important component of the system.

It means that contingency and double contingency are the components of the system. These two elements formed an order and formed the current occlusal system including the jaw, joints, and teeth. The "jaw system" as an entity was then created. It also means that the social system, to which man is an emergent entity, is accessible only when he stands at a point where he can divide it into the elements of contingency and double contingency. No other point is sufficiently accessible.

By setting up the pair of contingency and double contingency, we can clarify each other's meaning, value, and other aspects of existence. The reason why this is possible is that they are both hypothetical and complementary terms created for human beings.

Thus, the concept of autopoiesis is expressed from a standpoint that combines the opposing views of the social sciences and the natural sciences. Social science is a hypothesis about the world from the standpoint of human beings, which can be rewritten through new discoveries. Natural science is also a hypothesis about the world from the standpoint of nature, and may be rewritten in the future due to new discoveries.

The situation in which humans are compelled to be centrally involved in the world will continue as long as humans exist. The social and natural sciences are one way of describing the world, and each exists on its own, in a way that the two separate hypotheses support each other.

This is the idea that when human beings are involved in the world, it is necessary to separate them with the "scalpel of responsibility". The idea is that by dividing the world into two, we can view the social and natural sciences from that cross-section. The world is never two, but one.

At the present time, I believe that the idea of dividing the world into social and natural sciences is an idea in which humans have great faith, among other hypotheses. Natural science is the half of the world that we have carved out in terms of human responsibility, and that natural science cannot exist independently in the world without human existence and responsibility.

Life forms have a destiny of continuity and change with respect to their existence, and I believe the same is true for the universal common consciousness of human beings. I believe that this subconscious awareness that every human being has to deal with a destiny that is predetermined even before birth has led to the formation of the system of human society. That is social science.

Luhmann considered the world to be a complex system that is structured by meaning. Luhmann's system theory based on autopoiesis is characterized by the fact that the world and human society are always viewed as a complex system, that the fundamental unit that forms the world and human society is "meaning," and that everything that processes or edits the "meaning" that humans perceive is derived from the system. This is to say that all the processing and editing of "meaning" as perceived by human beings is derived from the system.

The concept of autopoiesis is a scalpel that separates the black box of the natural world into the natural sciences and the social sciences, requiring reference to both positions. They do not have a side-by-side relationship, but rather a specified relationship, such as (A/non-A) or (system/environment) to each other.

How do you think the teeth came to be in their present form?

Let me refer to the concept of autopoiesis in terms of tooth generation. The concept of autopoiesis includes elements that are not completely manageable by humans. However, it is expressed in a positive sense in the theory. The expression is positive, but I suppose it means that it is something that cannot be determined in one way or another. It may mean that there are things that exist in the real world that we cannot know how and why they came to exist in the way they do today. This was attempted with the special intention of expressing this from a human standpoint. Since teeth are not created by humans, it is probably a natural consequence for the teeth themselves, including the element of evolution, that they have come to exist in their present form.

The reason for this is that, with very great probability, teeth, regardless of race or ethnicity, have a similar shape in the same area, even if there are some individual and racial/ethnic differences. We know the conclusion, but we do not know the process by which it was made. Thus, I think this concept is necessary to understand the nature of tooth shape.

I believe that Japan needs a dynamical systems theory with the concept of autopoiesis as an element. If you advocate "Japan is a manufacturing power," I would like you to deal with this issue.

The autopoiesis concept, in part, allows us to hypothesize about the process of tooth and dentition formation. The hypothesis would allow for human involvement in the generation of teeth. If it is found to be useful, it would mean that the hypothesis has some validity. This "process of formation" does not mean that we can explain the process of tooth development and gradual formation in the fetus. It is very difficult to say how the teeth formed into their current shape.

From an archaeological perspective, apes, which are thought to be the ancestral relatives of the hominids, have jaws and teeth similar in structure to those of present-day humans. The basic structure of the "jaw system as an entity" existed long before humans acquired language as we know it today.

Apes today are also highly intelligent and lead social lives. Although their language is less sophisticated than human language, they communicate and share emotions and intentions through vocalizations and pronunciations. It is thought that the ancestors of humans were similarly intelligent. Since apes are vertebrates and have vocal cords, it is likely that our ancestors also had the functions of mastication, vocalization, and pronunciation at the same time.

This is the independence of multiple systems in the autopoiesis concept. The "mastication system" and the "speech and pronunciation system" are duplicated in the same "jaw system as an entity.

Today, I believe we have not only this "masticatory system" and "speech and pronunciation system" but also an "aesthetic system". Using the system theory based on the autopoiesis concept, we can hypothetically express "how the tooth shape was formed into its present shape" in terms of the system, albeit roughly and partially.

What factors could have caused the tooth to be produced?

When the autopoiesis concept is used to explain tooth generation, there are two terms as communication codes responsible for functional differentiation, and they are extremely important. One is called contingency and the other is called double contingency. Contingency is a very important word, yet its meaning is very difficult to understand.

Once again, this image of "dependence" is often translated as "possibility of another kind" or "functional equivalence," or explained as "contingency," "contingency," or "inherent contingency," but this is not clear. There are two semantic constructions of "contingency" in the Anglo-Saxon tradition.

One is "contingency," which in everyday terms means "depending on something." The other is "contingency" in the sense that other things are possible, thus as a negation of impossibility and necessity. This is one of the key terms for systems theory expressed in the concept of autopoiesis.

Therefore, everything that is uncertain or indeterminate for human beings is also implied as contingent. Furthermore, the possibilities that may arise are also considered contingent. Contingency involves the "inherent contingency" that exists in everyday life, and it also involves the "nature of occurrence" of things.

First, let us use the term contingency to describe the fact that the shape of the teeth was determined as it is now. The contingent is the sequence of events that accompanies the fact that the universal shape of the teeth has been determined as it is now, by a contingent event.

This is a representation that is created because it expresses an event in which humans are not involved, such as the generation of teeth, from a human standpoint. A sudden incident or accident is expressed as "I didn't expect this to happen to a contingent.

To be contingent means, first of all, to be aware of coincidences and contingencies. It means being aware of their existence. It means that the occurrence of change in the state of continuity and its response are required, and that one's own projection is directed toward the direction of progress.

From the standpoint of the tooth, the tooth perceives the contingencies and coincidences that have occurred to it, its origin, and where it is going. It edits anew all the events, information, perceptions, and contemplations that come in and out of that contingent occasion. This is what it means to be contingent.

Let me try to describe it simply. The forerunner of teeth, which at some point realizes that it is forced to exist in the world, becomes aware of these things through anxiety, looks at its current situation, and from there, reassesses its own shape and structure anew. From there, I think it can be expressed as starting to form a new shape and structure.

We believe that the present tooth shape was generated by this repetition. Of course, teeth are not supposed to have a mind or consciousness, but since there is no appropriate way to describe them, we have put ourselves in the shoes of the teeth. The approach is still one that appeals only to physical and chemical laws of nature, without the help of supernatural forces or principles.

Another term used in Luhmann's systems theory is double contingency. Combining this term with contingency makes it self-referential and can further explain the generation of teeth.

By defining the state of reality as the result of what has been done by chance, it means that the operation of the autopoiesis system is entirely by chance. In other words, it is open to chance. The term "double contingency" was originally coined by Parsons and used in Parsons' social systems theory, but Luhmann changed Parsons' double conditional dependence to his own interpretation.

Luhmann is similar to Parsons in the cycle in which what one does is a precondition for what the other does, and vice versa. Unlike Parsons' "based on shared values," however, Luhmann sought the basis for the establishment of a social system on the basis of dual conditional dependence.

It is a model in which two parties face each other, both with their own requirements and viability. One depends on the other's way of doing things, and the other depends on this one's way of doing things. In other words, the instability of the "if you do what I want, I will do what you want" cycle, a situation that is not determined by any of the systems involved, creates a self-referential and autonomous functional differentiation.

Luhmann held that such emergent occurrences point the way to the formation of social systems. I think what Luhmann has in mind here is the emergent property of a system, which is a structural property of the system. I believe the same is true for tooth generation.

What is the virtual kinematic axis method?

In order to experiment, I have built a special articulator in which the motion of the left and right mandibular head can be represented by a curve. For this purpose, I have to

obtain data on mandibular motion according to that method. One method is to use a pantograph to obtain curve data, but here I used two check bites on each side during lateral movement. This articulator was not made for use in clinical cases. Therefore, it cannot be used in clinical cases.

One method for determining the amount and direction of mandibular motion is to use a check bite. Normally, one check bite is taken for each lateral movement. In the case presented here, however, two check bites are taken on one lateral movement.

In the case of the method using a single check bite, the movement of the mandibular head on the working side is ignored. This method has been used for semi-adjustable articulators. However, the two check bite methods introduced here handle the working side differently. The Bennett movement of the working side will also be reproduced with a curve.

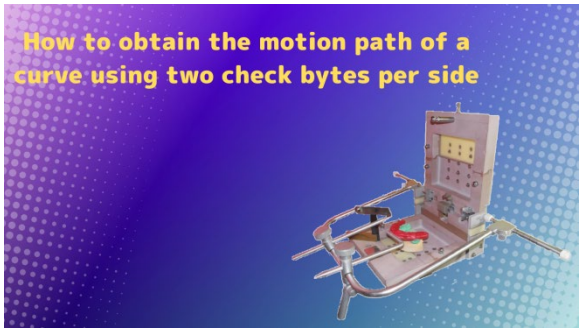
Semi-adjustable articulators have no adjustment mechanism for the working side of the condylar path, and its path of motion is predetermined by the intention of the articulator designer. The adjustment mechanism of only the non-working side cannot accurately reproduce mandibular motion. The Bennett movement, which is the movement of the working side, has been ignored as a slight blur, and the adjustment mechanism of the condyle path of the non-working side only has been used.

The method of using two check bites, presented here, allows the correct reproduction of mandibular motion in the articulator, with the same response to the movement of the mandibular head on the working side as on the non-working side. With one on one side, the path of motion is a straight line, but by using two on one side, the path can be curved. Also, while anterior and lateral movements of the mandible are usually required to create a dental prosthesis, posterior movements could be incorporated into the creation of the condylar path if you so desire.

Two check bites are used per unilateral lateral movement; the first check bite is occluded between the maxillary and mandibular dental models. The mandibular momentum is measured by measuring the movement of the left and right condylar balls of the experimental articulator and the tip of the incisal pin. The amount of movement of the condylar ball is measured by measuring the gap between the condylar ball and the inner, posterior, and upper walls with a gap gauge. The amount of movement of the

tip of the incisal pin is measured by measuring the amount of movement of the incisal table and the tip of the incisal pin. after the measurement of the first check bite is completed, a second check bite is occluded and measured in the same way.

The data just measured is applied to an experimental articulator reconstructed in CAD to reproduce mandibular motion. In this case, we used four check bites for lateral movement on the left and right sides and one check bite for anterior movement. A total of five check bites were used.

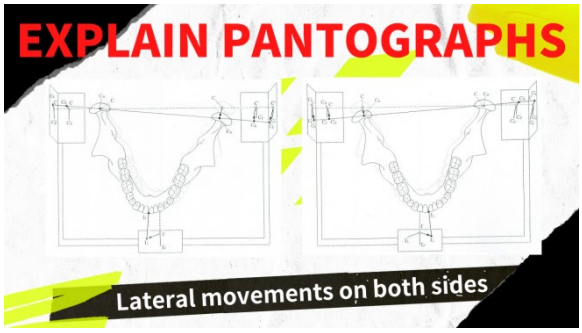


Traditional mechanical and electronic pantographs have been used to measure mandibular movement. This method is too loaded for a dental technologist to mention, and if one wishes an explanation of how to use such an instrument, the dentist should be in charge of the explanation.

The transfer of data from the body to the articulator requires very careful handling when using such a measuring device. The positional relationship from the body to the articulator must be strictly transferred and reproduced on the articulator so that the relationship between the body and the reference plane is the same as the relationship between the articulator and the reference plane. It may also be necessary to reproduce the distance between the left and right mandibular condyles of the body on the articulator.

Actually measuring the distance between the left and right mandibular condyles of the body is a difficult task. Careful attention must be paid when transferring the maxillary model to the articulator. This is because any error in this process will render the physically precise measurement of the angle of the condyle paths meaningless. The angle between the reference plane and the condylar path as measured by the pantograph is input into the adjustment mechanism of the articulator, but it is essential

that the reference plane set on the body be accurately reproduced on the articulator. Thus, when measurements are made by the conventional pantograph method, strict instrument handling is required.

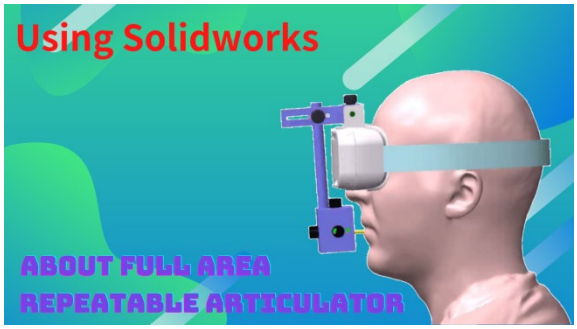


Here is one of the features of the virtual motion axis method. When reproducing mandibular motion with an articulator, even if the distance between the left and right mandibular condyles on the body and the distance between the condyles on the articulator are different, the difference in distance does not cause accuracy problems in the reproduction of motion.

The usual check bite method uses the change in position of the mandibular dentition relative to the maxillary dentition to obtain the motion path of the condyle ball of the articulator. Since there is only one check bite, the motion path is a straight line. In the mechanical or electronic pantograph method, the change in the position of the condyle head is measured with the reference plane as "0" and calculated as the condylar guidance inclination. The measurement principle is different from the check bite method.

The method using two check bites takes advantage of the change in position of the mandibular dentition relative to the maxillary dentition to obtain the motion path of the lower condylar ball of the articulator. Since two check bites are used, the path of motion is curved.

Adding another check byte adds a midpoint to the motion path of the condyle ball. The motion path of a condyle ball is represented by a curve. Usually, the curves are circular arcs, which are easy to handle in CAD. I wanted to realize this example, so I built a special articulator to obtain the curved path of motion of the condylar ball needed for the experiment. And I made a video of it.



what kind of articulator is born from the category of uniqueness and diversity, a new way of thinking, and which employs the virtual kinematic axis method?

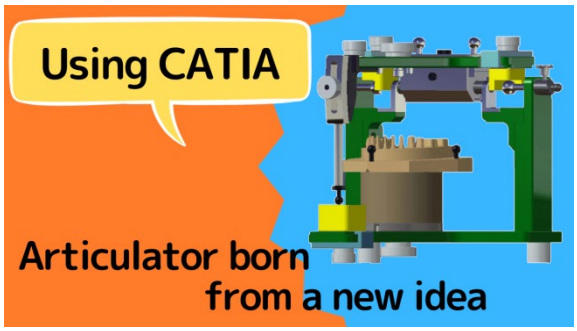
The articulator employing the virtual kinematic axis method that I am about to introduce is slightly different from conventional articulators. The difference is the structure of the adjustment mechanism that allows the lower part of the articulator, to which the mandibular model is attached, to move forward or sideways.

In conventional articulators, a mechanical adjustment mechanism similar to a condyle path is created and set on either side of the upper part of the articulator. It is the mechanism that allows the lower part of the articulator to rotate and slide.

The improvement is that the motion path can be freely machined from a resin block, or a 3D printer can be used to form the motion path. In other words, it is free from the mechanical adjustment mechanism that the articulator's designers had in mind. The guide surfaces can be created any way the operator thinks fit. The most important thing is that the path of motion of the condylar path can be expressed as a curve. It is also possible to reproduce the Bennett movement on the working side.

The operator can add elements to the path of motion that would otherwise be omitted due to chance in the operation of the measurement. The ease of customization by the user is an advantage of the method of machining from a resin block or using a 3D printer. If the motion pathway is simple, the left and right condyle and incisor pathways can be formed as in the conventional method.

The category of uniqueness and diversity means that the user can arbitrarily choose a motion path from among the many mandibular motion paths acquired. As with the body's mandibular motion, it is not possible to reproduce a number of motion paths in an entity's articulator. The motion paths to be given to the articulator should be those that are necessary to produce a dental prosthesis. The CAD system can reproduce all of the motion paths that have been obtained, and it can also reproduce the movement of the mandible during opening and closing, which has not been done in the past.



In view of the fact that dentists are inconvenienced, dental technologists have created a theory of occlusion!

I am a dental technologist and I see and hear messages about dental technology from dentists fragmented from published cases in professional journals and at lectures. It is now common practice for dental technologists to reconstruct these messages to fit the individual cases of dental laboratory work that is their practice. However, there is no guarantee that this method will produce a prosthetic that is satisfactory for both the patient and the dentist!

The reason for this is that the dental technologist has no contact with the patient and may not be able to fully fulfill his/her responsibilities if entrusted with the task without sufficient information. I would greatly appreciate it if the dentist would integrate the problems that exist in each individual case, optimize them for that case, and present them to the dental technologist as a concrete image. Optimization also means that it is important to be able to fully explain to the patient how the prosthesis will be made, and it is not enough to just say that the prosthesis has been "optimized". It is not sufficient to think that what is not bad is good, or that if it is not bad, it is good. This is a recommendation for dentists who want to put their own ideas into dental prosthetics.

Recognizing changes in the space between the occlusal surfaces of the upper and lower molars

It is difficult to come up with a plausible answer to the question of why teeth were created in the mouth, and we cannot go beyond the realm of hypothesis. Or is it safe to assert that teeth were indeed created for biting, and that they are based on such an assumption? The issue here is not whether or not biology as a philosophy, such as evolution, is correct. When human beings become aware of themselves, when they recognize that there are things that exist without being directly visible, and when they try to manage and maintain these things, it is necessary to consider things that are not directly visible.

When we consider purpose and means, the purpose is what we cannot see, and what we can see is the means. In order to do this, tools that have not been used in the past, such as computer aided engineering (CAE), are necessary, and without such tools, it would not be possible to carry out the project. The shape and structure of teeth are created by the laws of nature. How can human beings use these laws and how can they be involved? There are not many systems theories that go beyond the conceptual level of the laws of nature, and can refer to specific mechanisms. I suggest that we adopt a systems theory called autopoiesis.

Autopoiesis recommends considering from which perspective (1) overlapping functions, (2) supporting outcome media, (3) types of codes, and (4) classification of programs. There are binary codes that humans should check in advance because they are performed by humans, and here we will focus on doing dental work and making dental prosthetics.

For prosthetics that have been designed and optimized by the dentist down to the last detail

Even today, I believe that basically anything approved by a dentist and set in the mouth can be considered an optimized dental prosthesis. In other words, the definition of "optimization" is a concept and method that is in line with the concept of autopoiesis. So what are some specific examples of optimization?

As for the complex cases of the natural world, I believe that we need a method that is appropriate to the subject we are dealing with. Science can expand the range of what we can refer to the natural world by increasing the options of possibilities that humans can think and think about. Complexity reduction means that humans will be able to handle complexity. It means changing the levels and channels of human thought at will. To handle complexity, we must acquire a way to understand and operate it. Anyway, the natural world is very complex, and the more we know about it, the more complex it is waiting for us. We can say that optimization is to make sure that humans have sufficient management control over their objectives.

I say "full area reproducibility articulator system" and "cad assisted by artificial intelligence" because it seems to me to be an application of a symmetrical concept and an example of its practical application.

I am a dental technologist. I believe that the dental technologist was requested to speak on the creation of dental prosthetics, which is not the dentist's point of view.

If ideas based on conventional ideas from dentistry, "solely for the purpose of advancing dental care," were required, I believe that it could have been done by dentists in the name of their central position in dental care and their responsibility regarding dental care. Japanese universities should have a system for such research, so it could have been done at a suitable research institution without having to be done by an individual like myself.

I have continued to prioritize this project above all else because it seemed to me that the request to put "full area reproducibility articulator system" and "cad assisted by artificial intelligence" out into the world by all means was a request from "Almighty God." Had I not felt that way, I would not have become a Christian, nor would I have created such a thing. Continuing to do so would only cost me money and gain me nothing. Also, if a dental technologist proposes a "definition concerning the centric relation", he will be called a "very naive or innocent person" and no one will take him up on it. (Reference URL:https://krdental.com/project/centric-relation/)

Nevertheless, I continued to do so because I had the feeling that there was a strong request working from "God Almighty" for me to express dental technology in a new way and to modify the conventional method.

That is, "The only way that the Japanese can build the future that they themselves desire is to make something practical out of a symmetrical concept in the real world, and show us the process of doing so." This is what I mean. I think it is to propose a "definition concerning the centric relation" from a new point of view that has not existed before, and to show the technological results concerning it.

I believe that by not being involved in treatment or diagnosis, dental technologists can speak to a perspective on tooth shape, etc. that has never been seen before.

Is it true that the uneven occlusal surfaces of the molars were created for biting things?

Is it a new discovery to find a reason for the formation of teeth around the mouth, or is it one of the hypotheses that can be drawn from a number of facts? Is it a natural selection of individuals that accidentally formed tooth-like hard objects around the mouth but remained as they are because they are very good for getting food into the body? I have never seen a dental treatise that makes such a sweeping statement as "the uneven occlusal surfaces of the molars were created for biting". Perhaps this is because their origin is not considered particularly problematic for dentistry. I think it means that at the moment it is treated as a hypothesis.

By the way, Newton recognized that the phenomenon of an apple falling when you let go of your hand was special, and he named it gravitation and discovered its law. It is not necessary to mention it now, but the phenomenon of falling actually means that objects are attracted to each other. Newton, an English physicist, discovered that all objects with mass have an “attractive force”.

This phenomenon is named "universal gravitation." The universal gravitation between two objects is proportional to the product of the masses of the two objects and inversely proportional to the square of the distance between them. The tides in the ocean are also caused by the "universal gravitation" between the earth and the moon. If we simply take it for granted that an object will fall out of our hands, it will not be a subject of special interest and will be treated as a phenomenon that we dare not mention.

The reason why Newton was able to recognize it was because he recognized it as uniqueness in "falling. Newton experimentally formulated and proved that universal

gravitation is a force that occurs in all things with mass as a mathematical formula. It has been pointed out that he made a great achievement in systematizing universal gravitation through experiment and theory.

The discovery of gravitational attraction and the discovery that "the bumps on the occlusal surface are there to make it easier to bite" are essentially the same thing. These are both created by nature. They were not created by humans. However, chewing with teeth is something that not only humans but also other animals do on a daily basis, so there is nothing to say now about the reason for the existence of teeth. In using them for dental technology in dentistry, I will try to express them again.

The idea that there is some objective reason in nature and that a mechanism based on that reason created teeth around the mouth is an idea that arises from the categories of necessity and chance. It is very difficult to discover the reason. It would be an extremely difficult task to try to think about or explain the generation of teeth in this way. We have to start not with the occlusion of monkeys, but with an earlier generation.

By using the categories of uniqueness and diversity here and combining natural and social sciences, we can begin our research with the human generation. Since the purpose of the research is human occlusion, it serves the purpose. It is my opinion that if we gradually work our way bottom up by building up from a natural science standpoint, we will never get to the bottom of why the unevenness of the occlusal surface of the molars was created. It seems to me that since it was created naturally, natural science should be able to solve everything, but apparently that is not the case.

I believe that humans need a pair of natural and social sciences to understand the world. Living organisms are not created by humans. I believe that we need access to both sides to understand and unravel the whole mechanism of such things.

I think the answer to the question of why this is so is that the traditional bottom-up method of accumulation did not work, so we invented other methods, which led us to the idea of autopoiesis. I think it is extremely difficult to explain organisms in an orderly manner from their development, in other words, to explain how the mechanisms of organisms came to be the way they are from the beginning, as in the case of evolutionary theory.

There are many aspects of how organisms work that are not explained by Darwin's theory of evolution. In particular, it is said that there is no mention of the development of organisms. I think that the way to access the mechanisms of the human oral cavity is to access the presently recognizable oral cavity from both the natural and social sciences to get at the objective. I do not think it is necessary to "go back in time" on an archaeological level.

I believe that the natural and social sciences are paired, but never in opposition to each other. Therefore, I believe that incorporating the two sciences into the same subject does not create a contradiction; when dynamical systems theory is applied to one subject and the question of priority is asked, the natural science takes precedence over the social science. The dynamical systems theory presented here is also called emergent dualism, and it gives priority to the contingency side over the double contingency.

By the way, crowns, inlays and ceramic frames are designed using general purpose CAD (Solidworks). Creating and editing tooth geometry in this general-purpose CAD is a very time-consuming and labor-intensive process by hand, even if the number of teeth is small. If you use a dental-specific CAD system, it may be easy to operate because it has dedicated commands. However, it is quite difficult to operate a dental CAD system with a general-purpose CAD system. When editing the outline of a crown, the basic shape is first read in, and then the outline is deformed by moving the edit points according to the case. Particularly difficult is the editing of inlays. It is very difficult to create a surface just for the missing part of the occlusal surface of a molar. General-purpose CAD does not have such dedicated commands. It is not impossible, but it is difficult. Examples of these creations are shown in the video later in the text.

If these tasks were performed directly by humans, they would be time-consuming, labor-intensive, and impractical. To perform these tasks efficiently, we would definitely like to take advantage of the capabilities of artificial intelligence. Doing them manually is nothing short of a painful process.

Deep learning 3D polygon mesh representation learning determines the most important high-level features that describe how a group of meshes are displayed so that any point in that feature space is a qualified spatial representation.

New representations created by manipulating the values of features in the feature space have a higher probability of looking like real teeth when transformed back into the original polygon mesh region than if a human attempted to manually manipulate individual meshes directly. These can be represented by mathematical formulas or programmatically.

On Descartes' Theory of Biomechanics

(Descartes' philosophy and the problem of theory of biomechanics, Eitaro Honda, bulletin of the faculty of foreign studies, Aichi Prefectural University, No. 38, Language and Literature, "This text is excerpted and additionally edited from the PDF version")

Descartes' role in the history of the quest for scientific knowledge is undeniable. His mechanical world theory can be applied to various fields and, according to the traditional division of worldviews, is deeply relevant not only to the macrocosm, which is the universe, but also to the microcosm, which is the living organism. We should not look for the significance of the scientific revolution of the 17th century only in its physical achievements, but also in the fact that in Harvey and Descartes the human being became the subject of serious medical and physiological research. Descartes' unfinished book on physiology, "Description of the Human Body," which he was working on in his later years, describes the following.

William Harvey (1578-1657) was an anatomist and physician in England and the English Republic. While honing his skills as a physician and rising to the rank of court physician, he also studied anatomy and advocated the theory of blood circulation.

One of the important achievements of Hippocrates medicine was to separate it from primitive superstition and witchcraft and to develop it into an empirical science that emphasizes clinical practice and observation. Descartes' philosophy of the living body is not the kind of medicine that preserves the health of the human body, cures disease, and expels it, as in Hippocratic medicine. The distinctive feature of Descartes' philosophy of the living body, which is medicine, is that it remains in the realm of physiology, the full description of healthy human nature, which is the first division of its basic sciences.
It was Descartes who most clearly presented human and animal mechanism on the basis of a mechanistic view of nature, and given the magnitude of his influence, we are compelled to consider this issue in Descartes' terms. The characteristic feature of

Descartes' idea of biomechanics is that the natural and the mechanical are homogeneous, since they can be interpreted by mathematics when illuminated from the viewpoint of natural science.

The central issue of natural science in the modern era may be considered to be the problem of motion of objects. In this case, two worlds are traditionally considered. One is the macroscopic world. It is the world of infinitely addable, decomposable, and thus open to infinity and infinitesimals. The other is the micro world of living organisms. It is a spatially limited and closed world whose underlying principle motion can be understood.

The former is the motion of celestial bodies, rooted in the principle of inertia that led to Galileo Galilei, Descartes, and Newton. The latter is the "perpetual circulatory motion" of the blood represented by Harvey's physiology. Thus, if we take the two motions as images, we can think of the motion of each world as represented by a straight line and a circle, respectively. The inertial motion of an object in a celestial body is a straight line. And the circulatory motion of blood in a living body is a circular motion. In this case, which seeks the principle model of mandibular motion in the field of dentistry from Descartes' biomechanics, the circulatory motion of blood in a living body is irrelevant, so I will not mention it here.

Descartes states that the motion of living bodies and the motion of machines are the same, so they do not require special principles, but are under the laws of the mechanics of objects, which are rooted in the law of inertia. The motion of living bodies and the motion of machines are continuous. We are entering the realm of mechanics, a point about as far removed from physiology or biology as we can be from the organism. Descartes, however, does not believe that this way of understanding the living organism lacks scientific verification and rigor.

Descartes' theory of living organisms is characterized by many references to machines. Descartes made many references to machines while relying on anatomy. Descartes relied on anatomy, but made many references to machines because he wanted to place the motion of living organisms in a mathematical dimension. This is because natural science is strictly the study of mathematics, and mathematics is the foundation on which mechanics is based.

The investigation of the motion of living organisms should not be thought of as an object of knowledge inquiry based on some unknown principle unrelated to the rigor of mathematics, since its object is a living object, i.e., life as an object that moves automatically. Descartes believed that anatomy and mechanics would reveal the direction of knowledge in the study of living organisms. The sure inference of the essential identity of the machine and the organism is disassembly in the case of the machine and anatomy in the case of the organism. Descartes attempted to elucidate the motion of living organisms from a mechanistic point of view, supported by an experimental spirit. Descartes' thought should not be easily judged as an argument that begins with dogmatic definitions and principles based on hypotheses.

Descartes' work may not be sufficient as a scientific truth, but it still holds great potency in the direction of the study of the physiology of the living body. As long as man is considered as an object of natural science, the functions of the body can be explained essentially on the basis of the laws of mechanics.

Descartes describes the difference between living organisms and machines as follows. “Man is capable of building many different kinds of automatic machines, moving machines that resemble animals. But the machines that imitate animals use very few parts compared to the multitude of bones, muscles, nerves, arteries, veins, and all the other parts of the living body. Since the human body is made by the hand of God, it may be regarded as a machine that has order and motion in it that is incomparably more orderly and marvelous than any machine that could be invented by man. We can think of the difference between a machine made by the hand of God and a machine made by the hand of man not as an intrinsic difference, but as a quantitative difference in degree of complexity.”

What Gnathology Left Behind

From this heading, gnathology is already being described as a forsaken concept, but as a dental technologist, I don't think I am qualified to make a statement. What I am trying to say here is that gnathology was a discipline that aimed to study and treat the maxillofacial system as a functional unit, and it set the direction regarding subsequent dental treatment. As a matter of fact, in a report titled "Reconsidering the centric relation (Theory)" in the special issue of the July 2022 issue of Shikai Tenbo, it is reported that "Today, few clinicians record the terminal hinge axis.”

Here I have tried to introduce the concept of autopoiesis into dental technology, although it is of course impossible to think about it without knowledge of dental technology. This is not something that I started by coming up with in my clinical experience in dental technology. Hence, I thought that dental technologists, not dentists, could make some reference to gnathology. The concept of autopoiesis is not specifically related to dentistry. Descartes' theory of biomechanics is not specifically related to dentistry, but American dentists introduced it and created gnathology. I think that the introduction of the concept of autopoiesis into dental technology is similar to the introduction of Descartes' biomechanics.

Gnathology is a discipline proposed by American dentists Harvey Stallard (1888-1974) and Beverly B. McCollum (1883-1968) that aims to restore oral and maxillofacial function, primarily through occlusal reconstruction of the dentulous jaw.

Let us consider the definition of an ideal bite. Ideal occlusion is the bite state assumed to be most appropriate for humans. Descartes does not mention the state of the human jaw or bite, but he states that the human body was created by the hand of God. If Descartes did mention the state of occlusion, he would have assumed that it was physically created in an ideal state. I tried to imagine how Descartes would have described it.

The human body is ideal, perfect and impeccable because it was created by God. Therefore, the human bite is also ideal. God created the human “design”. However, the actual human bite, made of matter, was not directly created by God.

What does God's design look like? The upper and lower rows of teeth are ideally aligned. Furthermore, the occlusion of the upper and lower dentition is also ideal. When the mandible begins to open, the mandibular head initially moves in a pure rotational motion without any blurring. The ideal occlusion is one in which the mandibular head gradually moves forward and downward as the degree of opening of the mandible increases. However, we will not go into the specifics of how the individual teeth are aligned and how the upper and lower meshing is constructed.
(URL: https://krdental.com/project/centric-relation/)

What is the difference between "the real biological jawbone and dentition" and "the ideal jawbone and dentition designed by God?" Let us borrow a concept from Descartes' biomechanical theory to express the definition of centric relation.

When the mandible opens in the ideal state created by God, the mandibular head of the mandible undergoes a pure rotational motion with no blurring at all in the initial state of the opening motion. However, it is inconceivable that the mandibular head of the real jaw would rotate in a pure, unshakeable manner. I do not think that a pure hinged axis exists in a living organism. There are six degrees of freedom in a kinematic rigid body. Therefore, the mandible also has 6 degrees of freedom. Although a kinematically pure hinge axis exists in the mandible, I do not think that muscles can actually make the mandible do only geometrically pure hinge axis motion.

The centric relation can be described as the positional relationship between the condyle head of the mandible and the mandibular fossa of the maxilla when the upper and lower dentition are in the central occlusal position, which is the ideal state created by God. What is the difference between the ideal state created by God and the actual positional relationship between the condyle of the mandible and the mandibular fossa of the maxilla in the actual living organism?

I think the difference is whether the tissues around the joint head of the mandible, including the muscles and other driving systems that move the mandible, are optimized by the organism itself, or whether the tissues around the joint head of the mandible are built by God.

However, since the ideal state is God's design, humans cannot know what exactly it is like. The only example that can be used as a reference is the state of the tissues of similar parts of a healthy human being. This is the closest we can get to God's design. The ideal state is specifically unknown. Since God's design is an ideal, even an optimized version of reality may be slightly different from the original ideal state. The question is whether God's design and optimization in reality are congruent.

How have humans optimized their dentition, jaw bones, tissues around the mandible head, etc. during periods of physical growth and completion, etc.? In my opinion, perhaps the organism has a kind of divine blueprint and grows to match it. However, this may change depending on the individual's living environment and lifestyle. The

meshing of the human dentition and the positional relationship between the condyle head of the mandible and the maxilla within the mandibular fossa/articular fossa would be expected to have gradually established a relationship as the body grew. Therefore, even if the centric relation must be determined in a short period of time for treatment, it will have to be done by trial and error.

When treatment requires occlusal reconstruction, a new centric relation must be determined. Conventional thinking, in order to understand Descartes' biomechanical theory in terms of the categories of "necessity and chance," has led dentists to dogmatically determine the position of the mandibular head as a matter of necessity.

I believe that "optimization" arising from autopoiesis, which I introduced, embodies the original Cartesian idea of biomechanics, rather than a dentist's dogmatic determination of the centric relation.

The centric relation is the kinematic reference position for the biomechanical theory. I think that the application of the dynamical systems theory of "variety and uniqueness" suits Descartes' biomechanical theory. When the ideal becomes reality, it is considered to be optimized by the organism itself, even if it does not coincide with the ideal for various reasons.

The terms "centric relation" and "terminal hinge-axis" are similar concepts, but I believe that "terminal hinge-axis" is the very "centric relation" designed by God in Descartes' biomechanical theory. I believe that the positioning of the upper and lower jaws in the centric occlusion of a healthy human being is referred to as the "centric relation". Descartes would have thought of it this way.

This is my opinion, but I think that conventional gnathology is an idea derived from Descartes' biomechanical theory, and that meaning is made in a theoretical system from the combined categories of necessity and chance. I think conventional gnathology is one way of expressing biomechanical theory in dentistry. The treatment from the combined categories of necessity and chance has been reworked into the problem of determining the position of the "centric relation". Although the term "inevitability" and "contingency" are used, the strict rules of inevitability and the ambiguity of contingency are so closely intertwined that it is difficult to separate them accurately in practice. It seems that Japanese dentists have had quite a bit of trouble with this. Some dentists

took it seriously, but others were not interested in this kind of thing.

I first learned the word gnathology more than 40 years ago. It was some time after I became a dental technologist. What I learned then was that the human mandible has a purely rotational axis, like a robot's jaw. I thought, "This is a curious story." Other than that, I thought it made a reasonable amount of sense. But then again, this is all about diagnostics. It would be valuable to know where the "centric relation" is if the dentist himself were actually doing the dental work. However, I also thought that it would be meaningless for a dental technologist who specializes in making prosthetics to study such things.

The reason for this is that the dental technologist actually makes the dental prosthesis, but basically has no access to the patient in question. In difficult cases such as these with occlusal reconstructions, it is quite troublesome to try waxing up the dental prosthesis and ask the dentist for his/her opinion and correction at that time, due to the discretionary power regarding the fabrication of dental prosthetics. In addition, the dental technologist cannot see the result of the treatment. So, although it may not be a waste of time to think about this and that, it was tedious and I wondered how it would be done.

In fact, where the axis of rotation is located is a diagnostic matter and is not relevant to the dental technologist. Wherever it is, it is the dentist's own problem and does not directly concern the dental technologist. If it matters to the dental technologist, misalignment of the axis can lead to greater adjustment of the fabricated dental prosthesis and, in the worst case, possible remanufacturing.

Why was gnathology applied in this way to the movement of the mechanical human mandible, despite the fact that gnathology is about the movement of the human mandible? I found it very unnatural. I now wonder again if gnathology was not a starting point from the viewpoint of Descartes' theory of biomechanics, rather than dental medicine as preached from clinical experience in dentistry. The definition of the determination of the mandibular position, the central position associated with the terminal hinge axis, has changed many times over the course of time.

By the way, this is what I think now, that the gnathologists who first devised it asked the people of the world how to interpret the terminal hinge axis. I propose a way to use the “virtual kinematic axis” to address the first invented gnathologists' question that emerges from that deeper reading. The purpose of this is to urge that more consideration should have been given to metaphysical concepts rather than to the relationship between the real world and materialistic worldviews. In the real natural world, few things about motion have a purely rotational and translational component that is separate, and I believe that the motion of the mandible is no exception to this rule.

I believe that conventional gnathology has contributed to binding together the fragmented pieces of dental knowledge. In other words, it means to think of dentistry as a system. It also means treating not only the teeth but also the entire oral cavity, including the jaw joints, as a single unit.

Metaphysics is a field of study or philosophy that considers the world beyond the senses and experience to be true existence and attempts to recognize the universal principles of the world through rational thought (or Logos). It considers things that transcend the senses, such as the reasons for the fundamental origins of the world (the root causes of the world) and the reasons and meanings for the existence of things and people. From Wikipedia

Examples of interpenetration of necessity and chance

If you line up 10 steel cubes with 10 mm on a side and measure their dimensions, they will probably be 100.1 mm or 99.9 mm, and they will rarely be exactly 100 mm. In mathematical or arithmetic terms, 10mm times 10 = 100mm. This is in an ideal world, and the reality is that even very small errors, invisible to the eye, can become unwieldy when added up. 10,000, 100 million, or 10 billion pieces would be more significant.

Two measurement and reproduction methods derived from ontology and epistemology

The method of measurement and reproduction from ontology is the so-called conventional pantograph method. Let us discuss the ontological mandibular movement.

As the mandible opens, it begins a rotational movement near the axis that penetrates the right and left intercondylar axes. As it opens more widely, the left and right mandibular heads slide anteroinferior almost equally as they rotate.

Next, let us consider right and left lateral movements. During right lateral movement, the right condyle head rotates with a small lateral shift within the mandibular fossa. In contrast, the left condyle head slides anteriorly inferiorly medially. The opposite is true for left lateral movement. During left lateral movement, the opposite is true.

This is the method of consideration governed by the determinants of mandibular motion. For the anterior determinant, it is anterior guidance during contact movement. During mouth opening motion, there is no anterior determinant.

These expressions are ontological interpretations of mandibular movement derived from biological mechanisms. No one would dispute this. That is why conventional measurement methods used instruments such as pantographs to explore the position of the condyles under the skin to determine the intercondylar axis. They also examined the movement and rotation of the working and non-working condyles during left and right lateral movements. These measurements are truly "ontology-derived methods.

On the other hand, my proposed method of measuring and reproducing mandibular movement, the virtual kinematic axis method, is a method that does not derive from the biological mechanism of mandibular movement, the left and right condyles or anterior guidance.
What does the virtual kinematic axis method dependent on? It can only depend on how mandibular movement is measured. The mandible can be thought of as a rigid body. However, the mandible is covered by soft tissues such as muscle and skin, and it is not easy to locate the exact position of the mandibular head from the outside.

The mandible is connected to the dentition, which is exposed to the outer skin. The dentition and mandible are tightly integrated by the periodontal ligament. Thus, they can be considered as one rigid body.

In other words, measuring the movement of the mandibular dentition is measuring the movement of the mandible. This method of measurement is independent of the intercondylar distance, which varies from individual to individual. It is truly an epistemological measurement method.

The exact path of motion of the mandible can be obtained by giving the mandible three points on the dentition, which is tightly connected to the mandible by the periodontal ligament. These three points do not have to be set directly on the dentition. As shown in this example, a probe with three points can be rigidly connected to the dentition.

The path of movement of the mandibular cannot be known without mathematical processing of the displacement of three points in three-dimensional space. If we want to know the path of movement of a specific position of the mandible, such as the mandibular head, we need a 3D MRI image. In other words, these two measurement methods are complementary, and we need information from both to know the entire mandibular movement.

A face-bow transfer and a three-point motion pathway are sufficient to use the acquired data in the articulator; MRI three-dimensional images are not required.

The virtual kinematic axis method measures three coordinate points attached to the dentition. This means that mandibular motion must be represented mathematically in three-dimensional space. When it is not necessary to strictly locate the position of the condyles, a face-bow transfer is all that is needed to make the rotational axis of the articulator the intercondylar axis of the organism.

The 3D MRI image data of the mandible can be superimposed on the dentition to view accurate condyle head movement. These methods can be achieved extremely easily with "general-purpose CAD".

Living organisms have a slightly different mode of motion than human-made machines. Unlike the geometric motion of a robot, the motion of a living body fluctuates. The detailed movement of the mandible can be viewed again and again by accurately extracting the subtle motions and restoring them on the CAD system.

In any three-point measurement, the left and right condyles and the anterior reference point can be likened to the oscillator since they are the determinants of mandibular motion. Any three points can be the transmitter of the position and path of motion of the entire mandible. The camera captures the movement of the dentition and changes in mandibular posture, so the camera and other sensors are the receivers.

The position of the condyle head can be reconstructed by superimposing the MRI image in the CAD. A face-bow transfer is sufficient to transfer the data to the articulator; if the only purpose is to know the path of mandibular motion within the CAD, a face-bow transfer is not necessary. This is possible because of the method derived from the measurement method.

Autopoiesis speaks for itself, looking for a new gnathology

The new gnathology, as I see it, begins with the transformation of the real world into the ideal world. The development of the technology of prosthetic dentistry was intended to obtain an indirect environment for the creation of dental prosthetics. In addition, it could be said that it was a history of searching for a kind of norm regarding the alignment of teeth and so on. Specifically, these norms are things like the relationship between the articulator, which is face-bow transferred and fitted with upper and lower dental models, and each reference point on the face, and the rules for how the teeth are aligned.

They ranged from complex to simple. For example, the ideal environment for the creation of dental prosthetics is the articulator. Since we cannot create dental prosthetics directly in the mouth, we need an indirect environment for fabrication. In addition, "Bonwill triangle," "curve of Spee," and "Monson's spherical theory" provide various guidelines for tooth alignment, etc.

Recently I have come to believe that the gnathologists who first devised gnathology asked the people of the world how to interpret centric relation. I propose a way to

answer that question using the "virtual kinematic axis" and the "Cartesian coordinate system". Today, computer technology, as represented by CAD, is well developed. Computer technology allows the dentist to obtain any number of mandibular motion paths if he or she so desires. In addition, the open/close movement of the mandible, which is not directly related to occlusion, can be added to the path of movement. Thus, instead of seeking an ideal environment in an actual "articulator" as in the past, we can consider mandibular motion in a flexible environment by using a new item called CAD.

In my opinion, the term “terminal hinge axis” or "centric relation" in gnathology is actually not of this world, but the ideal world in dentistry, or the central item in a metaphysical narrative. That is to say. In other words, it is not a real world story. There is a gap between the ideal world and the real world. It is not easy for an ideal world entity to appear in the real world. Some procedure is required.

It has been quite some time since the gnathology was published, and the definition of centric relation has changed many times in that time. That is how difficult it is to define. I think the cause of this difficulty lies in the gap between the ideal world and the real world. I feel that this gap has not been resolved for any length of time. In the real world, necessity and chance permeate each other, and one of the reasons is that it is very difficult to confirm only the pure rotational motion of the mandible in the intercondylar axis applied to the centric relation, i.e., the hinge axis alone.

This is not easy to do, no matter how much the patient himself tries to make only open-close movements that do not involve mandibular movement, and no matter how meticulously the dentist tries to guide the patient to make only purely open-close movements. This has been the experience of many dentists historically. However, it is not absolutely impossible.

If the mandibular head were perfectly spherical and the mandible were symmetrical, there might be only one axis of rotation. However, the human mandibular head is not perfectly spherical, and the mandible is not perfectly symmetrical. Furthermore, there may be two or more axes of rotation due to the presence of various buffering tissues as well as bones around the mandible. On the contrary, it may exist as an area. If that is the case, then there could be an infinite number of rotational axes. This is just a consideration, and the actual situation is not clear without careful investigation.

Let us now consider the relationship between the terminal hinge axis and the centric relation. As quoted from the article "Reconsidering the Centric Relation (Theory)" featured in the July 2022 issue of "Shikai Tenbo," we understand the definition as follows

（Centric relation in the terminal hinge position of the mandible , in which the hinge axis is constant to both the mandible and maxilla.）

Let us again consider the definition of terminal hinge axis or centric relation. The first question is whether the terminal hinge axis is a pure axis of rotation that does not allow even a micron of motion, or whether it allows some motion blur. Currently, there does not seem to be a strict definition of a terminal hinge axis. The latest situation in this area is featured in the July 2022 issue of "Shikai Tenbo," a dental trade publication, which contains an article titled "Reconsidering the Centric Relation (Theory). It is written by a dentist named Ryushiro Sugita. According to this article, the rotation axis in the centric relation is not "not allowed to blur even one micron," as defined by metaphysics, but rather "should not blur when visually observed.

On welcoming a “Centric Relation” with a terminal hinge axis to the Cartesian coordinate system

The dentist's idea of "axis of rotation in the centric relation" seems to be defined in the real world in a practical sense, not in an ideal world. In the real world, necessity and chance are inseparable and interpenetrate with respect to action, making it difficult to extract only pure rotational motion. In the ideal world of computer-aided CAD, from the various mandibular opening and closing motions, the motion can be analyzed and separated into a rotational component and a translational component. Computer-aided CAD employs a Cartesian coordinate system, which can be clearly seen when the motion data is imported and analyzed.

It will allow us to explore whether or not the initial pure mandibular intercondylar axis rotational movement, i.e., the initial rotational movement of the hinge axis only, is possible during the opening movement. It would also show, for example, the possibility that there is more than one. Any number of opening and closing motion paths can be taken, and any number of lateral movement, etc., can be added.

Applying the 3D Cartesian coordinate system to the analysis of the motion of artificial objects such as robots is easily accomplished. However, precisely analyzing the motion of living organisms is a difficult task because of the complex rotational and translational motions involved, which are difficult to reproduce exactly. If we introduce the 3D Cartesian coordinate system, which is the ideal world of computer-aided CAD for analyzing centric relations, we will be able to perform various analyses and verifications.

In CAD, the 3D Cartesian coordinate system allows for easy coordinate transformation. Even if the position where the mandible motion is measured on the body and the position of the drive unit of the articulator are different, the coordinate data of the measurement position can be converted to the coordinate data of the drive unit of the articulator. By using the coordinate conversion, it is possible to reproduce the motion of the mandible model on the articulator as it has been in the past. Also, by introducing the equation of motion, the mandible position can be managed in time because the equation of relationship between the mandible position and time is created on the CAD.

As a procedure to achieve this, it would be good to introduce the dynamical systems theory, as detailed in the autopoiesis theory, to the dental field. In the history of gnathology, we read, "In 1921 McCollum devised the hinge-axis locator and demonstrated the existence of a terminal hinge-axis." However, this would only be at the visual level. No matter which dentist guides the mandible, there will always be a blur at the micron level. In the real world, it is not easy to find a pure terminal hinge axis that can be reproduced.

When the centric latch of the articulator is activated, the mandibular part of the articulator can only perform pure rotational motion without any blurring. I do not think it is possible to make the mandible move in the real world in a similar way. It would be quite difficult even if dentists applied manual restraints. In the real world, all or several of the "six degrees of freedom of motion" are intricately bound together by the body; in an ideal world using a three-dimensional Cartesian coordinate system, the intricately combined "six degrees of freedom of motion" of the mandible could be broken down to display each component.

About the Virtual Kinematic Axis Method

Why is it necessary to align the axis of rotation of the articulator with the hinge axis of the organism? Rather than a necessity, I believe it stems from the conventional method of measuring mandibular motion. The axis for opening the mandible set in the articulator would have had to be set in a position similar to that of the biological jaw. The July 2022 issue of "Shikai Tenbo," a dental trade publication, features the following article, "Reconsidering the Centric Relation (Theory)," which also states the following.

The terminal hinge axis is the central tenet of gnathology. The supreme goal of gnathology was to reproduce the patient's open/closed mouth motion on the articulator by identifying the terminal hinge axis and aligning it with the open/closed axis of the articulator. Once this is done accurately, the clinical benefits are immeasurable, as a dental prosthetic device fabricated with a modified occlusal vertical dimension on the articulator can be placed in the patient's mouth with minimal adjustment."

This is how the purpose of gnathology is described. As a matter of fact, the relationship between the terminal hinge axis and the centric relation in many people is such that in the centric occlusion, few people have the centric relation and terminal hinge axes coincide. The fact that these are misaligned does not seem to cause or predispose to TMJ disorder. While there are operational advantages for the dentist in the above statements, there does not seem to be a health reason for the purpose of gnathology. After all, gnathology is a concept derived from structuralism in accordance with the fundamentalist theory of biomechanics.

Structuralism is one of the modern philosophies of the 20th century. In a broad sense, the term has been extended from modern thought to refer to a methodology for extracting the latent structure of any phenomenon and using that structure to understand and, in some cases, control the phenomenon. Adapted from Wikipedia

If there are many teeth that have nothing to do with the treatment, the standard of occlusion is the centric occlusion. Usually, the tooth shape of a dental prosthesis is formed based on this position for both anterior teeth and molars. In the real world, if the centric relation of the living body and the axis of rotation of the articulator can truly be aligned, the centric occlusion can be freely determined on the articulator. This means that the height of the occlusion can be changed. This can be done simply by adjusting

the incisal pin of the articulator. However, this can only be used in practice when creating dental prosthetics for the entire upper and lower dentition. It is useful, for example, when fabricating occlusal surfaces in ceramic.

In my opinion, in the real world, it is very likely that there is no pure axis of rotation of the mandible in a living organism. If there is even a micron of deviation, it is not the pure axis of rotation of the mandible. The pure axis of rotation of the mandible definitely exists in the ideal world. There is a gap between the ideal world and the real world, and they do not easily overlap. It is necessary to eliminate the gap or bridge the gap between the two. How can we bridge the gap between the ideal world and the real world?

One idea is the virtual kinematic axis method. What is the virtual kinematic axis method? In a few words, it can be described as follows. When the maxillary model is mounted on the articulator, the intercondylar axis of the articulator automatically becomes the kinematic axis of the mandibular model. When the maxillary dental model is mounted on the articulator by means of the face-bow transfer, the intercondylar axis of the mandible is set at the average position of the body. If done by eye, it will be set in a reasonable position. This is the virtual kinematic axis method.

The opening and closing motion of the biological mandible is different from the opening and closing motion of the articulator. Even if they are different, I do not think it is a problem. When making dental prosthetics, differences in the position of the axes in simple open-close motion have no effect on the tooth shape and do not cause any problems in the work. The virtual kinematic axis method is based on the idea that in the real world it is very difficult to find a purely rotational axis in the centric relation with a terminal hinge axis. In cases where only the centric occlusion is at issue, the coincidence of axes is irrelevant, so the virtual kinematic axis method is sufficient. We believe that the terminal hinge axis exists in an ideal world. I just haven't found a way to make that position appear in the real world.

The virtual kinematic axis method does not measure the amount of movement of the axis of rotation when the patient moves the mandible open and closed. Nor does it have a method to reproduce it. Therefore, when the incisal pin of the articulator is adjusted to change the occlusal vertical dimension, an error will always occur. Whenever it is necessary to change the occlusal vertical dimension, in other words, to change the

centric occlusion, it is necessary to obtain a mush bite for confirmation in vivo. The mandibular model must be reattached to the articulator using the mush bite.

If we want to know the true axis of open/closed mandibular motion, we need to load the MRI 3D image of the mandible into an environment where the upper and lower dental models are attached to the articulator on the CAD. When the 3D MRI image of the mandible is loaded and superimposed on the mandibular model, the left and right condyle heads of the organism are displayed. It will probably be slightly off from the intercondylar axis of the articulator. If you use the measured data to move the mandible, you can see on the CAD how the condylar part of the MRI 3D image of the mandible moves.

Dentists have probably never seen a video of the mandibular head moving in three dimensions because they have been measuring mandibular motion using conventional methods. In the conventional method, the three-dimensional movement of the mandibular head is determined based on the projected trajectory on a two-dimensional plane. It is also impossible to reproduce the opening and closing movements of the mandible on an actual articulator.

About the Ideal World

Let us invite the "centric relation with terminal hinge axis" to the ideal world. In the ideal world, there is no error. Even at the micron level, there is zero motion of the axis of rotation. In the ideal world, the "six degrees of freedom of rigid body motion" can be driven individually. It is also possible to combine multiple elements of motion and rotation. In the ideal world, time can move forward or backward. Objects can overlap, touch, or move away from each other, collide, or pass through each other. The ideal world may be the equivalent of the world described by mathematics, for example, theory or physics.

There is no error in the ideal world; there is error in the real world. This error refers to dimensional differences that occur unexpectedly due to chance and necessity. Even in the ideal world, depending on the setting, there can be a very large number of mathematical decimal places in the setting.

Also, in the ideal world, elements can exist individually, whereas in the real world, multiple elements exist in connection. This arises from the idea of interpenetration. They cannot be easily separated by humans. Therefore, there must be an interface between the real world and the ideal world, and trying to directly superimpose or connect the ideal world and the real world will not work. To access the ideal world from the real world requires error resolution and interpretation of the ideal world from the real world.

It is the dentist who actually operates the mandibular measurements. Dentists and dental technologists operate CAD and other equipment, but the operation must be within the scope of their daily work. Equipment that is too expensive or time-consuming to operate is not acceptable for practical use.

About Ideal Parts

The component-related elements for mandibular movement that are indirectly represented are fabricated as "ideal parts" in CAD. For example, the length of the left-right intercondylar axis in the ideal world is the same for all, 110mm. In the conventional method, the inter-condylar distance would have to be changed. In the ideal world, the shape of the left and right condyles of the mandible are perfectly spherical and perfectly symmetrical in position with the midsagittal plane. There is only one axis of rotation. The reason for this is that the focus is on accurately reproducing the motion of the dentition rather than the mandible. These were made possible by performing a "coordinate transformation" in a three-dimensional Cartesian coordinate system.

If the maxillary dental model is mounted on the articulator without face-bow transfer, the maxillary dental model will be mounted off the reference plane of the articulator. Even in such a case, the virtual kinematic axis method does not cause any error in the motion data of the mandible. There is only an error between the reference plane of the organism and the reference plane set in the articulator. If no face-bow transfer is used, the Bennet angle and Condylar guidance inclination and the Angle of incisal path may deviate from the average values.

In the virtual kinematic axis method, the length of the left and right intercondylar axis is fixed at 110 mm. There is no difference between men and women, no difference in age, and no difference in ethnicity. It is constant in all. If for some reason we want to know

the true left-right condylar motion, we can do so by showing the positional relationship between the mandibular dentition and the left-right condylar regions of the organism on CAD. The length of the left-right intercondylar axis is 110 mm, which is the length currently employed in articulators of similar size to the living body. The technique of "coordinate transformation" in a three-dimensional Cartesian coordinate system makes this possible.

The left and right condylar areas of the articulator are the reference for manipulating the movement of the mandibular portion of the articulator. The length of the axis between the left and right condyles in a living body differs from person to person. In addition, the three-dimensional position of the condyles in a living body is not perfectly symmetrical about the median plane. What is important in this virtual kinematic axis method is the change in the three-dimensional position of the mandibular dentition in relation to the maxillary dentition.

Three-dimensional positional changes of the mandibular dentition are collected using the "pre-labial measurement method". This data is used to reproduce the displacement of the mandibular model position on the articulator in the CAD. The data collected in front of the lips is converted into the motion of the condylar ball and the tip of the incisal pin on a virtual kinematic axis with a left-right intercondylar axis length of 110 mm. It is not a reproduction of the specific positional motion pathways of the left and right mandibular heads that exist in the organism.

About Precision Provisional Restorations for Measurement

When fabricating a dental prosthesis with a large number of teeth, a precise provisional restoration will probably be needed to measure the positioning of the maxillary and mandibular dentition. Its anterior tooth county portion has anatomical morphology and is given accurate anterior guidance. The molars have a occlusal vertical dimension that the centric occlusion is maintained and reproduced. It would be even better if the molars also had an anatomical form. A 3D printer could be used.

What can you do in an ideal world?

There are ideas from the categories of coincidence and inevitability, but suddenly something interferes or leads to something else, and this was a story that works among

those who look only at the real world. When we stick to the real world in this way, there is nothing definite about the future. There is always uncertainty.

Also, the term "ideal world" does not mean a world of convenience. In the ideal world, the future is already determined, and there is no such thing as a future based on ideas of chance and inevitability. In the ideal world, the past, the future, and everything else is already known. Even if you hide in the shadows, you will be found. Everything is in full view. It is like the world of Adam and Eve in the Old Testament book of Genesis.

However, not everything about the ideal world is revealed to humans. And although humans are trying, they still do not have full access to the ideal world. The categories of chance and inevitability cannot describe, explain, or access the ideal world because they belong to different worlds. Thus, we cannot interact with the ideal world from the categories of chance and necessity.

To access the ideal world, we need to think from uniqueness and diversity. Thinking in terms of uniqueness and diversity, we think of convergence to one reality out of many possibilities. In the ideal world there are all possibilities, but not all can be realized in the real world. This is because there is a consistency problem. The ideal world is a higher concept than the real world, and by sharing the ideal world with the real world, the real world can be brought closer to the ideal world. The ideal world may be paraphrased as dealing with the abstract world from the perspective of the real world.

The term symmetry is used as a means of explaining or expressing the connection between the ideal world and the real world. Symmetry has a slightly different meaning depending on the academic discipline with which it deals. In general, symmetry refers to operations that do not change appearance, such as symmetric transformations. Also, in physics, symmetry is the symmetry of a physical system, that is, the invariance of the appearance of the system under a particular transformation. In mathematics, there are issues such as the solvability of equations, as in Galois theory, and the representation of constructive methods of algebraic structure, as revealed by the exercise of group theory.

Symmetry is the property that "moving it does not change its appearance". Therefore, it is inversely related to "movement" or "change". This property could be used to analyze the change of space between occlusal surfaces. I believe that the study of the proximity relationship between the occlusal surfaces of the maxillary and mandibular molars and

the mechanism of mastication has not been the subject of much research or has been done. I believe that symmetry is the key to solving the problem of changes in the space between the occlusal surfaces. The shape of the occlusal surfaces of the maxillary and mandibular molars may change, but what remains the same is the occlusal vertical dimension at the centric occlusion. What shape of the occlusal surface should be used for a good bite? In addition, there are many factors to be studied, such as the shape of the occlusal surface that is physiologically reasonable when considering the load on the roots of the teeth.

No matter how good a tooth is, it is impossible to talk about function without considering the opposing teeth. In other words, analysis of the shape of the occlusal surfaces of the molars is meaningless without taking into account the opposing teeth. Function is largely a function of the movement of the mandible. This means analyzing the proximity of the occlusal surfaces of the upper and lower molars, or to put it another way, looking at the shape of the occlusal surfaces in terms of symmetry. In summary, I believe that rather than studying the occlusal surfaces of the teeth themselves, we should now study the changes in the space they create, which will lead to the discovery of new functions.

It is true that the concavity and convexity of the occlusal surfaces of molars exist in response to the concavity and convexity of the opposing teeth, but why are they shaped the way they are? We don't know what is the purpose of the shape of the occlusal surfaces. I don't think it is just a random unevenness, but I don't know why. Of course, I think it is shaped based on the presence of the opposing teeth and the movement of the mandible.

In dentistry, symmetry is the study of how the space between the occlusal surfaces changes with the opposing teeth. The use of finite element methods and fluid analysis is important. Symmetry is the mechanism of the natural world, which is made up of structure and energy. Symmetry allows us to know the whole from one part or half of things, based on relationships, etc. By abstracting things, idealizing things, and using mathematical models, we can create a depth and breadth that has never been seen before. Humans extracted the abstract world from the real world, but I believe that the ideal world actually preceded the real world, and the real world was created by the fruition of the abstract world.

For dentists interested in dental technology

One reason for the decline of gnathology is that dental technology has been transferred to dental technologists over time. Dental technology has become less involved with dentists. To fully and freely design a dental prosthesis requires 100% discretion over the treatment. I believe that dentists who embrace and practice gnathology have an extraordinary interest in dental technology. This is evident in the history of dentistry. The history of the construction of the occlusal appliance, an ideal environment that simulates the living body, was intended to produce an ideal dental prosthesis, and I think there is a strong recognition that dentists should be actively involved in dental technology as well. Today, we have entered an era in which the use of artificial intelligence is becoming possible in earnest. I believe that many dentists would like to design their own dental prosthetics. I would like to see the "design of dental prosthetics" put back in the hands of dentists with the help of artificial intelligence.

The design of dental prosthetics using CAD called Solidworks

Solidworks has three license styles: Standard, Professional, and Premium. The basic price differs depending on the features. The "General-Purpose CAD" is a better value than the dental-specific CAD, not only in terms of features, but also in terms of price. There are two types of product specifications: the traditional perpetual license type and a license type that can be used only for the duration of the contract. In the perpetual license type, once purchased, the user can continue to use that version of the license forever, although version upgrades are not possible. To upgrade to a newer version, you must sign an annual maintenance contract called a subscription, which is separate from the license. If you purchase a perpetual license, a subscription is only required for the first year.

There are two types of licenses, one for one year and the other for three months, available only for the duration of the contract. Any service pack updates or version upgrades within this contract period are available at no additional charge. Prices for license purchases vary somewhat from agency to agency, and conditions and services also seem to differ.

The reason why we recommend "general-purpose CAD" is because it is a format that supports both surface and solid modeling. It also allows the use of subdivision surface

functionality with the addition of third-party options. Subdivision surface functionality means that surfaces or solids can be treated like polygonal modelers, i.e., like clay modeling. This versatility allows you to use a single CAD system for a wide variety of modeling styles and purposes.

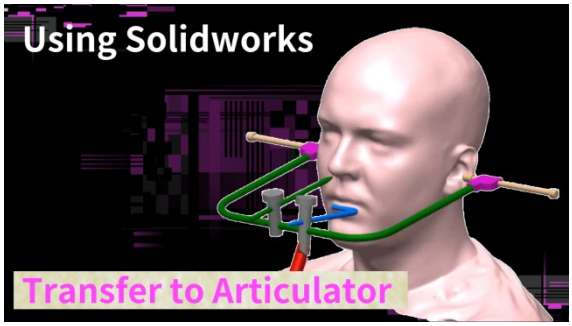
Now, with the addition of subdivision surface modeling capabilities that work seamlessly with Solidworks, users can easily create non-geometric shapes and complex surfaces in the original Solidworks product.

Use of dedicated plug-ins

Power Surfacing RE v6 for Solidworks is a plug-in for Solidworks that adds the ability to work with subdivision surfaces in Solidworks. Thanks to this, Solidworks can now be used for dental technology.

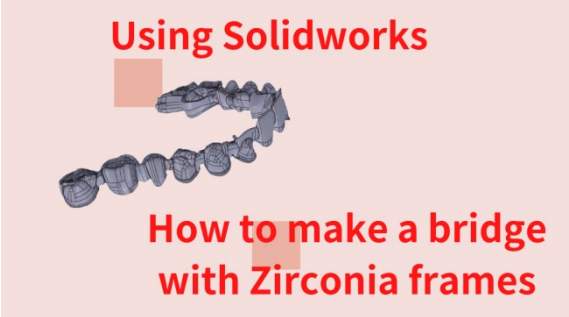
Dental technology using general-purpose CAD requires a bit of preparation

The value of using "generic CAD" goes beyond modeling tooth geometry. It allows you to study mandibular motion and also to study occlusion in your own unique way. The trajectories of multiple mandibular movements can be imported into CAD, allowing you the freedom to create devices within CAD to measure and analyze them.



How to fabricate bridges with zirconia frames

We demonstrated the fabrication of a full bridge made of zirconia. Although we do not actually fabricate such long bridges in practice, we created this demonstration video to discuss the fabrication process. It shows the process of creating the cement space and the pontic of the bridge. It also includes the creation of the molar reinforcement.



How to make a single crown with a zirconia frame

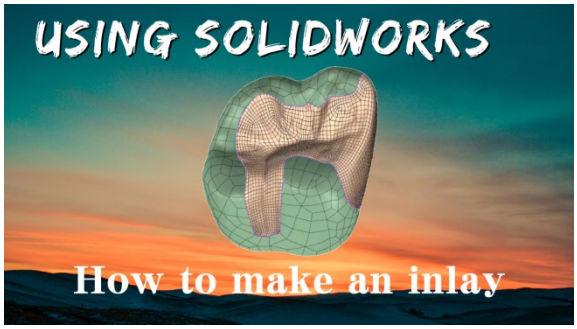
The presentation focuses on the creation of frames for the anterior teeth of the mandible.

How to Create Ceramic Crowns

Even though we go to the trouble of using computers to perform dental work, I think it would be boring to simply replace the traditional wax-up operation with computer operation. After all, I think that "crown shape recovery" by artificial intelligence is essential when using computers to perform dental work. Once computers acquire this kind of functionality, I believe that anyone will be able to perform the work easily and without stress. Unfortunately, it is not possible to do so at present.

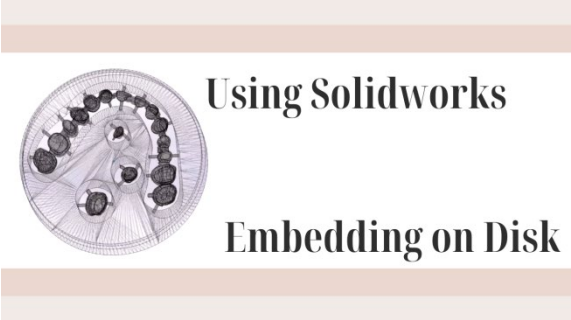
How to make an inlay

This is a maxillary molar case. Creating the basic surface shape is quite tedious.



Embedding on Zirconia Disk

This operation is used to shave the frame shape.



How to make a metal plate

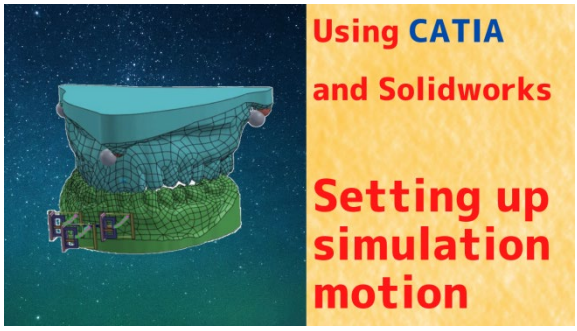
This is a case of missing right-sided first and second molars

How to make a complete denture (lower jaw only)

The demo will be the lower jaw. Ready-made artificial teeth may not be usable.

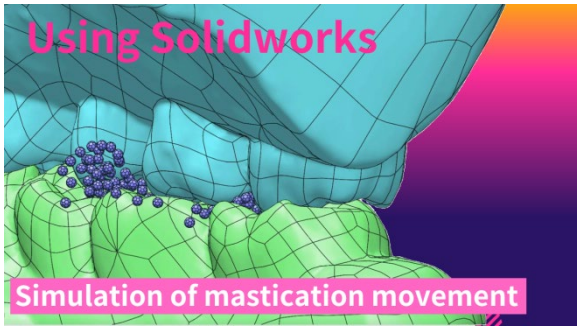
Using CATIA and Solidworks:　Setting up simulation motion

It can motion the mandible. The following shows the settings for this.



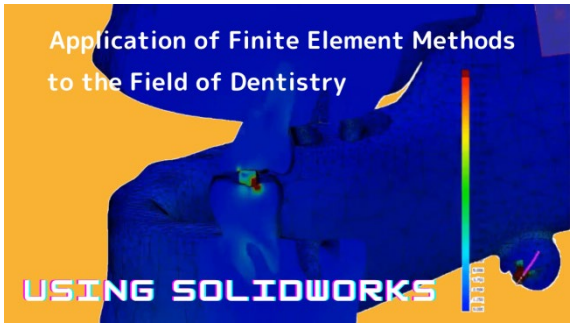
Masticatory movement simulation

Simulate how crushed food fragments are ejected buccally and lingually when an object is actually chewed instead of the usual lateral movement.



Applications of the Finite Element Method

I don't know to what extent this is valid, but I applied the finite element method.



Applying Artificial Intelligence to Dental Technology

It has been some time since the use of artificial intelligence, machine learning, and deep learning became a hot topic in the industrial world, and it has already been put to practical use in various fields such as voice synthesis and image restoration. I hear that some of this technology is already being used in dental CAD. I have been advocating the use of "general-purpose CAD" in the dental field, but unfortunately, "general-purpose CAD" with the desired artificial intelligence functionality built in does not yet exist today.

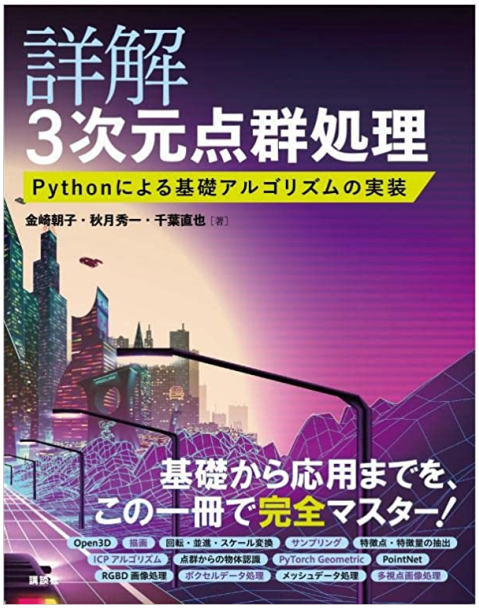
My ultimate goal is to enable dentists to design their own prosthetics using CAD, or to provide direct study of crown geometry in clinical practice. If CAD is too complicated to use, dentists will probably leave it to dental technologists to do it for them. Although we have been trying to port dental technology to "general-purpose CAD" so that anyone can do it easily and accurately, the problem of "generation and editing" of individual crown shapes still remains.

For a single crown or a 3-unit bridge, it is not too burdensome to read a pre-made basic crown shape and manually edit it individually. However, for a full bridge consisting of an upper and lower jaw, it would be very difficult to manually edit each of the 28 teeth individually. It is not possible for a dentist to do this during the day while practicing dentistry. The technology of "automatic crown shape generation with mandibular movement" has been a dream of mine for many years. The main reason for the transfer of dental technology to "general-purpose CAD" was to combine the automatic crown shape generation and shape editing operations.

So how can we achieve automatic crown shape generation? I think we will use artificial intelligence functions, but at this point I don't know exactly how to do that. In the field of deep learning, examples of using "Python" often appear in many reference books, but most of them seem to be used for 2D image recognition.

PyTorch3D seems to be useful for special libraries that manipulate "point clouds," such as machine learning for 3D, even when creating 3D shapes, as in this example. However, it is not so widely used at this time, and there are no appropriate manuals available to the general public.

Even Google Trends is unable to collect data on "PyTorch3D" at this level. Although it seems to be rarely searched for today, 3D is an area that will surely become popular in the near future. Google Trend is a tool provided by Google Inc. that allows users to check the trend of searches on Google and shows the number of searches for keywords.



Recently, this kind of book was published. The book "Detailed 3D Point Cloud Processing: Implementing Basic Algorithms in Python - Publisher, KS Science and Engineering Specialty Book, 2022_10_5" has been published. I believe that the day when 3D shape restoration can be realized will come gradually.

The End